ELECTRONIC
CIRCUITS
MANUAL

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ELECTRONIC CIRCUITS MANUAL
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HANDBOOK OF ELECTRONIC CONTROL CIRCUITS
HANDBOOK OF INDUSTRIAL ELECTRONIC CIRCUITS
HANDBOOK OF INDUSTRIAL ELECTRONIC CONTROL CIRCUITS
HOW TO GET AHEAD IN THE TELEVISION AND RADIO SERVICING BUSINESS
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SOURCEBOOK OF ELECTRONIC CIRCUITS
TELEVISION AND RADIO REPAIRING
WHAT ELECTRONICS DOES

ELECTRONIC
CIRCUITS
MANUAL

Over 3,100 modern electronic circuits, complete with values of all parts, organized in 99 logical chapters for quick reference and convenient browsing

JOHN MARKUS

Consultant, McGraw-Hill Book Company
Senior Member, Institute of Electrical and Electronics Engineers
Editorial Board, American Society for Information Science

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ELECTRONIC CIRCUITS MANUAL

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Preface

More than 3,100 electronic circuits, published largely within the past 5 years in the United States and abroad, are presented here in 99 chapters, logically organized for convenient reference and browsing by practical electronics engineers, technicians, and experimenters. Each circuit has the values of all significant components, an identifying title, a concise description, performance data, and suggestions for applications. At the end of each description is a citation giving the title of the original article or book, its author, and the exact location in the source. After a circuit is selected, the construction details, performance graphs, and calibration procedures can usually be found in the original publication if needed.

The circuits in this book are completely different from those in the highly successful predecessor volume, "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968. New chapters provide easy access for the first time to circuits for Audio Control, Automotive Control, Flashers, Lamp Control, Lasers, Metal Detectors, Opamps, Optoelectronics, Tachometers, Voltage-Level Detectors, and 14 other new categories. Internal connections for the most-used IC chips are given in the Integrated Circuits chapter as an extra aid for analyzing the modern solid-state circuits that dominate this book.

This electronic circuit compendium serves as a highly effective desk-top information retrieval system for tested practical electronic circuits developed throughout the world. Engineering libraries, particularly in foreign countries, will find it a welcome substitute for the original sources when facing limitations on budgets, shelving, or searching manpower. The circuits for this new book were located by cover-to-cover searching of five years of back issues of 39 U.S. and foreign electronics periodicals, the published literature of several hundred manufacturers, and hundreds of recent books, together filling well over 100 feet of shelving. This same search would take weeks or even months at a large engineering library, plus the time required to write for manufacturer literature and locate elusive sources.

To find a desired circuit quickly, start with the alphabetically arranged table of contents at the front of the book. Note the chapters most likely to contain the desired type of circuit, and look in these first. Remember that most applications use combinations of basic circuits, and could therefore be placed in any of several different chapters.

If a quick scan of these chapters does not give the exact circuit desired, use the index at the back of the book. Here the circuits are indexed in depth under the different names by which they are known. In addition, the index contains hundreds of cross references that speed up your search.

In most cases, you can locate a desired circuit in a few minutes. It should be free of drafting errors, because corrections pointed out in subsequently published errata notices have been made; this alone can save many frustrating hours of troubleshooting.

Values of important components are given for every circuit, because these help in reading the circuit and redesigning it for other requirements. The development of a circuit for a new application is speeded when design work can be started with a working circuit, instead of starting from scratch. Research and experimentation are thereby cut to a minimum, so even a single use of this circuit-retrieval book could pay for its initial cost many times over.

This book is organized to provide a maximum of circuit information per page, with minimum repetition. The chapter title, heading, and original title in the citation should therefore be considered along with the description when studying a circuit.

Abbreviations are used extensively to conserve space. Their meanings are given after the table of contents. Abbreviations on diagrams and in original article titles were unchanged, but their meanings can be deduced by context.

Few publications are able to maintain a supply of back issues, but many are willing to make copies of individual articles. A charge is usually made for this service, per page or per article. Similarly, libraries are usually willing to make copies of articles in publications brought to their copying machines.

Mailing addresses of some U.S. electronics publications are given after the list of abbreviations for convenience in writing for back issues or copies of articles. Addresses for foreign sources are generally included with the citations for the 420 foreign circuits given.

To artist and orchid-hybridizer Jack Quint, more active than ever in Florida retirement, goes full credit for arranging the circuits so well on these pages, each unmistakably associated with its text. Secretaries Joyce MacIntyre and Diane Jacobs deserve recognition for perseverance in learning the language of electronics and typing it exactly as dictated, hyphens, kHzs, and all. Other co-workers for this book include Claire del Aguila, Joan Clough, Barbara Jankowski, and Pat Qualls (typing), Ann Fioto (retyping), Debbie Zlendick (editing), and Mike Wechsberg (140 abstracts).

To the original publications cited and to their authors and editors should go the real credit, however, for making possible this contribution to electronic circuit design.

John Markus

Contents

Preface ... v
Abbreviations used ... ix
Addresses of Electronics Publications ... ix
1. Alarm circuits ... 1
2. Amplifier circuits ... 6
3. Audio amplifier circuits ... 23
4. Audio control circuits ... 49
5. Automatic gain control circuits ... 57
6. Automotive control circuits ... 63
7. Automotive ignition circuits ... 70
8. Battery-charging circuits ... 78
9. Bridge circuits ... 84
10. Capacitance control circuits ... 90
11. Cathode-ray circuits ... 95
12. Chopper circuits ... 105
13. Clock circuits ... 111
14. Code circuits ... 117
15. Comparator circuits ... 121
16. Control circuits ... 128
17. Converter circuits—d-c to d-c ... 138
18. Converter circuits—general ... 145
19. Converter circuits—radio ... 151
20. Counter circuits ... 158
21. Current control circuits ... 180
22. D-c amplifier circuits ... 185
23. Delay circuits ... 194
24. Detector circuits ... 199
25. Digital-analog converter circuits ... 204
26. Display circuits ... 209
27. Electronic music circuits ... 221
28. Filter circuits—active ... 230
29. Filter circuits—passive ... 239
30. Flash circuits ... 244
31. Flasher circuits ... 250
32. Flip-flop circuits ... 260
33. Frequency divider circuits ... 266
34. Frequency measuring circuits ... 274
35. Frequency modulation circuits ... 279
36. Gate circuits ... 288
37. High-voltage circuits ... 294
38. Hobby circuits ... 300
39. I-f amplifier circuits ... 308
40. Infrared circuits ... 314
41. Integrated circuits ... 321
42. Inverter circuits ... 332
43. Lamp control circuits ... 344
44. Lamp dimmer circuits ... 350
45. Laser circuits ... 361
46. Latching circuits ... 366
47. Logic circuits ... 370
48. Magnetic tape circuits ... 381
49. Measuring circuits ... 392
50. Medical circuits ... 407
51. Metal detector circuits ... 415
52. Modulator circuits ... 423
53. Motor control circuits ... 431
54. Multivibrator circuits ... 461
55. Noise circuits ... 488
56. Operational amplifier circuits ... 495
57. Optoelectronic circuits ... 524
58. Oscillator circuits—a-f ... 531
59. Oscillator circuits—r-f ... 538
60. Phase control circuits ... 547
61. Phonograph circuits ... 555
62. Photoelectric circuits ... 564
63. Photography circuits ... 585
64. Power supply protection circuits ... 591
65. Protection circuits ... 601
66. Pulse generator circuits ... 612
67. Pulse shaping circuits ... 618
68. Radiation circuits ... 625
69. Receiver circuits ... 629
70. Regulated power supply circuits ... 638
71. Regulator circuits ... 654
72. Relay circuits ... 674
73. Remote control circuits ... 681
74. Sampling circuits ... 689
75. Sawtooth generator circuits ... 696
76. Servo circuits ... 708
77. Shift register circuits ... 716
78. Single-sideband circuits ... 722
79. Square-wave generator circuits ... 727
80. Switching circuits ... 741
81. Staircase generator circuits ... 751
82. Tachometer circuits ... 756
83. Telemetry circuits ... 763
84. Telephone circuits ... 769
85. Television circuits—black-and-white ... 775
86. Television circuits—color ... 801
87. Temperature control circuits ... 818
88. Test circuits ... 838
89. Timer circuits ... 852
90. Transceiver circuits ... 872
91. Transmitter circuits ... 877
92. Triangular-wave generator circuits ... 892
93. Trigger circuits ... 899
94. Ultrasonic circuits ... 908
95. Video circuits ... 913
96. Voltage-controlled oscillator circuits ... 919
97. Voltage-level detector circuits ... 928
98. Voltage reference circuits ... 941
99. Zero-voltage detector circuits ... 947
Author index ... 953
Subject index ... 957

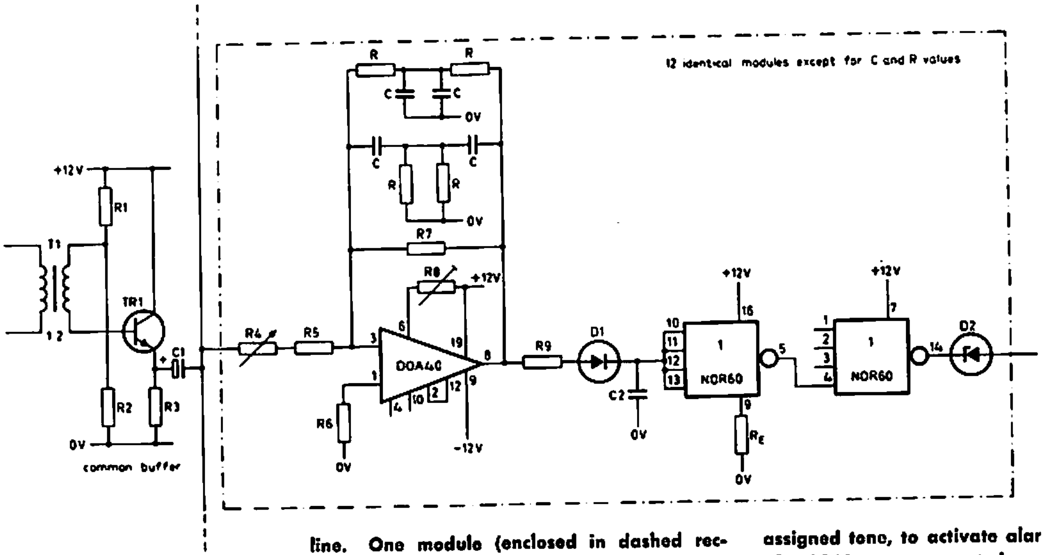
ABBREVIATIONS USED

a	atto (10^{-18})
A	ampere
a-c	alternating current
a-c/d-c	alternating current and direct current
a-f	audio frequency
afc	automatic frequency control
aft	automatic fine tuning
agc	automatic gain control
a-m	amplitude modulation
bcd	binary coded decimal
bfo	beat-frequency oscillator
b-w	black-and-white
c	centi- (10^{-2})
C	Centigrade; capacitance; capacitor
CATV	Community Antenna Television
CB	Citizens Band
CCTV	Closed-Circuit Television
cm	centimeter
cr	cathode-ray
cro	cathode-ray oscilloscope
crt	cathode-ray tube
c-w	continuous-wave
d-a	digital-analog
d-c	direct current
d	deci- (10^{-1})
dB	decibel
dBm	decibels above 1 milliwatt
deg	degree
diac	diode a-c switch
DTL	diode-transistor logic
dvm	digital voltmeter
ecg	electrocardiograph
eeg	electroencephalograph
emf	electromotive force
f	femto- (10^{-15})
fet	field-effect transistor
f-m	frequency modulation
fsk	frequency shift keying
ft	feet
G	giga (10^{9})
GHz	gigahertz
G-M	Geiger-Muller
hp	horsepower
hr	hour
Hz	hertz
IC	integrated circuit
i-f	intermediate frequency
IR	infrared
k	kilo- (10^{3})
K	kilohm (,000 ohms)
kHz	kilohertz
kV	kilovolt
kW	kilowatt
L	inductance; inductor
las	light-activated switch
lascr	light-activated scr
lascs	light-activated scs
m	milli- (10^{-3})
M	mega- (10^{6})
meg	megohm
mH	millihenry
MHz	megahertz
mil	0.001 inch (10^{-3} inch)
min	minute
ms	millisecond
mm	millimeter
modem	modulator-demodulator
mono	monostable multivibrator
mosfet	metal-oxide semiconductor field-effect transistor
μ	micro- (10^{-6})
μA	microampere
μF	microfarad
μH	microhenry
μs	microsecond
mV	millivolt
mvbr	multivibrator
mW	milliwatt
n	nano- (10^{-9})
nA	nanoampere
nF	nanofarad
npn	negative-positive-negative
ns	nanosecond
nW	nanowatt
opamp	operational amplifier
p	pico- (10^{-12})
pA	picoampere
pam	pulse-amplitude modulation
pcm	pulse-code modulation
pep	peak envelope power
pF	picofarad
piv	peak inverse voltage
p-m	phase modulation; permanent magnet
pnp	positive-negative-positive
p-p	peak-to-peak
ppi	plan position indicator
ppm	pulse per minute
pps	pulse per second
preamp	preamplifier
prf	pulse repetition frequency
prr	pulse repetition rate
psc	permanent split capacitor
pW	picowatt
pwm	pulse-width modulation
R	resistance; resistor
RCTL	resistor-capacitor-transistor logic
RDTL	resistor-diode-transistor logic
r-f	radio frequency
rfi	radio frequency interference
rms	root-mean-square
rpm	revolutions per minute
RTL	resistor-transistor logic
sbs	silicon bilateral switch
scope	oscilloscope
scr	silicon controlled rectifier
scs	silicon controlled switch
s	second
s/n	signal-to-noise
spdt	single-pole double-throw
sq cm	square centimeter
ssb	single-sideband
ssl	solid-state lamp
sus	silicon unilateral switch
s-w	short-wave
sync	synchronizing
T	tera- (10^{12})
td	tunnel diode
t-r	transmit-receive
triac	triode a-c switch
TTL	transistor-transistor logic
tv	television
twt	traveling-wave tube
uhf	ultrahigh frequency
ujt	unijunction transistor
V	volt; voltage
VA	voltampere
vco	voltage-controlled oscillator
vdr	voltage-dependent resistor
vfo	variable-frequency oscillator
vhf	very high frequency
vlf	very low frequency
v-o-m	volt-ohm-milliammeter
vswr	voltage standing wave ratio
vu	volume unit
W	watt; wattage
Z	impedance

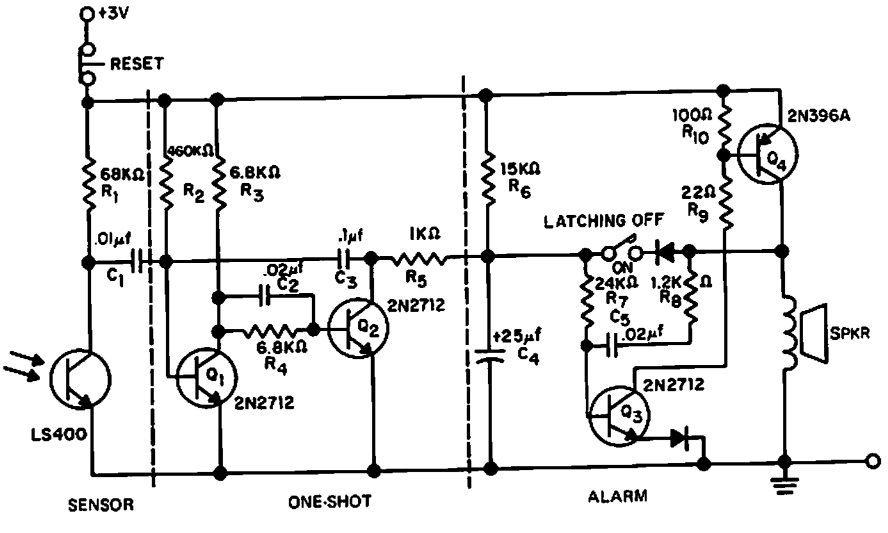
ADDRESSES OF ELECTRONICS PUBLICATIONS

CQ, 14 Vanderventer Avenue, Port Washington, L.I., New York 11050
EDN (now *EDN/EEE*), Cahners Publishing Company, 270 St. Paul Street, Denver, Colorado 80206
EEE (now *EDN/EEE*), Cahners Publishing Company, 270 St. Paul Street, Denver, Colorado 80206
Electronic Design, Hayden Publishing Company, 850 Third Avenue, New York, New York 10222
Electronic News, 7 E. 12th Street, New York, New York 10003
Electronic Products, 645 Stewart Avenue, Garden City, New York 11530
Electronics, 330 W. 42d Street, New York, New York 10036
Electronics World, P.O. Box 1093, Flushing, New York 11352
Electronic Technician, 1 East First Street, Duluth, Minnesota 55802
Elementary Electronics, 229 Park Avenue South, New York, New York 10003
IEEE Publications, 345 East 47th Street, New York, New York 10017
Popular Electronics, Ziff-Davis Publishing, 1 Park Ave., New York, New York 10016
QST, 225 Main St., Newington, Connecticut 06111
Radio-Electronics, Boulder, Colorado 80302

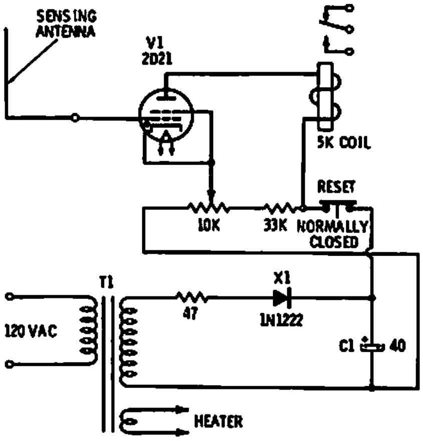
CHAPTER 1
Alarm Circuits


12 identical modules except for C and R values
+12V
R1
T1
TR1
R2
R3
0V
common buffer
C1
R4
R5
R6
0V
R
R
C
C
0V
C
C
R
R
0V
R7
R8
+12V
DOA40
3
6
19
8
1
4
10
2
12
9
-12V
R9
D1
C2
0V
+12V
10
11
12
13
16
1
NOR60
5
9
RE
0V
+12V
1
2
3
4
7
1
NOR60
14
D2

MULTITONE ALARM RECEIVER—Input consists of 12 different audio tones in range from 330 to 2,850 Hz, coming from remote monitoring points over 600-ohm double-core transmission line. One module (enclosed in dashed rectangle) is used for each tone frequency. Report gives values of R and C for the 12 frequencies used. Twin-T network converts Philips DOA40 opamp into selective amplifier that delivers 6.5-V rms output only for its assigned tone, to activate alarm through pair of NOR60 gates connected as Schmitt trigger. —L. J. Lemmens, Single-Line Multitone Transmission for Alarm and Warning Systems, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 75.

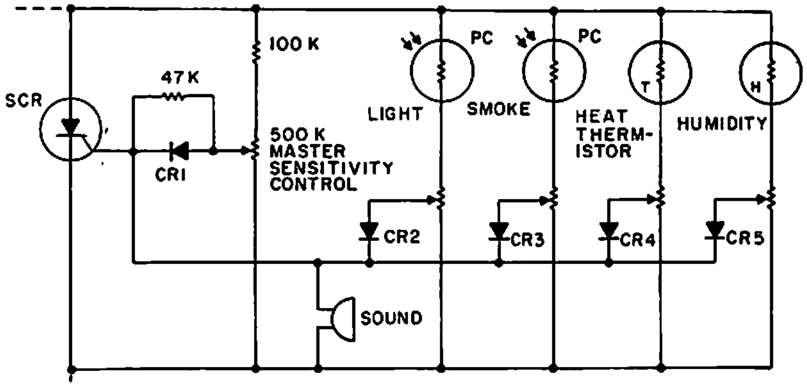

+3V
RESET
68KΩ
R1
.01µf
C1
LS400
SENSOR
460KΩ
R2
6.8KΩ
R3
.02µf
C2
6.8KΩ
R4
Q1
2N2712
.1µf
C3
1KΩ
R5
Q2
2N2712
ONE-SHOT
15KΩ
R6
+25µf
C4
LATCHING OFF
ON
24KΩ
R7
1.2KΩ
R8
C5
.02µf
Q3
2N2712
100Ω
R10
22Ω
R9
Q4
2N396A
SPKR
ALARM

PULSED-LIGHT INTRUSION ALARM RECEIVER—Can be used up to 10 ft away from pulsed-light transmitter. Sounds alarm only if no light pulses reach LS400 phototransistor for predetermined time. One-shot pulse generator stretches received pulses. Alarm consists of 200-Hz audio oscillator Q3-Q4 driving small p-m speaker. Optical filter is not required as long as ambient light is not strong enough to saturate phototransistor. If latching switch is closed, alarm will continue sounding after intruder passes through light beam.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 30.


SENSING ANTENNA
V1
2D21
5K COIL
RESET
10K
33K
NORMALLY CLOSED
T1
X1
120 VAC
47
1N1222
C1
40
HEATER

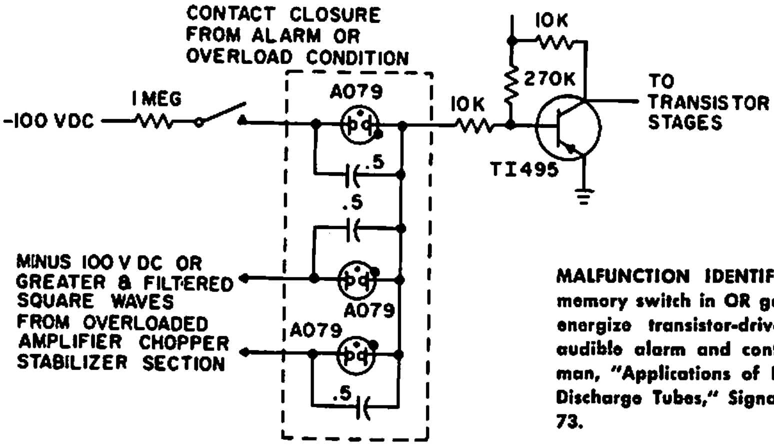
T1 - STANCOR PA-8421

TOUCH SWITCH—Touching of sensing antenna wire with tip of finger is enough to fire 2D21 thyratron and pull in relay that can actuate burglar alarm or close any other circuit.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 78.

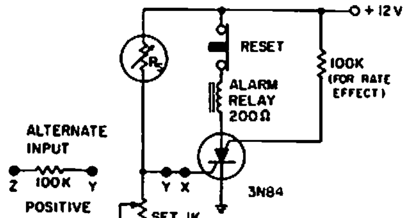

SCR
47K
CR1
100 K
500 K MASTER SENSITIVITY CONTROL
PC
PC
LIGHT
SMOKE
HEAT THERMISTOR
HUMIDITY
T
H
CR2
CR3
CR4
CR5
SOUND

CR1,2,3,4,5-G-E TYPE IN1692

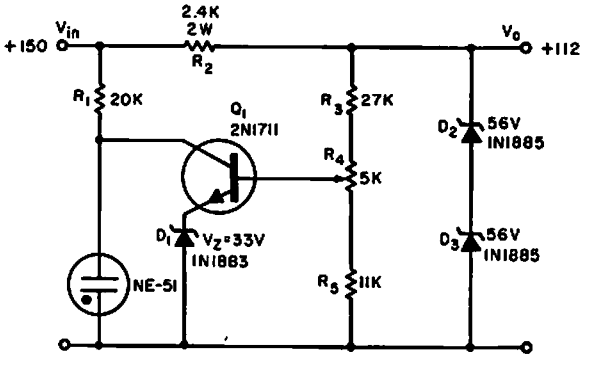
MULTIPLE-SENSOR ALARM—When connected as shown between electrodes of scr in oscillator circuit driving alarm speaker, alarm will respond to flame, smoke, heat, or sound of fire. Response to humidity is optional. Can also be used to wake up bird watchers at sunrise without causing loss of sleep on cloudy days.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 127.


CONTACT CLOSURE FROM ALARM OR OVERLOAD CONDITION
-100 VDC
I MEG
A079
.5
.5
MINUS 100 V DC OR GREATER & FILTERED SQUARE WAVES FROM OVERLOADED AMPLIFIER CHOPPER STABILIZER SECTION
A079
A079
.5
10K
10K
270K
TI495
TO TRANSISTOR STAGES

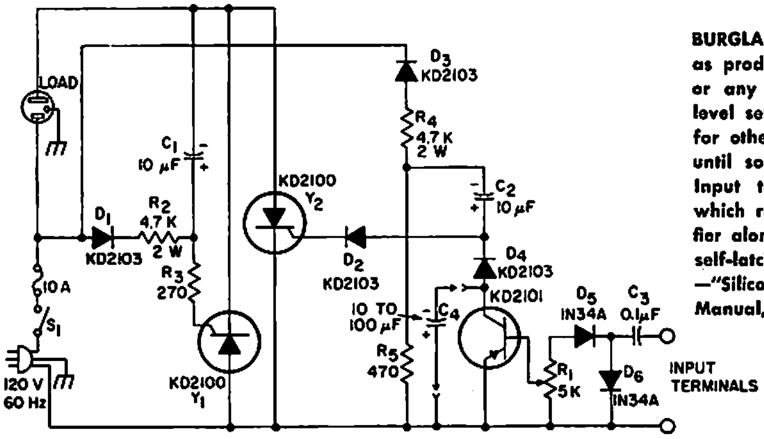
MALFUNCTION IDENTIFICATION—Uses neon-memory switch in OR gate. Lamps flash and energize transistor-driven relay to actuate audible alarm and control circuitry.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 73.


+12V
R_S
RESET
ALARM RELAY 200Ω
100K (FOR RATE EFFECT)
ALTERNATE INPUT
Z 100K Y
Y X
3N84
POSITIVE PULSE TRIGGERS SCS
SET 1K TO 1M
-12V

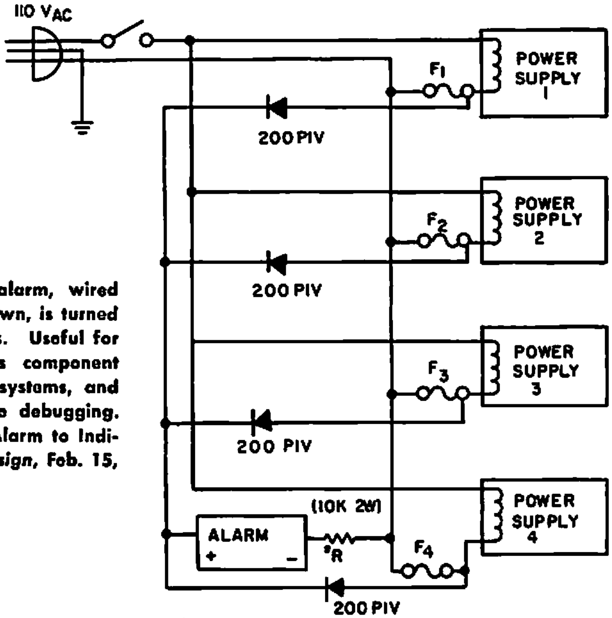
BASIC SCS ALARM—Transducer can be any resistor sensitive to temperature, light, or radiation, up to 1 meg. Alarm is triggered whenever resistance of transducer drops below setting of preset potentiometer. Alternatively, alarm can be triggered by 0.75 V applied to scs through 100K. Interchanging RS and pot gives triggering for increase in transducer resistance.—Planar Silicon Controlled Switch 3N84/3N85, General Electric, Syracuse, N.Y., No. 65.18, 1964.


+150
V_{in}
2.4K 2W
R_2
V_o
+112
R_1 20K
Q_1 2N1711
R_3 27K
R_4 5K
R_5 11K
D_1 V_Z=33V 1N1883
NE-51
D_2 56V 1N1885
D_3 56V 1N1885

OVERLOAD—Inexpensive overload indicator uses neon lamp, three zeners, and transistor. Neon glows to indicate overload whenever output voltage drops below 112 V. If R4 is properly adjusted, lamp will glow for only 1 V drop.—M. R. Johnson, Overload Indicator Utilizes Inexpensive Neon Bulb, *Electronic Design*, June 8, 1964, p 74–75.

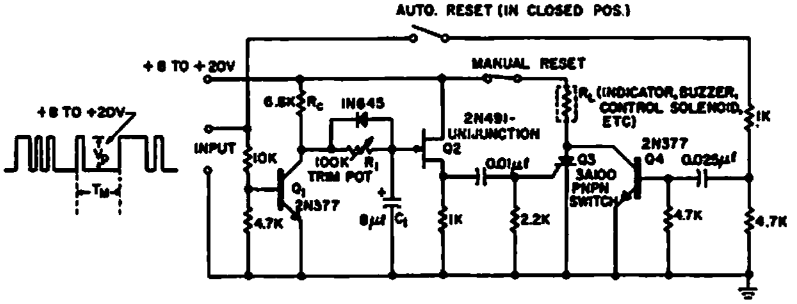

LOAD
C1
10 μF
R2
4.7 K
2 W
D1
KD2103
R3
270
10 A
S1
120 V
60 Hz
KD2100
Y1
KD2100
Y2
D2
KD2103
D3
KD2103
R4
4.7 K
2 W
C2
10 μF
D4
KD2103
KD2101
10 TO
100 μF
C4
R5
470
D5
IN34A
C3
0.1μF
R1
5K
D6
IN34A
INPUT
TERMINALS

BURGLAR NOISE ALARM—When sound level, as produced by burglar breaking into home or any other cause, exceeds predetermined level set by R1, circuit turns on alarm horn for other load up to 1 kW and keeps it on until sound level drops in monitored area. Input terminals require 1-V audio signal, which requires use of preamplifier or amplifier along with microphone. Circuit becomes self-latching if mike picks up sound of alarm. —"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 127.

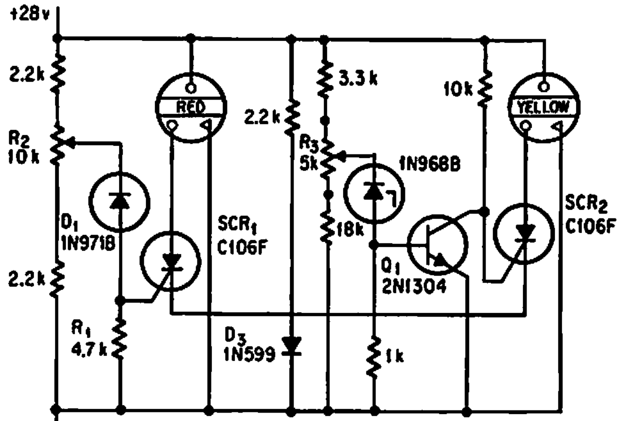

110 VAC
F1
POWER
SUPPLY
1
200 PIV
F2
POWER
SUPPLY
2
200 PIV
F3
POWER
SUPPLY
3
200 PIV
(10K 2W)
ALARM
+
-
*R
F4
POWER
SUPPLY
4
200 PIV

*CHOSEN ACCORDING TO ALARM CURRENT RATING

BLOWN-FUSE ALARM—Audible alarm, wired across all fuses of system as shown, is turned on whenever one of fuses blows. Useful for unattended equipment such as component life-test racks, process control systems, and equipment undergoing prototype debugging. —T. E. Skopal, Use an Audible Alarm to Indicate a Blown Fuse, *Electronic Design*, Feb. 15, 1970, p 84 and 86.


AUTO. RESET (IN CLOSED POS.)
+8 TO +20V
MANUAL RESET
+8 TO +20V
T
Vp
TM
INPUT
6.8K
RC
IN645
10K
100K
R1
TRIM POT
Q1
2N377
4.7K
8μf
C1
2N491-
UNIJUNCTION
Q2
RL (INDICATOR, BUZZER, CONTROL SOLENOID, ETC)
0.01μf
1K
2.2K
Q3
3A100
PNPN
SWITCH
2N377
Q4
0.025μf
4.7K
1K
4.7K

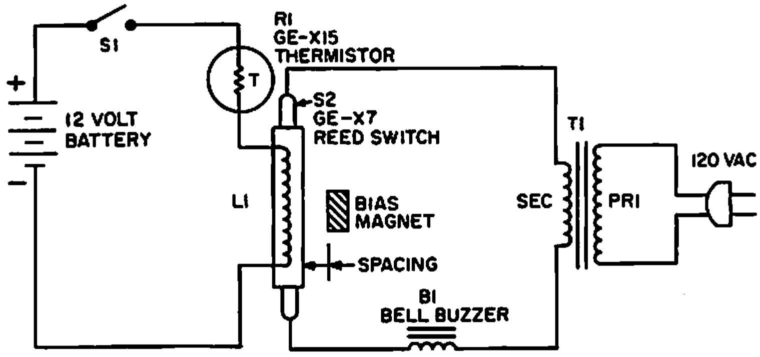
MISSING-PULSE DETECTOR—Circuit actuates indicator, alarm buzzer, or control solenoid when interval between consecutive pulses at input exceeds preset time determined by setting of R1. Has been used to detect misfeed of answer sheet in test-scoring machine and shut off feed before jam occurs. Will also detect momentary dropout longer than preset period, if monitoring d-c line. Reset can be either manual or automatic. Uses diode in ujt timing circuit to provide alternate discharge path without interfering with normal charging cycle of C1. R1 can be set for intervals of 100 ms to 1.5 s.—J. V. McMillin, Versatile Transistorized Alarm Detects Pulse Dropouts, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 113–114.

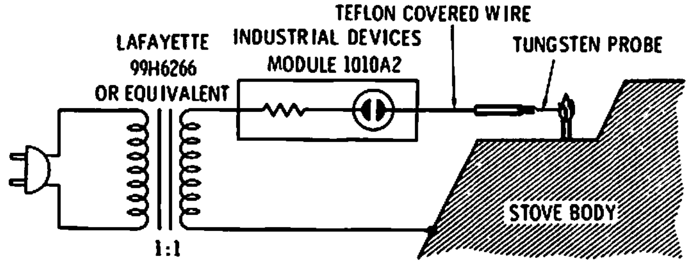

+28v
2.2k
R2 10k
D1 1N9718
2.2k
R1 4.7k
RED
SCR1 C106F
2.2k
D3 1N599
3.3k
R3 5k
18k
1N968B
Q1 2N1304
1k
10k
YELLOW
SCR2 C106F

BOTH LAMPS NO. 327 IN AIRCRAFT TYPE PRESS-TO-TEST LAMP FIXTURES

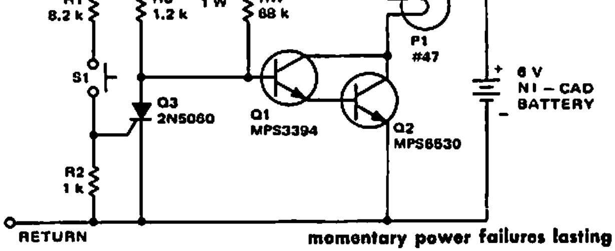
AIRCRAFT D-C OVERVOLTAGE—Red lamp comes on when 28-V supply voltage rises to 32 V because of voltage regulator malfunction, so repairs can be made before aircraft storage battery is damaged. Yellow undervoltage warning lamp comes on when voltage drops below 24 V. With appropriate changes of lamps and semiconductor devices, circuit can monitor voltages up to 600 V.—R. L. Nuckolls III, Warning Lights Monitor D-C Supply Voltage, *Electronics*, Dec. 12, 1966, p 106.

TEMPERATURE ALARM—Will ring bell, turn on lamp, or turn on attic ventilating fan when temperature exceeds predetermined adjustable value in room. Once relay pulls in, alarm cannot be turned off until temperature is reduced or battery switch is opened. If bell or buzzer is operated from battery instead of 12-24 V secondary of bell transformer, alarm becomes independent of power failure. L1 is 7,000 turns No. 38 wound on reed switch.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 152.

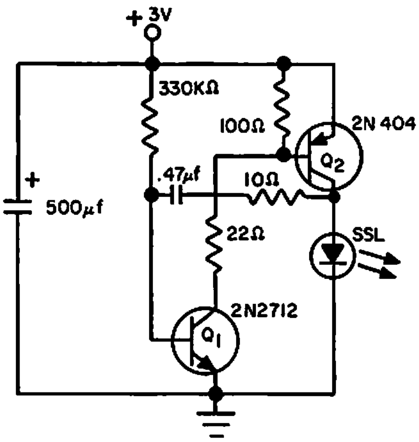

S1
+
12 VOLT BATTERY
R1 GE-X15 THERMISTOR
T
S2 GE-X7 REED SWITCH
L1
BIAS MAGNET
SPACING
B1 BELL BUZZER
T1
SEC
PRI
120 VAC


LAFAYETTE 99H6266 OR EQUIVALENT
INDUSTRIAL DEVICES MODULE 1010A2
TEFLON COVERED WIRE
TUNGSTEN PROBE
STOVE BODY
1:1

PILOT FLAME MONITOR—Utilizes flame as high-impedance conductor to keep neon lamp lit. When pilot flame goes out, lamp extinguishes.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 24.

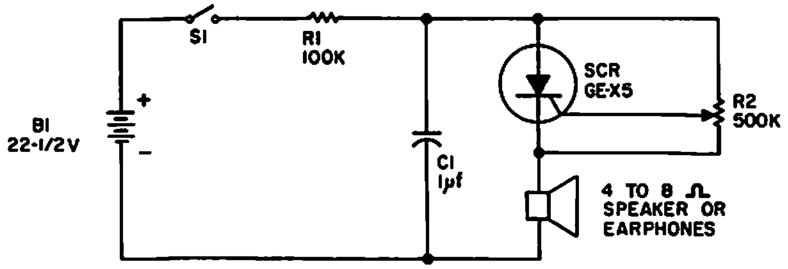

D1 1N4001
+9 V
D2 1N4001
R4 56 1 W
R1 8.2 k
R3 1.2 k
RW 68 k
P1 #47
S1
Q3 2N5060
Q1 MPS3394
Q2 MPS6530
6 V NI-CAD BATTERY
R2 1 k
RETURN

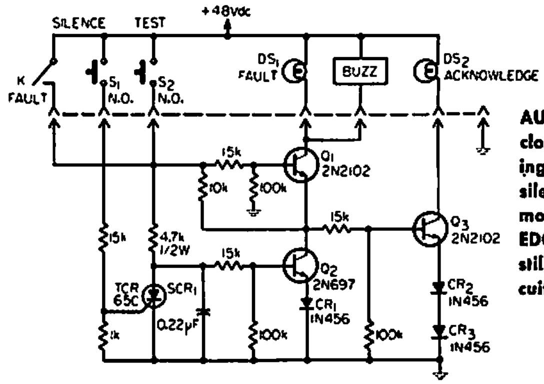
POWER-FAILURE INDICATOR—Lamp comes on whenever 9-V power source fails either because of open or short, and stays on after power is restored, until circuit is reset with S1. Lamp will also come on and stay on for momentary power failures lasting longer than 5-μs recovery time of scr. When circuit is reset, power source will trickle-charge lamp battery to keep it at full charge.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6—40.


+3V
330KΩ
100Ω
2N404
Q2
.47μf
10Ω
+
500μf
22Ω
SSL
2N2712
Q1

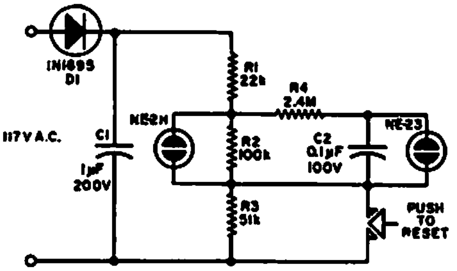
PULSED-LIGHT INTRUSION ALARM TRANSMITTER—Operates from pair of D flashlight cells, drawing only 0.7 mA. Relaxation oscillator applies 1-A current pulses to SSL-4 gallium arsenide lamp at rate of 10 pps. Used with receiver up to 10 feet away, which sounds alarm if no light pulses are received for predetermined time.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 29.

ALARM BOX—Single scr in relaxation oscillator circuit drives speaker to produce series of loud clicks for use as fire, smoke, or intrusion alarm controlled by switch. Setting of R2 determines frequency of clicks.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 124.

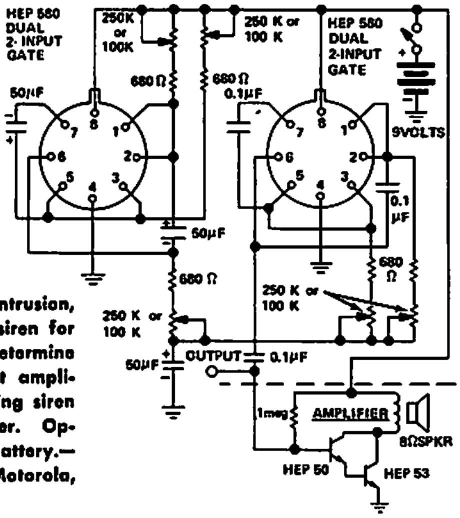

S1
R1
100K
B1
22-1/2V
+
-
C1
1µf
SCR
GE-X5
R2
500K
4 TO 8 Ω
SPEAKER OR
EARPHONES


+48vdc
SILENCE
TEST
K
FAULT
S1
N.O.
S2
N.O.
DS1
FAULT
BUZZ
DS2
ACKNOWLEDGE
15k
10k
100k
Q1
2N2102
15k
Q3
2N2102
15k
4.7k
1/2W
15k
Q2
2N697
TCR
65C
SCR1
CR1
IN456
CR2
IN456
CR3
IN456
1k
0.22µF
100k
100k

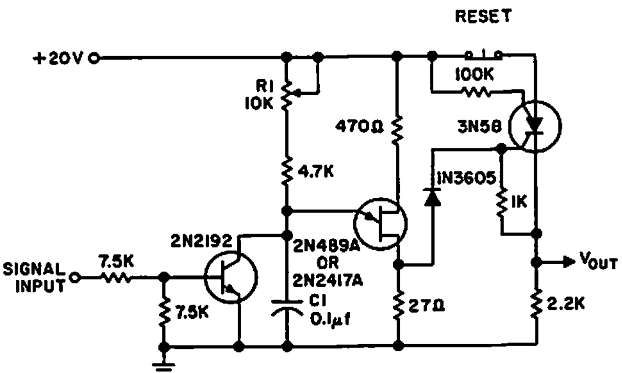
AUDIBLE-VISUAL FAULT ALARM—When fault closes contact K by any means, fault-indicating lamp and buzzer both come on. When silence switch is closed, or when fault is removed, lamp and buzzer go off. ACKNOWLEDGE lamp then comes on only if fault is still present.—R. Breazzano, Fault Alarm Circuit, *EEE*, May 1967, p 180.


IN1695
D1
117V A.C.
C1
1µF
200V
NE2H
R1
22k
R4
2.4M
R2
100k
C2
0.1µF
100V
NE-23
R3
51k
PUSH
TO
RESET

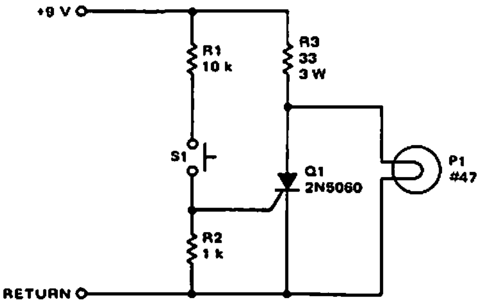
A-C POWER FAILURE—Neon lamp NE-23 begins blinking when a-c line voltage drops below 100 V or power fails, and continues blinking until reset switch is closed. Intended for use with electronic equipment that is left operating unattended for long periods of time. —C. D. Geilker, A. C. Line Voltage Monitor, *Electronics World*, Jan. 1969, p 85.


HEP 580
DUAL
2-INPUT
GATE
250K
or
100K
250 K or
100 K
HEP 580
DUAL
2-INPUT
GATE
680Ω
680Ω
0.1µF
50µF
9VOLTS
0.1
µF
50µF
680Ω
680
Ω
250 K or
100 K
250 K or
100 K
OUTPUT
0.1µF
50µF
1meg
AMPLIFIER
8ΩSPKR
HEP 50
HEP 53

IC SIREN—Can be used for burglar, intrusion, and auto tamper alarms, or as toy siren for bicycles. Potentiometer settings determine type of siren sound obtained. Omit amplifier section (below dashed line) if using siren to feed external audio or p-a amplifier. Operates from 9-V transistor radio battery.—"Tips on Using IC's," HMA-32, Motorola, Phoenix, Ariz., 1968.


RESET
+20V
R1
10K
100K
470Ω
3N58
4.7K
IN3605
IK
2N2192
2N489A
OR
2N2417A
SIGNAL
INPUT
7.5K
7.5K
C1
0.1µf
27Ω
2.2K
VOUT

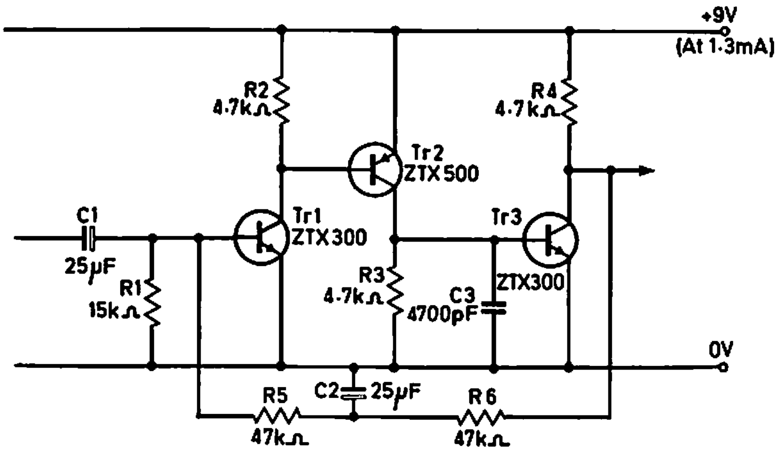
SIGNAL DROPOUT DETECTOR—Provides indication of momentary dropout of d-c, a-c, or pulse input voltage. R1 permits adjusting interval between signal disappearance and triggering of 3N58 scs to give d-c output signal for driving indicator or alarm. Output signal remains until scs is turned off by momentarily opening reset switch.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 4.

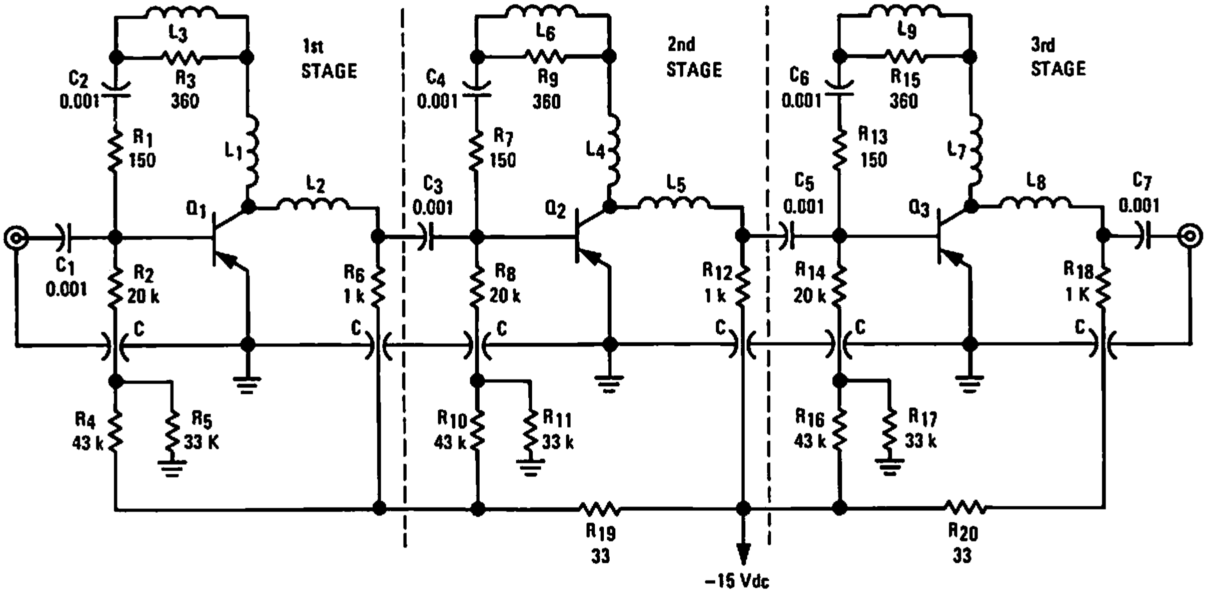

+9 V
R1
10 k
R3
33
3 W
S1
Q1
2N5060
P1
#47
R2
1 k
RETURN

POWER-INTERRUPTION INDICATOR—Lamp glows to indicate momentary interruption of power from source. Closing S1 momentarily turns on scr Q1, which shunts lamp and keeps it off. If power is interrupted longer than 50-µs recovery time of scr, scr will turn off and stay off. When power service is resumed, lamp will come on to indicate there has been an interruption. Switch must then be closed to turn on scr again and turn off lamp.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–39.

CHAPTER 2
Amplifier Circuits

DIRECT-COUPLED RING-OF-THREE—Provides voltage gain of 90 dB, which rises 4.5 dB at 40 Hz and drops 3 dB at 25 kHz. C3 determines high-frequency gain, while low-frequency gain is determined by C1, C2, and source resistance. Complementary transistors give simple circuit.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 49.


+9V
(At 1·3mA)
R2
4·7kΩ
R4
4·7kΩ
Tr2
ZTX500
C1
25μF
Tr1
ZTX300
Tr3
R1
15kΩ
R3
4·7kΩ
C3
4700pF
ZTX300
0V
R5
47kΩ
C2
25μF
R6
47kΩ


L3
R3
360
1st
STAGE
C2
0.001
R1
150
L1
L2
Q1
C1
0.001
R2
20 k
R6
1 k
C
C
R4
43 k
R5
33 K
L6
R9
360
2nd
STAGE
C4
0.001
C3
0.001
R7
150
L4
L5
Q2
R8
20 k
R12
1 k
C
C
R10
43 k
R11
33 k
R19
33
−15 Vdc
L9
R15
360
3rd
STAGE
C6
0.001
C5
0.001
R13
150
L7
L8
Q3
C7
0.001
R14
20 k
R18
1 K
C
C
R16
43 k
R17
33 k
R20
33

L_1, L_4, & L_7 = 3.5 turns #20 soft-drawn, ID = ¼ inch, Length = 1 inch

L_2, L_5, & L_8 = 6 turns #20 soft-drawn, ID = ¼ inch, Length = ¾ inch

L_3, L_6, & L_9 = 6 turns #24 tinned wire on CF103, Q_3 toroid with teflon sleeve.

C = 500 pF Erie button capacitor with 0.02 μF ceramic disk. - all other capacitors are ceramic disk.

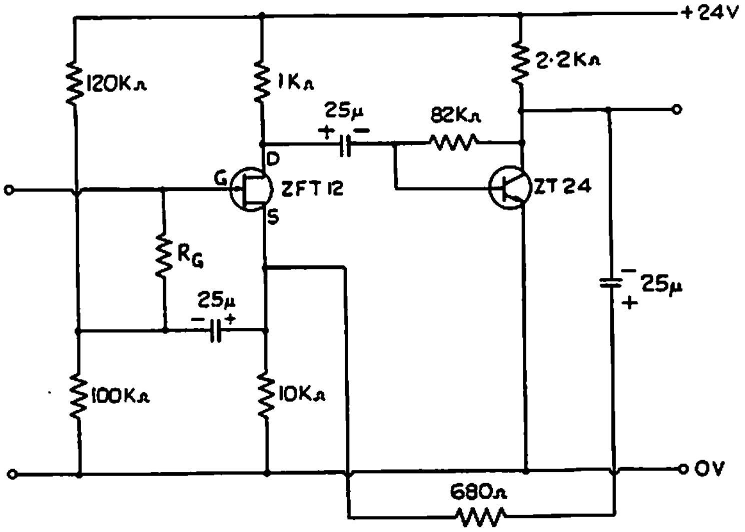
Bandwidth: 3.1 - 405 MHz at 3 dB point

Gain: 31 dB ± 1 dB

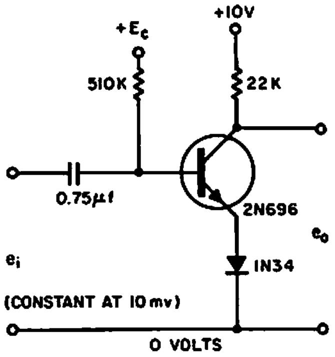
Sensitivity: 100 uV ($\frac{S+N}{N}$ = 10 dB)

I_C = 5 mA, V_{CE} = 10 Vdc for all devices

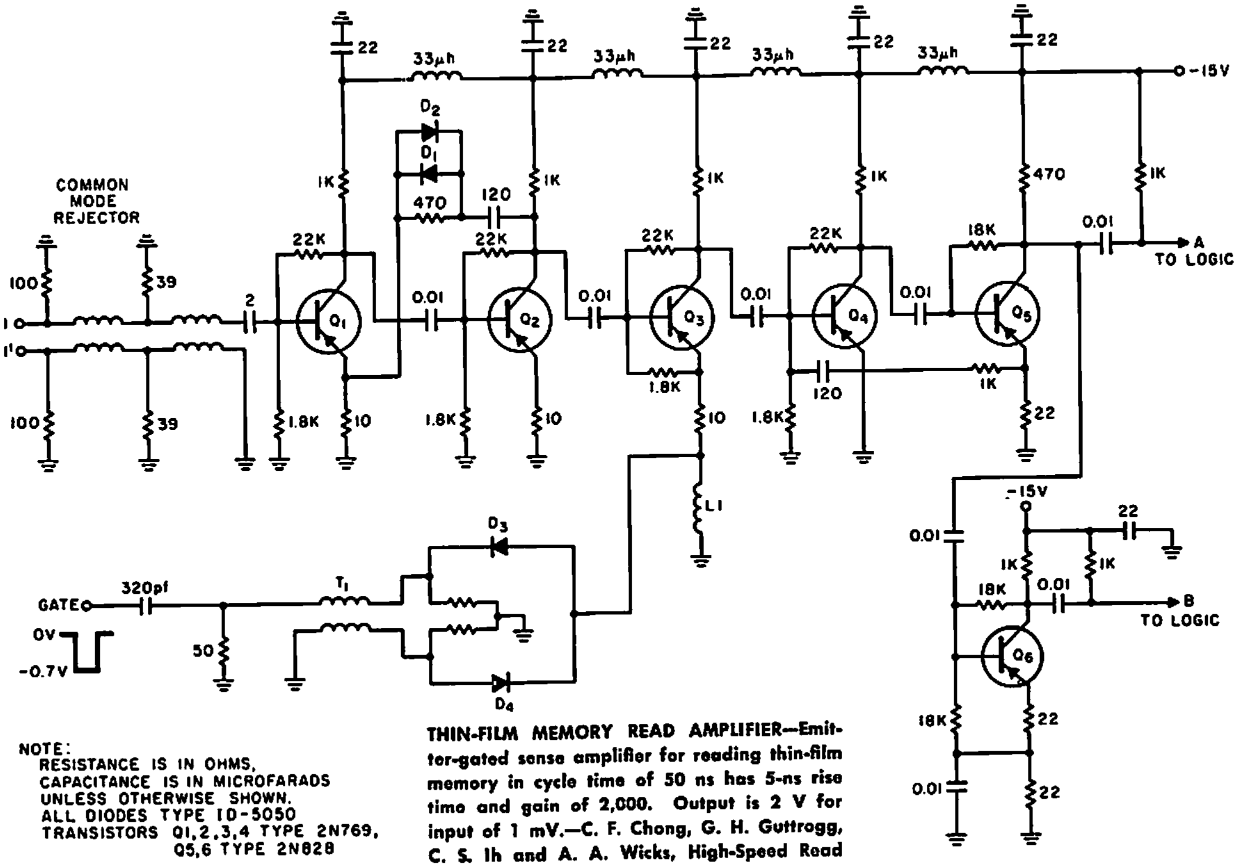
400-MHZ BROADBAND—Consists of three identical transistor stages using 2N4957 pnp silicon transistors. Both input and output have 50-ohm terminations. Gain is 30 dB, with 3-dB-down points at 3.1 MHz and 405 MHz. Report gives detailed design procedure based on use of Smith charts.—S. P. Kwok, UHF Broadband Amplifier Design, Motorola, Phoenix, Ariz., No. AN-406, 1967.


+24V
120KΩ
1KΩ
2·2KΩ
25μ
82KΩ
G
D
S
ZFT 12
ZT 24
RG
25μ
25μ
100KΩ
10KΩ
680Ω
0V

FET WITH NEGATIVE FEEDBACK—First stage is high-input-impedance bootstrapped source follower with drain load, giving gain well below unity. Output is capacitor-coupled to high-gain amplifier stage using conventional bipolar transistor, with almost entire output signal fed back to source of fet. This makes input impedance of complete amplifier much higher than that of fet first stage, while giving over-all unity gain. Input impedance is 65 meg when RG is 1 meg, and 500 meg when RG is 10 meg.—Field Effect Transistors and Applications, Ferranti Ltd., Oldham, Lancs., England, No. 22, 1965.

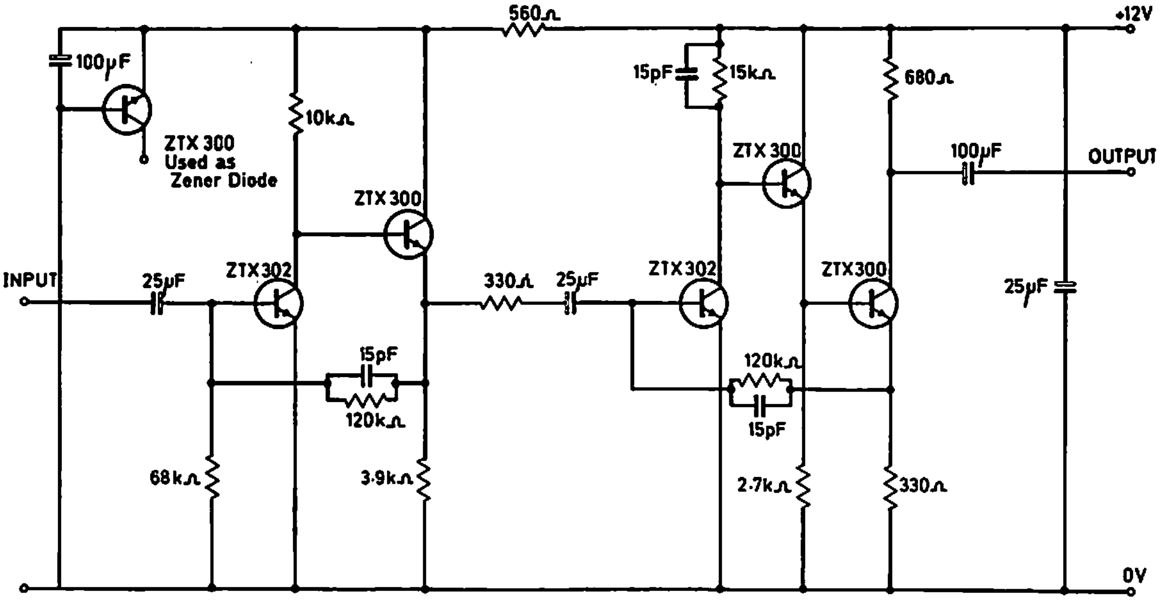

+Ec
+10V
510K
22K
0.75μf
2N696
e₀
eᵢ
IN34
(CONSTANT AT 10mv)
0 VOLTS

VARIABLE GAIN—Voltage-controlled common-emitter amplifier can be used for remote adjustment of gain, amplitude modulation of wideband signals, and avc. Control voltage range of 6 V for Ec provides 40-dB change in voltage gain, independently of frequency from 100 Hz to beyond 100 kHz. Action is based on use of diode in place of emitter resistor.—M. L. Patterson, Amplifier Provides Voltage-Controlled Gain, *Electronic Design*, Nov. 23, 1964, p 60.


22
33μh
-15V
D2
D1
470
120
COMMON MODE REJECTOR
1K
22K
100
39
1
1'
2
Q1
Q2
Q3
Q4
Q5
0.01
1.8K
10
18K
120
470
A TO LOGIC
L1
D3
D4
T1
GATE
320pf
0V
-0.7V
50
Q6
B TO LOGIC

NOTE:
RESISTANCE IS IN OHMS,
CAPACITANCE IS IN MICROFARADS
UNLESS OTHERWISE SHOWN.
ALL DIODES TYPE ID-5050
TRANSISTORS Q1,2,3,4 TYPE 2N769,
Q5,6 TYPE 2N828

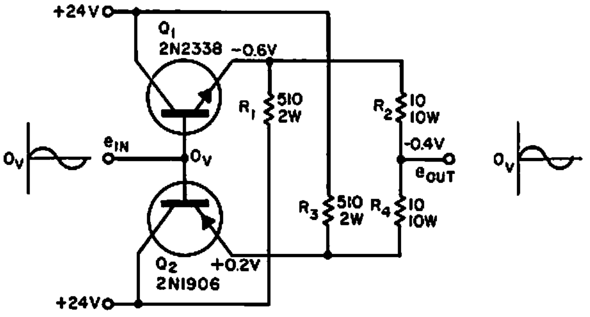
THIN-FILM MEMORY READ AMPLIFIER—Emitter-gated sense amplifier for reading thin-film memory in cycle time of 50 ns has 5-ns rise time and gain of 2,000. Output is 2 V for input of 1 mV.—C. F. Chong, G. H. Guttrogg, C. S. Ih and A. A. Wicks, High-Speed Read Amplifiers For Thin Films, *Electronic Design*, Aug. 3, 1964, p 38—40.



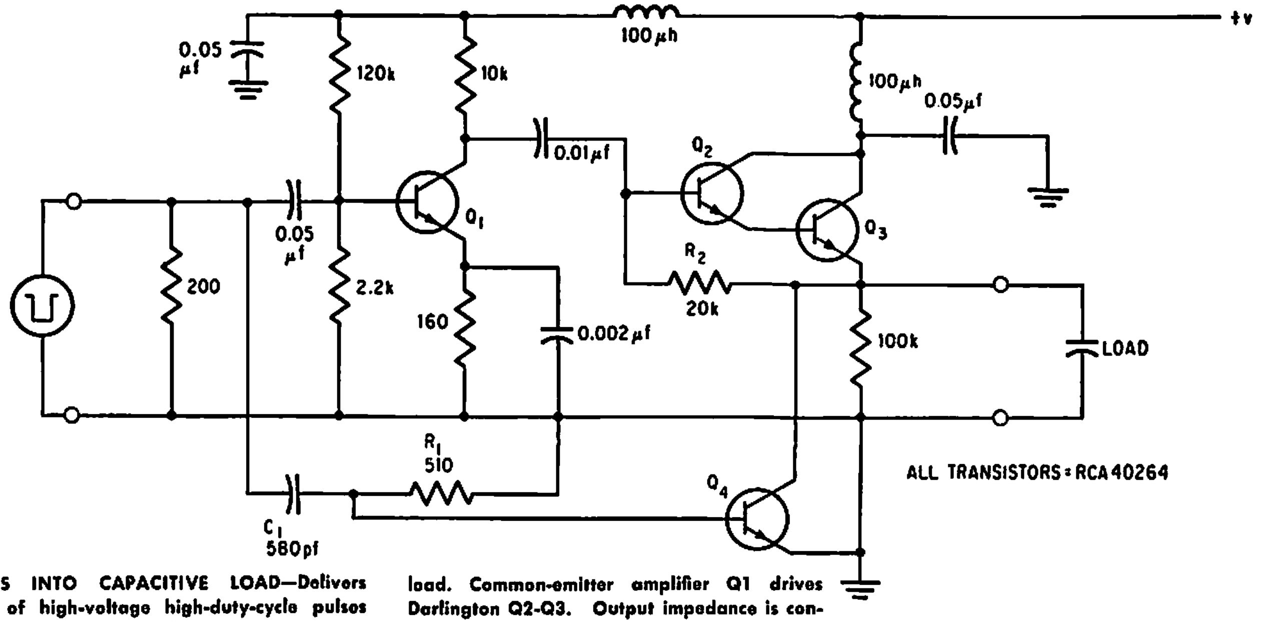
560Ω
+12V
100μF
ZTX 300
Used as
Zener Diode
10kΩ
15pF
15kΩ
680Ω
ZTX 300
100μF
OUTPUT
ZTX 300
INPUT
25μF
ZTX302
330Ω
25μF
ZTX302
ZTX300
25μF
15pF
120kΩ
120kΩ
15pF
68kΩ
3.9kΩ
2.7kΩ
330Ω
0V

20 HZ—150 KHZ—Provides power gain of 86 dB, with p-p noise below 10 μV referred to input. Developed for use in balanced chopper amplifier of microammeter.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 47.

COMPLEMENTARY PUSH-PULL—Simple push-pull emitter-follower with single input gives high drive power, symmetrical around 0 V, with very low quiescent power.—R. Zano, Single-Ended Input Provides Push-Pull Output, *Electronic Design*, July 20, 1964, p 77.

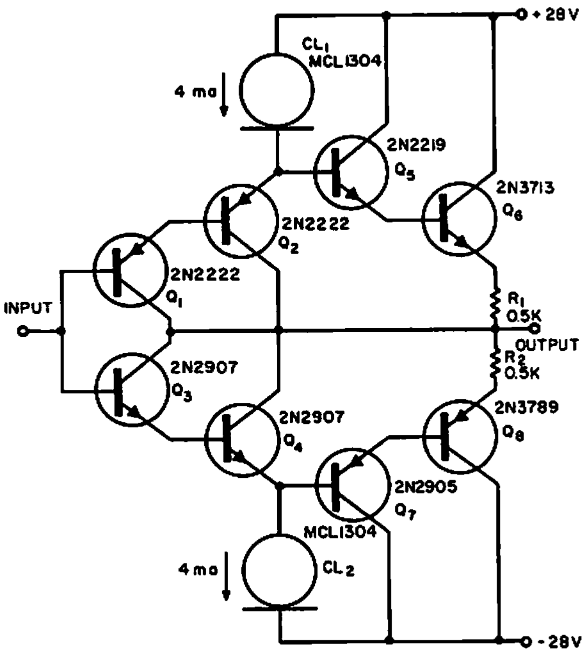


+24V
Q1
2N2338
-0.6V
R1
510
2W
R2
10
10W
0V
eIN
0V
-0.4V
eOUT
0V
R3
510
2W
R4
10
10W
Q2
+0.2V
2N1906
+24V

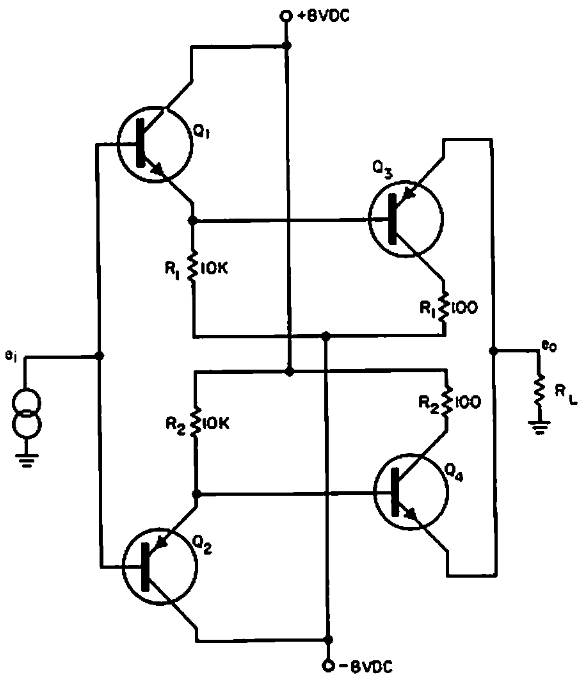


100μh
+V
0.05 μf
120k
10k
100μh
0.05μf
0.01μf
Q2
Q1
Q3
0.05 μf
200
2.2k
R2
20k
160
0.002μf
100k
LOAD
R1
510
Q4
C1
580pf
ALL TRANSISTORS = RCA 40264

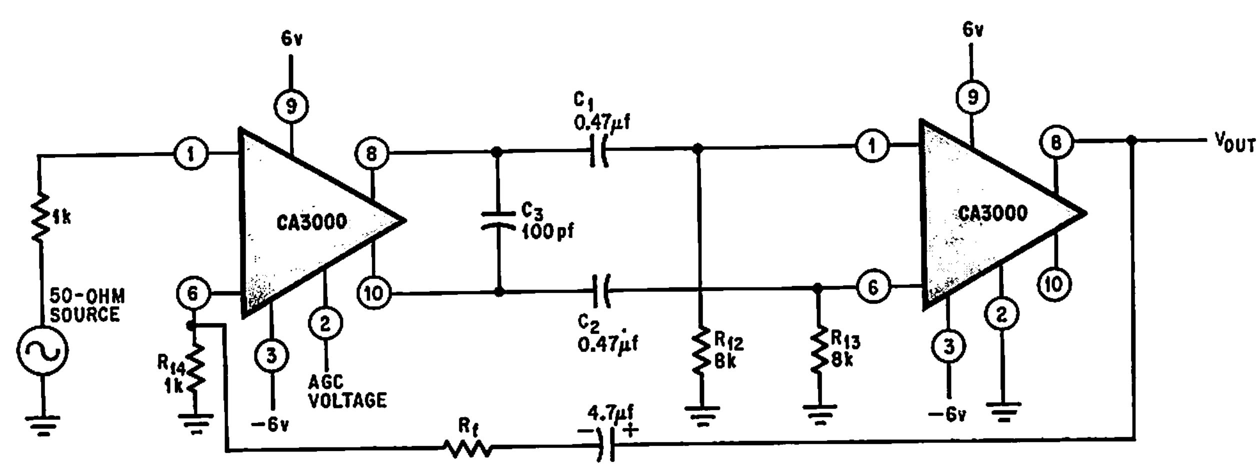
SPIKES INTO CAPACITIVE LOAD—Delivers train of high-voltage high-duty-cycle pulses to capacitive load, with low output impedance for transferring charge rapidly to and from load. Common-emitter amplifier Q1 drives Darlington Q2-Q3. Output impedance is controlled by R1-C1 connected across input and by Q4 shunting load.—D. Perlman, NPN Amplifier Delivers Fast, High-Voltage Pulses, *Electronics*, June 26, 1967, p 109—110.


+28V
CL1
MCL1304
4 ma
2N2219
Q5
2N3713
Q6
2N2222
Q2
2N2222
Q1
INPUT
R1
0.5K
OUTPUT
R2
0.5K
2N2907
Q3
2N2907
Q4
2N3789
Q8
2N2905
Q7
MCL1304
4 ma
CL2
-28V

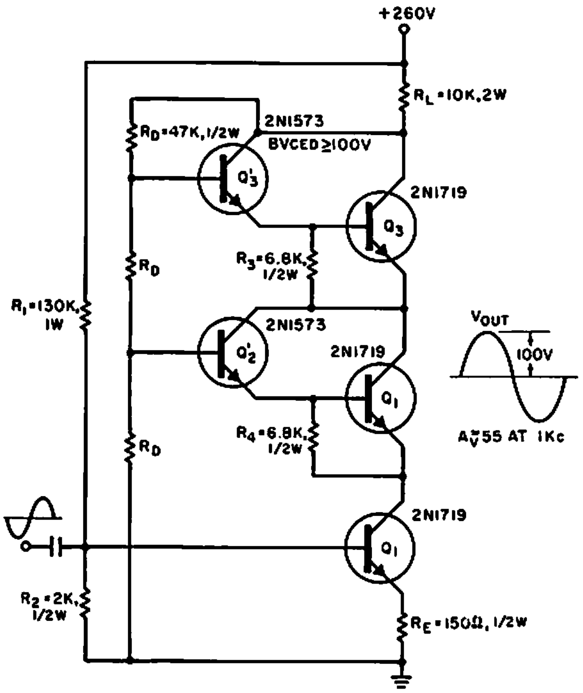
UNITY-GAIN BALANCED AMPLIFIER—Uses field-effect constant-current-source diodes CL1 and CL2 for full temperature compensation, minimum crossover distortion, and unity gain. Can handle signal peaks nearly equal to supply voltages, or 40 V p-p into 5-ohm load. Input impedance at low frequencies is above 1 meg. Can be used to increase power of opamp, either inside or outside feedback loop.—C. F. Andren, Symmetry Amplifier Compensated by FET Current-Source Diodes, *Electronic Design*, Oct. 25, 1965, p 70.


+8VDC
Q1
Q3
R1 10K
R1 100
e0
RL
e1
R2 10K
R2 100
Q4
Q2
-8VDC

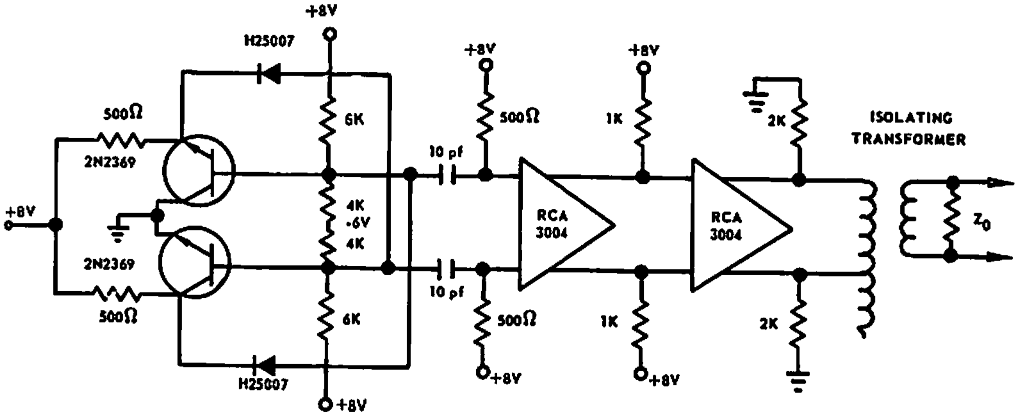
DUAL-FOLLOWER—Use of additional complementary pair of transistors in place of balanced diodes in dual emitter-follower gives increased input impedance and higher current gain while eliminating crossover distortion problem. No trimming adjustment is needed. 100-ohm resistors provide overload protection by limiting short-circuit current.—J. P. Chidester, Complementary Dual-Follower Increases Input Impedance, *Electronic Design*, Nov. 8, 1965, p 58–59.


6v
9
1
8
CA3000
1k
50-OHM SOURCE
6
10
R14 1k
3
2
-6v
AGC VOLTAGE
C1 0.47µf
C3 100pf
C2 0.47µf
Rf
4.7µf
R12 8k
R13 8k
6v
9
1
8
VOUT
CA3000
6
10
2
3
-6v

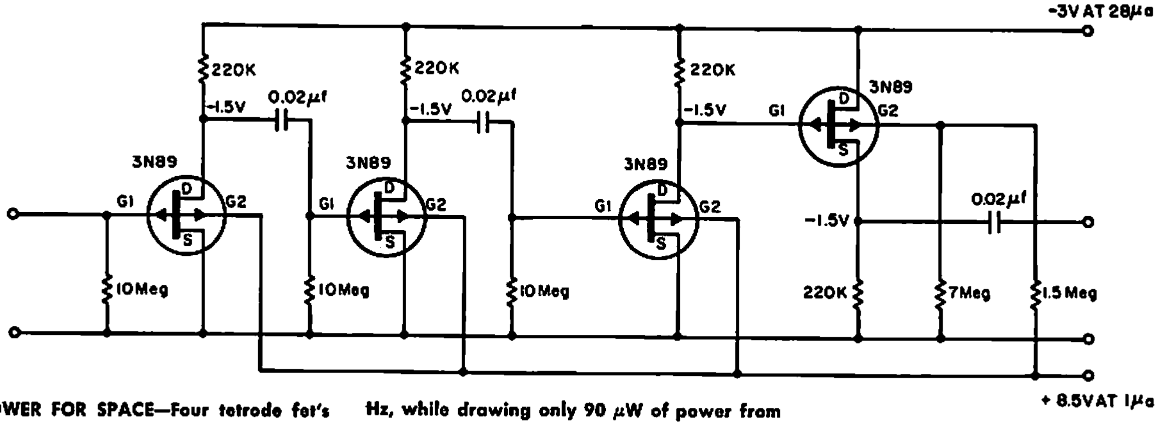
62 DB GAIN WITH IC PAIR—Uses two RCA IC video amplifiers, the first connected as a double-ended differential amplifier and the other single-ended, with R-C interconnecting network for frequency-shaping. Low-frequency rolloff starts at 22 Hz and high-frequency rolloff at 1 MHz. Can be adapted for agc. Bandwidth can be increased by changing feedback to reduce gain.—J. P. Keller, Linear IC's: Part 3—Differential Amplifiers At Work, *Electronics*, Sept. 18, 1967, p 96–104.


+260V
R_L=10K,2W
R_D=47K,1/2W
2N1573
BVCEO≥100V
Q'3
2N1719
Q3
R3=6.8K, 1/2W
R_D
R1=130K, 1W
2N1573
Q'2
2N1719
Q1
V_OUT
100V
A_V≈55 AT 1Kc
R4=6.8K, 1/2W
R_D
2N1719
Q1
R2=2K, 1/2W
R_E=150Ω, 1/2W

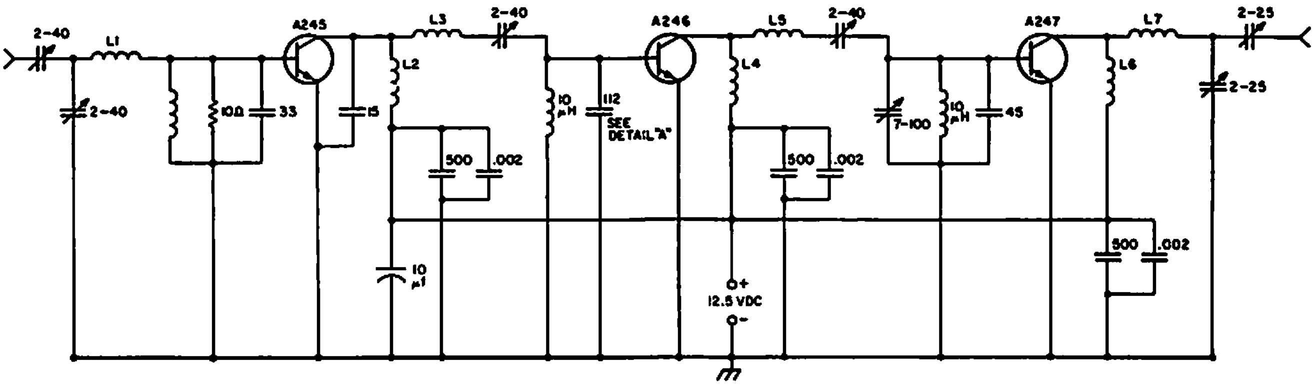
LINEAR DARLINGTON—Uses low-cost Darlington-connected series transistors in linear high-voltage amplifier. Arrangement gives high current gain and good power, along with satisfactory voltage division for transistors during quiescence.—V. Glover, Using Low-Voltage Transistors in High-Voltage Circuits, *Electronic Design*, July 20, 1964, p 62–67.


+8V
H25007
500Ω
2N2369
+8V
6K
4K
-6V
4K
2N2369
500Ω
6K
H25007
+8V
10 pf
10 pf
+8V
500Ω
500Ω
+8V
RCA 3004
+8V
1K
1K
+8V
RCA 3004
2K
2K
ISOLATING TRANSFORMER
Z0

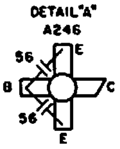
SENSE AMPLIFIER—Used in high-speed read-only memory of computer, in which information is stored by means of mutual inductive coupling between two concentric solenoids. Winding pattern determines points at which read and sense wires meet as solenoid pair for storing information pattern. Circuit also includes output latch.—Y. Hsia, Solenoid-Coupled READ-ONLY Memory, *IEEE Transactions on Electronic Computers*, June 1970, p 344–350.


-3V AT 28µa
220K
-1.5V
0.02µf
3N89
G1
D
G2
S
10Meg
220K
-1.5V
0.02µf
3N89
G1
D
G2
S
10Meg
220K
-1.5V
3N89
G1
D
G2
S
10Meg
3N89
G1
D
G2
S
0.02µf
-1.5V
220K
7Meg
1.5 Meg
+8.5VAT 1µa

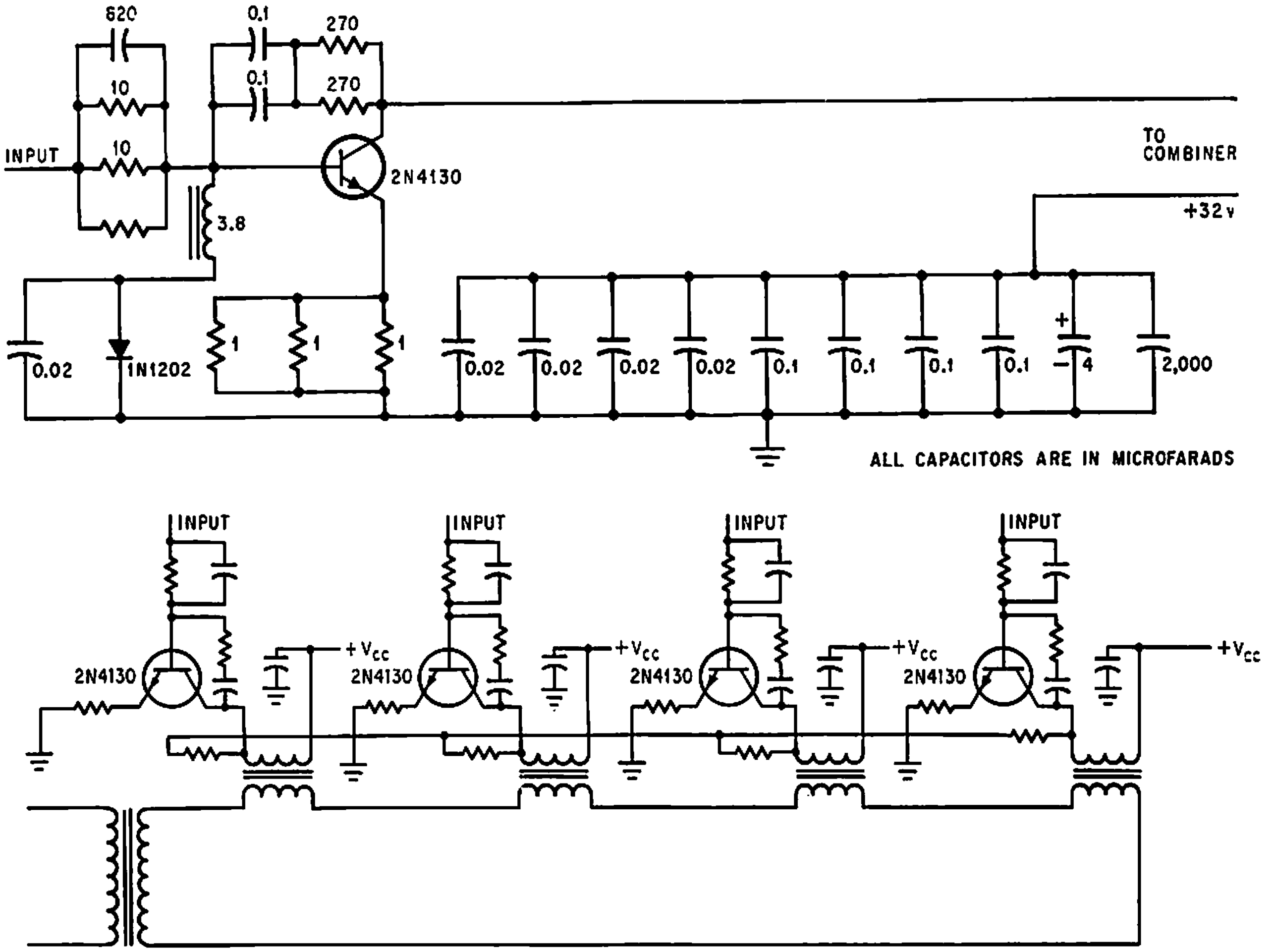
MICROPOWER FOR SPACE—Four tetrode fet's provide voltage gain of over 1,000 and 0.5 V rms output over bandwidth of 1 to 30,000 Hz, while drawing only 90 µW of power from spacecraft supply.—J. S. Sherwin, Need High Z and Low C? Turn to the Tetrode FET for HF Design, *Electronic Design*, June 7, 1965, p 20–25.


2-40
L1
2-40
100
33
A245
15
L3
2-40
L2
500
.002
10 μf
10 μH
112
SEE DETAIL "A"
A246
L5
2-40
L4
500
.002
+
12.5 VDC
-
7-100
10 μH
45
A247
L7
2-25
L6
2-25
500
.002

L1-1½T, NO.16, ¼" I.D.
L2,L3-3½T, NO.16, ¼" I.D.
L4,L5-4½T, NO.16, ¼" I.D.
L6-3½T, NO.16, ¼" I.D.
L7-2T, NO.14, ¼" I.D.
10μH - MILLER NO.9330-24

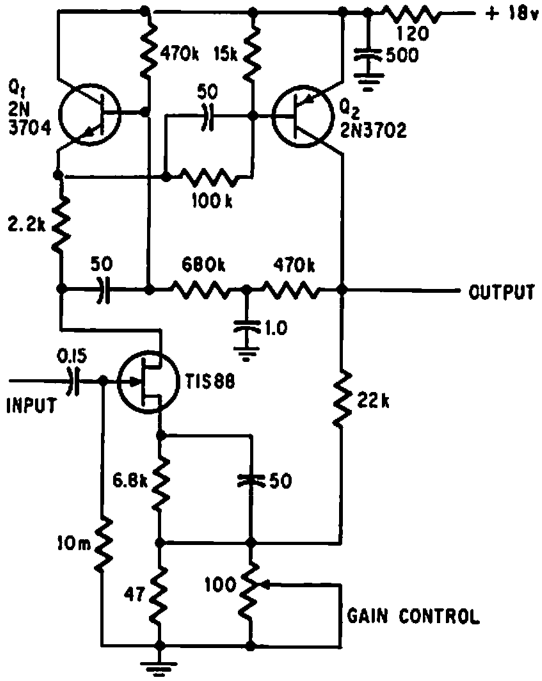

DETAIL "A"
A246

25-W THREE-TRANSISTOR POWER AMP—Provides excellent stability and minimum of harmonic and unwanted signal components, with bandwidth of 20 MHz. Power output increases about 8% at low end of 150–175 MHz mobile band. Drive power required is 100 mW. Requires 50-ohm load.—Two 175 MHz 12.5 Volt Mobile Communication Power Amplifiers for 25W and 40W Power Output, Amperex, Slatersville, R.I., No. S-140, 8/68.

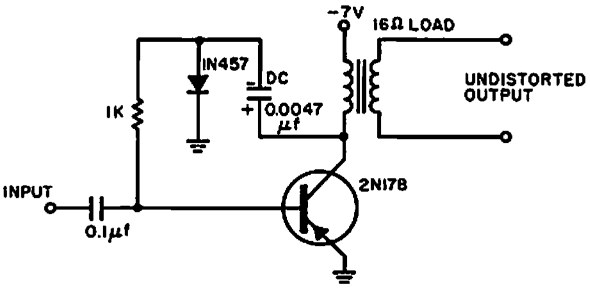

620
10
10
INPUT
0.1
270
0.1
270
2N4130
3.8
TO COMBINER
+32v
0.02
1N1202
1
1
1
0.02
0.02
0.02
0.02
0.1
0.1
0.1
0.1
+
4
-
2,000
INPUT
INPUT
INPUT
INPUT
2N4130
+Vcc
2N4130
+Vcc
2N4130
+Vcc
2N4130
+Vcc

ALL CAPACITORS ARE IN MICROFARADS

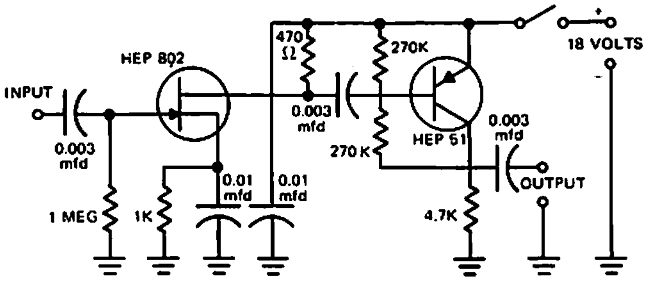
1 KW FROM 60 TRANSISTORS—Circuit developed by Westinghouse under Air Force contract, for use in communication systems, keeps transistors electrically isolated so outputs can be paralleled. With input drive as low as 0.25 W, peak envelope power output is 1 kW for bandwidth of 2 to 32 MHz. Basic four-transistor module consists of four 2N4130 IT&T transistors each connected as in upper circuit, with their outputs combined by transformers as in lower circuit to form module that can in turn be paralleled with similar modules to give desired power output. Resulting power output amplifier can be tuned as single unit.—C. H. Wood Jr., A. W. Morse, and G. R. Brainerd, Transistors Share the Load in a Kilowatt Amplifier, *Electronics*, Dec. 11, 1967, p 100–105.


+ 18v
120
500
470k
15k
50
Q1
2N
3704
Q2
2N3702
100 k
2.2k
50
680k
470k
OUTPUT
1.0
0.15
INPUT
TIS88
22k
6.8k
50
10m
47
100
GAIN CONTROL

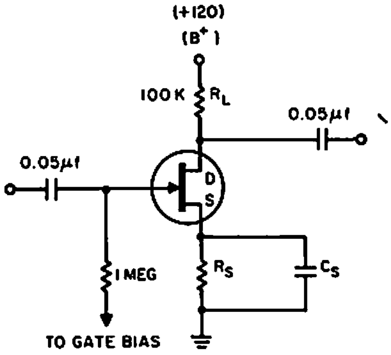
0.5 HZ TO 300 KHZ—Fet and only two other transistors give wide bandwidth and gain of 1,000, with low distortion. Npn stage Q1 controls fet. Stabilization is achieved with 20 dB negative feedback. Input impedance is 10 meg at 1 kHz and output impedance 2K. Current drain is about 1.5 mA. All capacitor values are μF.—T. C. Penn, High-Precision Preamp Built from 3 Transistors, *Electronics*, Dec. 23, 1968, p 58.


-7V
16Ω LOAD
IN457
DC
0.0047
μf
1K
UNDISTORTED
OUTPUT
INPUT
0.1μf
2N178

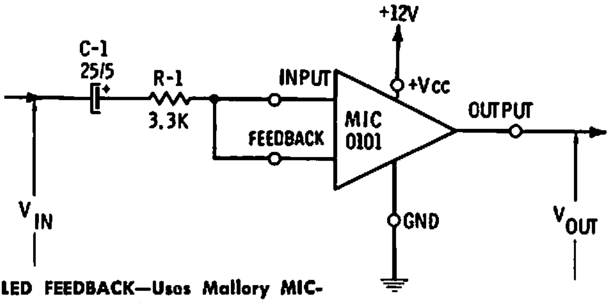
DISTORTIONLESS CLASS A—Self-generated bias voltage, developed by capacitor charging through diode, is proportional to input signal. Permits use of single-transistor output stage, with low d-c drain on battery through transformer primary.—C. G. Dorn, Capacitor Charge Sets Transistor Bias Point, *Electronic Design*, March 16, 1964, p 105.


INPUT
HEP 802
0.003
mfd
1 MEG
1K
0.01
mfd
0.01
mfd
470
Ω
0.003
mfd
270K
270K
HEP 51
0.003
mfd
OUTPUT
4.7K
18 VOLTS

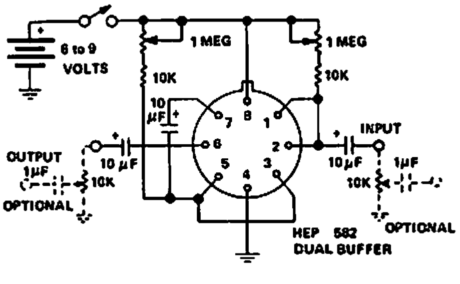
BROADBAND R-F FET—Covers range of 1–40 MHz with high s/n ratio, using two 9-V batteries in series. Gain drops from 100 at 1 MHz to about 20 at 40 MHz.—"Tips on Using FET's," HMA-33, Motorola, Phoenix, Ariz., 1969.


(+120)
(B+)
100K
RL
0.05μf
0.05μf
D
S
1MEG
RS
CS
TO GATE BIAS

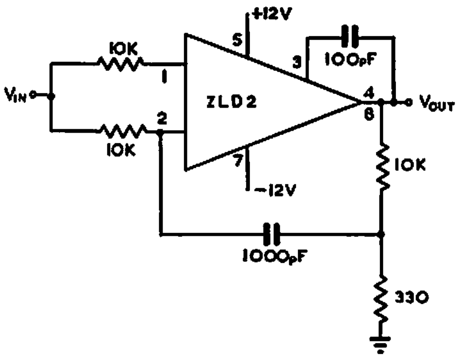
SELF-BIASING FOR FET—Voltage drop produced by drain current through RS serves as gate bias. Value of CS is chosen to prevent feedback at signal frequencies. Article discusses stabilization achieved with self-bias, and other design procedures for improving fet performance in linear voltage amplifiers.—W. A. Rheinfelder, FETs Outperform Bipolars, Pentodes in Linear Voltage Amplifiers, *Electronic Design*, Dec. 20, 1965, p 24–26 and 28–29.


+12V
C-1
25/5
R-1
3.3K
INPUT
+Vcc
FEEDBACK
MIC
0101
OUTPUT
GND
VIN
VOUT

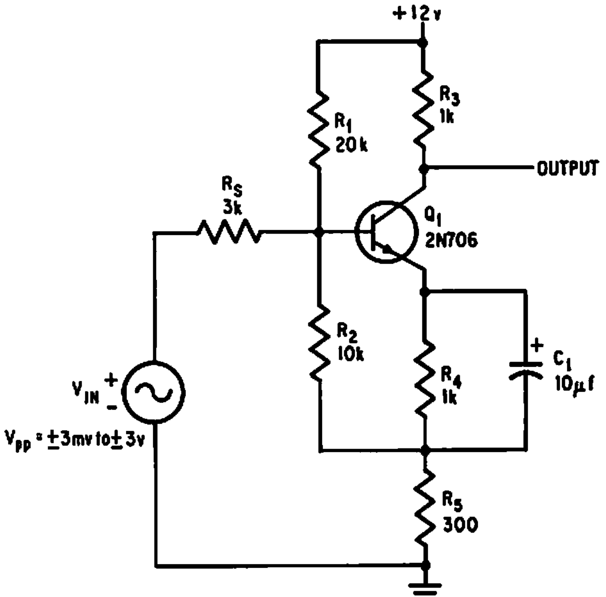
R-C COUPLED FEEDBACK—Uses Mallory MIC-0101 preamp with feedback terminal open with respect to a-c ground but returned to IC input terminal to maintain correct d-c bias. Feedback extends 3-dB bandwidth to almost 3 MHz and down to 10 Hz, but at sacrifice of voltage gain. With 3.3K feedback resistor, overall gain is 100 or 40 dB. Can be used as low-level video amplifier where source is either video tape head or another amplifier.—M. L. Deschler, Integrated Circuit Preamplifiers, Mallory, Indianapolis, Ind., APPN-2, 1968.


6 to 9
VOLTS
1 MEG
1 MEG
10K
10K
10
μF
OUTPUT
10 μF
1μF
10K
OPTIONAL
7
8
1
6
2
5
4
3
INPUT
10μF
1μF
10K
OPTIONAL
HEP 582
DUAL BUFFER

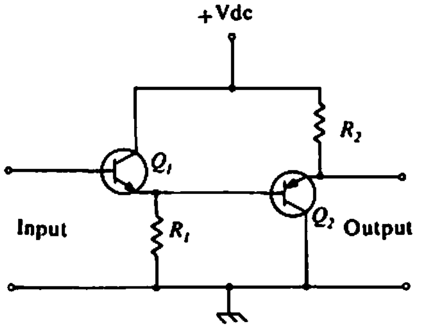
HIGH-GAIN IC—Takes input of 0.4 mV p-p and gives output of 2.5-6 V p-p for use as audio or low-frequency r-f amplifier or as preamp to increase cro sensitivity. Gain is 5,000 to 10,000. Adjust 1-meg pots for maximum undistorted output. May also be used with HEP580 2-input gate IC, using 1-meg resistors in place of 1-meg pots in series with 10K.—"Tips on Using IC's," Motorola, Phoenix, Ariz., HMA-32, 1968.


+12V
5
100pF
3
10K
1
VIN
ZLD2
4
8
VOUT
2
10K
7
10K
−12V
1000pF
330

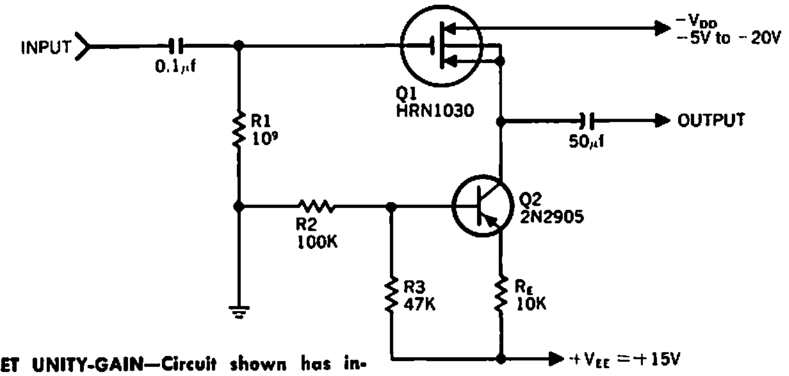
NONINVERTING WIDEBAND—Gives high input impedance, but is direct coupled and signal source must supply necessary base current for Ferranti ZLD2 IC differential-input d-c amplifier. Gain is 3 dB down at 220 Hz and 600 kHz.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967.


+12v
R3
1k
R1
20k
OUTPUT
RS
3k
Q1
2N706
VIN
+
−
Vpp = ±3mv to ±3v
R2
10k
R4
1k
+
C1
10µf
R5
300

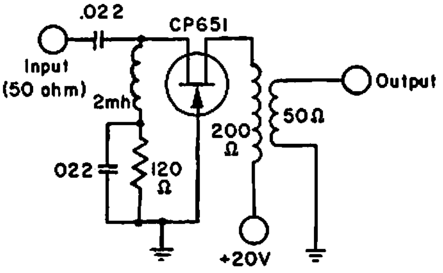
BOOTSTRAPPING—Combining positive and negative feedback in bootstrap amplifier gives both high input impedance and high voltage gain. Bootstrapping resistor R2 provides positive feedback. Article gives design equations.—G. P. Klein, Combined Feedback Builds Gain and Input Impedance, *Electronics*, Oct. 16, 1967, p 99.


+Vdc
R2
Q1
Q2
Input
R1
Output

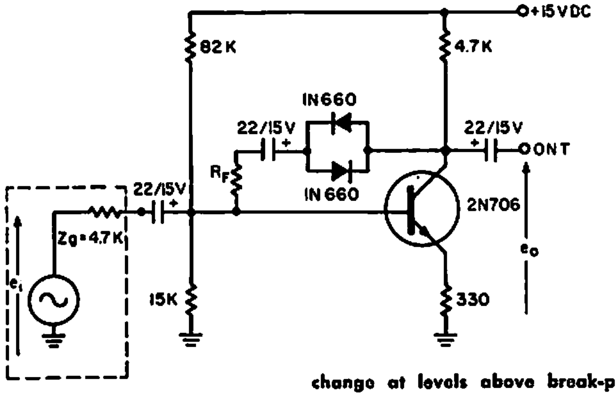
TEMPERATURE-STABLE EMITTER-FOLLOWER—With 2N780 for Q1 and 2N869 for Q2, average variation in output voltage will be only about 25 mV for temperature range of −20 to 200 F when R1 and R2 are 20K.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 65.


INPUT
0.1µf
−VDD
−5V to −20V
Q1
HRN1030
OUTPUT
50µf
R1
10⁹
R2
100K
Q2
2N2905
R3
47K
RE
10K
+VEE = +15V

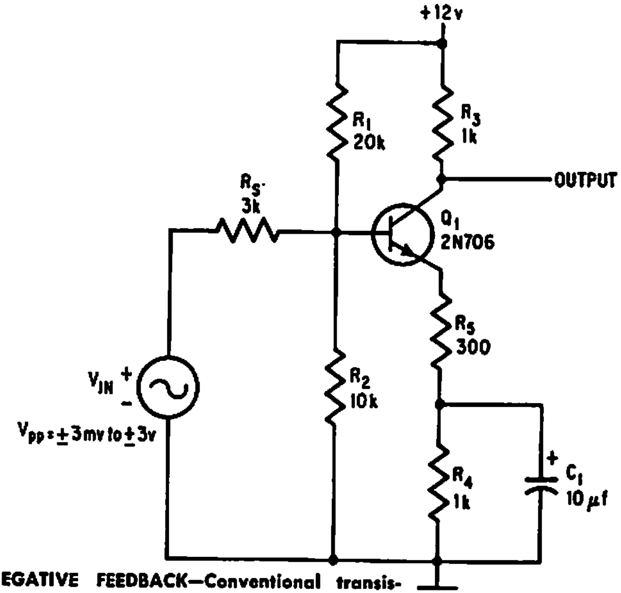
MOSFET UNITY-GAIN—Circuit shown has input impedance above 1,000 meg. Mosfet functions as source follower with constant-current generator instead of source resistance.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 10.


.022
CP651
Input
(50 ohm)
2mh
Output
50Ω
200
Ω
022
120
Ω
+20V

BROADBAND FET PREAMP—Gives bandwidth of 0.5 to 40 MHz for maximum input signal of 3 V p-p. Voltage gain is 10 dB, and dynamic range 140 dB.—FET Broadband R. F. Preamplifiers, Crystalonics, Cambridge, Mass., TMF1.

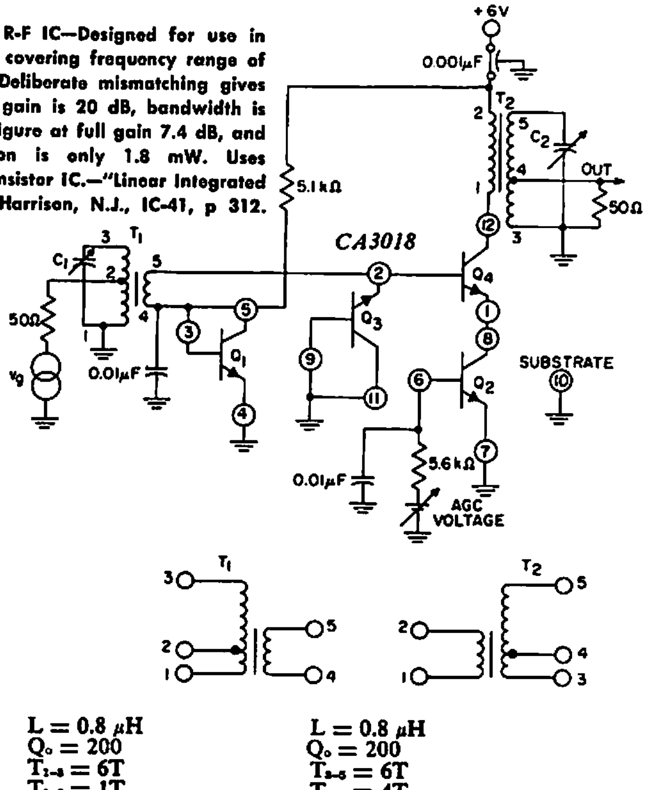

+15VDC
82K
4.7K
IN660
22/15V
+
22/15V
+
ONT
RF
IN660
22/15V
+
Zg = 4.7K
2N706
ei
eo
15K
330

NONLINEAR GAIN—Diodes in feedback network are biased into conduction when signal excursions exceed 0.6 V p-p, and resulting negative feedback reduces gain of stage. Value of feedback resistor RF determines gain change at levels above break-point; typical values range from 470 to 10,000 ohms. Used to emphasize specific input levels.—J. K. Hickman, Complementary Diode Feedback Produces Nonlinear Gain, *Electronic Design*, June 7, 1965, p 42.


+12v
R1 20k
R3 1k
OUTPUT
RS 3k
Q1 2N706
R5 300
VIN
Vpp=±3mv to ±3v
R2 10k
R4 1k
C1 10 µf

NEGATIVE FEEDBACK—Conventional transistor amplifier circuit shown uses negative feedback by R5 to increase input impedance, but does not give high voltage gain. Article gives design equations and tells how to add positive feedback for higher gain.—G. P. Klein, Combined Feedback Builds Gain and Input Impedance, *Electronics*, Oct. 16, 1967, p 99.

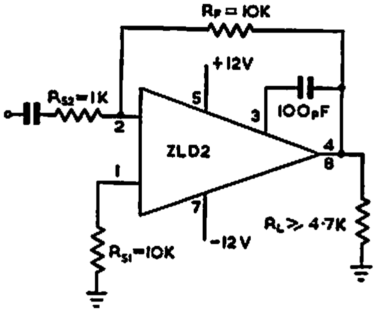
15-MHZ TUNED R-F IC—Designed for use in military receiver covering frequency range of 2 to 30 MHz. Deliberate mismatching gives stability. Total gain is 20 dB, bandwidth is 315 kHz, noise figure at full gain 7.4 dB, and power dissipation is only 1.8 mW. Uses CA3018 four-transistor IC.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 312.


+6V
0.001µF
T2
2
5
C2
4
OUT
1
50Ω
5.1kΩ
12
3
CA3018
T1
C1
2
5
2
Q4
50Ω
4
3
5
1
1
8
vg
0.01µF
Q1
Q3
9
11
6
Q2
SUBSTRATE
10
4
5.6kΩ
7
0.01µF
AGC VOLTAGE
T1
3
2
1
5
4
T2
5
2
1
4
3

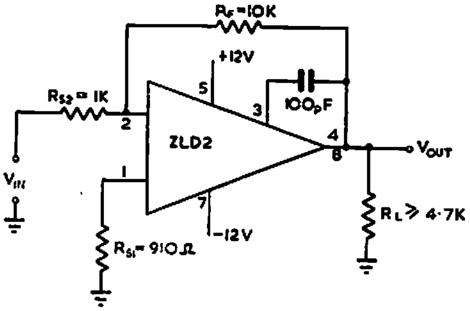
$L = 0.8\ \mu H$
$Q_o = 200$
$T_{1-3} = 6T$
$T_{1-2} = 1T$
$T_{4-5} = 2T$

$L = 0.8\ \mu H$
$Q_o = 200$
$T_{3-5} = 6T$
$T_{1-2} = 4T$
$T_{3-4} = 1T$

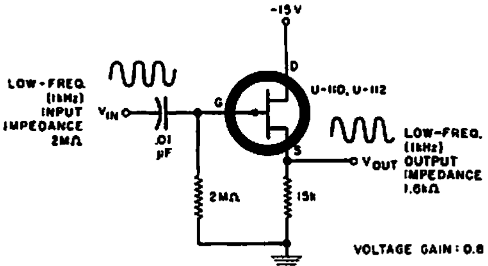
#22 wire on Q-2 material, CF107 Toroid from Indiana General.
C_1, C_2 = Arco 425 or equiv.


RF = 10K
+12V
RS2 = 1K
5
3
100pF
2
ZLD2
4
8
1
7
RL ≥ 4·7K
-12V
RS1 = 10K

IC INVERTING A-C AMPLIFIER—Uses Ferranti ZLD2 IC differential-input d-c amplifier connected to give gain of 10 with negative feedback. Intended for applications where d-c component is not required, so capacitance coupling is used at input. This unbalances values of RS1 and RS2, for which correction is made by making RS1 equal to RF. Alternatively, RS1 can be 910 ohms and an additional 1K resistor connected between terminal 2 and ground.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967.

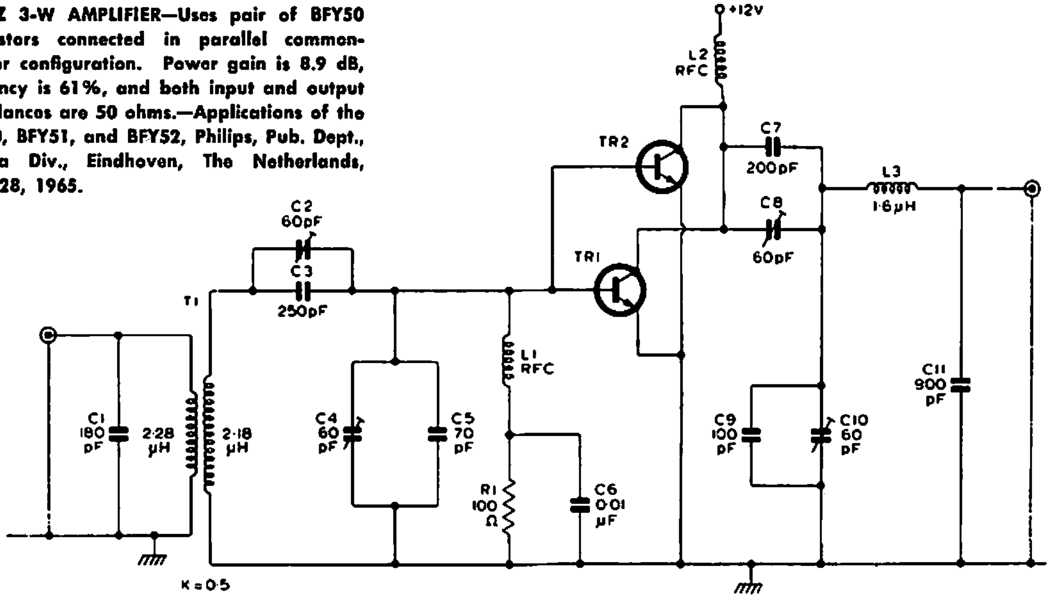

RF = 10K
+12V
RS2 = 1K
5
3
100pF
2
ZLD2
4
8
VOUT
VIN
1
7
-12V
RL ≥ 4·7K
RS1 = 910Ω

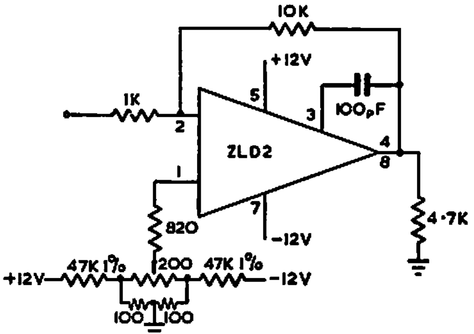
INVERTING A-C OR D-C AMPLIFIER—Uses Ferranti ZLD2 IC differential-input d-c amplifier connected to give gain of 10 with negative feedback. Values shown give bandwidth of 1.5 MHz.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967.


-15 V
D
LOW-FREQ. (1kHz) INPUT IMPEDANCE 2MΩ
VIN
G
U-110, U-112
.01 µF
S
VOUT
LOW-FREQ. (1kHz) OUTPUT IMPEDANCE 1.6kΩ
2MΩ
15k
VOLTAGE GAIN: 0.8

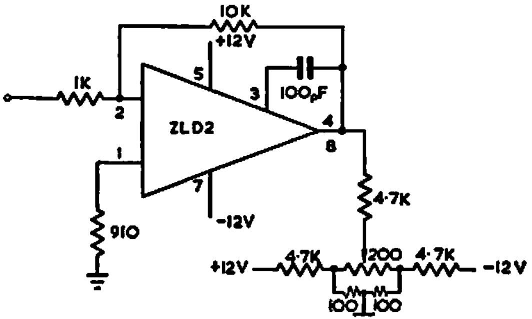
SOURCE-FOLLOWER FET—Circuit is analogous to tube cathode-follower or transistor emitter-follower. Gives high input impedance, relatively low output impedance, and voltage gain close to unity. Frequency response is flat to 1 MHz.—J. H. Wujek, Jr. and M. E. McGee, Field-Effect Transistor Circuits, *Electronics World*, May 1967, p 32–33 and 75.

8-MHZ 3-W AMPLIFIER—Uses pair of BFY50 transistors connected in parallel common-emitter configuration. Power gain is 8.9 dB, efficiency is 61%, and both input and output impedances are 50 ohms.—Applications of the BFY50, BFY51, and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.

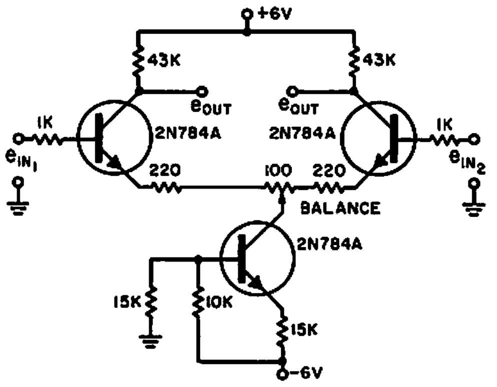

+12V
L2 RFC
TR2
C7 200pF
L3 1·6μH
C8 60pF
TR1
C2 60pF
C3 250pF
T1
L1 RFC
C11 900 pF
C1 180 pF
2·28 μH
2·18 μH
C4 60 pF
C5 70 pF
C9 100 pF
C10 60 pF
R1 100 Ω
C6 0·01 μF
K=0·5


10K
+12V
1K
5
3
100pF
2
ZLD2
4
8
1
7
820
-12V
4·7K
+12V
47K 1%
200
47K 1%
-12V
100
100

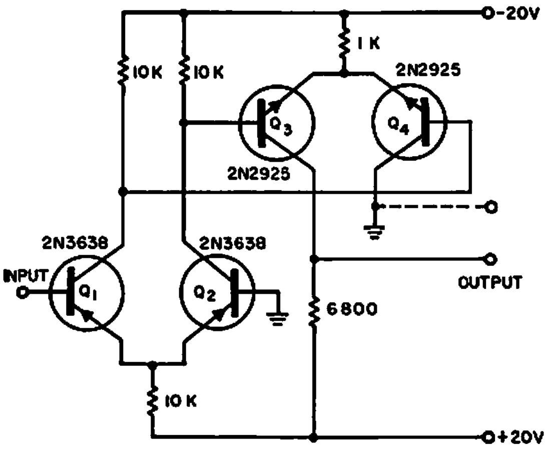
INVERTING AMPLIFIER WITH ADJUSTABLE INPUT BIAS—Provides gain of 10 and bandwidth of 1.5 MHz for either a-c or d-c inputs, with adjustable bias voltage applied to input for correcting offset voltage of amplifier, which may typically be about 20 mV.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967.


10K
+12V
1K
5
3
100pF
2
ZLD2
4
8
1
7
910
-12V
4·7K
+12V
4·7K
200
4·7K
-12V
100
100

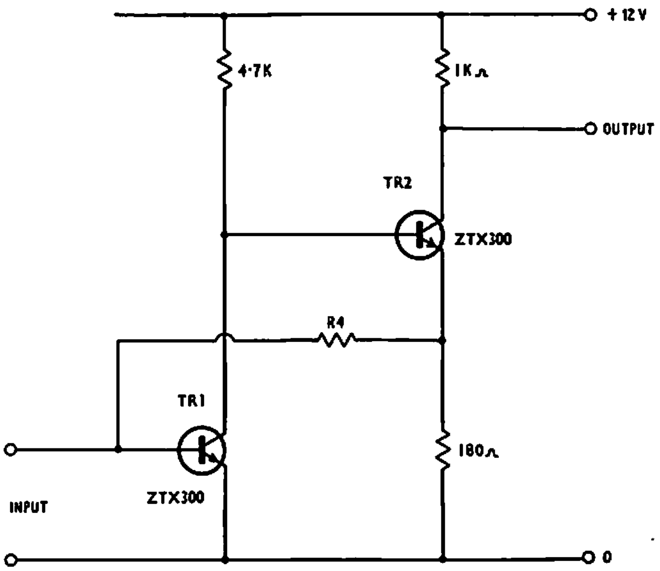
INVERTING AMPLIFIER WITH ADJUSTABLE OUTPUT BIAS—Provides gain of 10 and bandwidth of 1.5 MHz for either a-c or d-c inputs, with adjustable bias voltage applied to output for correcting offset voltage of amplifier, which may typically be about 20 mV.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967.


+6V
43K
43K
e_{OUT}
e_{OUT}
1K
2N784A
2N784A
1K
e_{IN_1}
e_{IN_2}
220
100
220
BALANCE
2N784A
15K
10K
15K
-6V

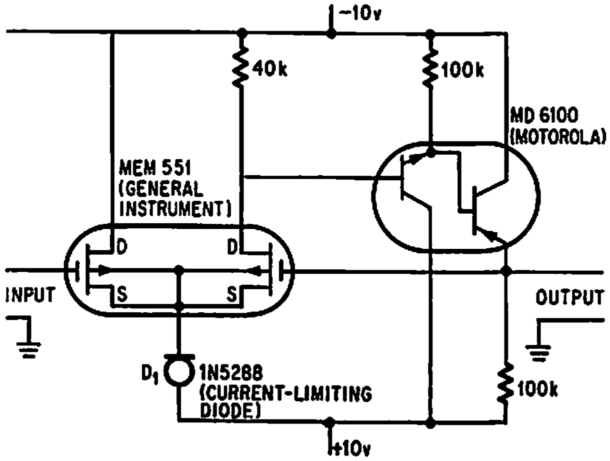
LONG LONG-TAIL PAIR—Drift is less than 75 μV per deg C referred to input, and differential mode voltage gain is 30. Addition of third transistor to differential pair improves common-mode rejection while requiring only extra −6 V source.—Differential Amplifier, *Electronic Design*, Feb. 3, 1964, p 44.


-20V
10K
10K
1K
2N2925
Q_3
Q_4
2N2925
2N3638
2N3638
INPUT
Q_1
Q_2
OUTPUT
6800
10K
+20V

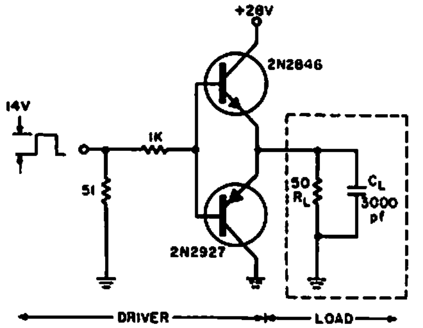
DIFFERENTIAL OUTPUT—Conventional differential-pair shown is often used as output stage of amplifier even though only one output phase is used. Q4 maintains gain at frequencies down to d-c without resorting to zener diode or large bypass capacitor.—S. G. Freshour, Differential Amplifier Offers Efficient, Dual Outputs, *Electronic Design*, July 19, 1965, p 37–38.


+12V
4·7K
1KΩ
OUTPUT
TR2
ZTX300
R4
TR1
180Ω
INPUT
ZTX300
0

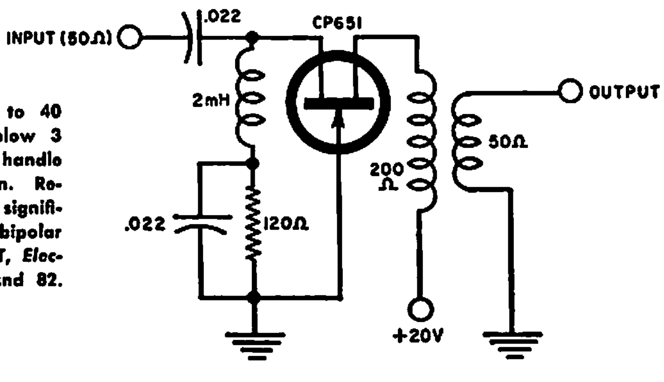
WIDEBAND CURRENT AMPLIFIER—Bandwidth is over 6 MHz, input impedance about 15 ohms, and output impedance 1K. Report gives design procedure. R4 determines current gain; 1.8K gives gain of 10 and bandwidth of 9 MHz, while 3.6K gives current gain of 20 and bandwidth of 6.5 MHz.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 29.


−10v
40k
100k
MD 6100
(MOTOROLA)
MEM 551
(GENERAL
INSTRUMENT)
D
D
S
S
INPUT
OUTPUT
D₁
1N5288
(CURRENT-LIMITING
DIODE)
100k
+10v

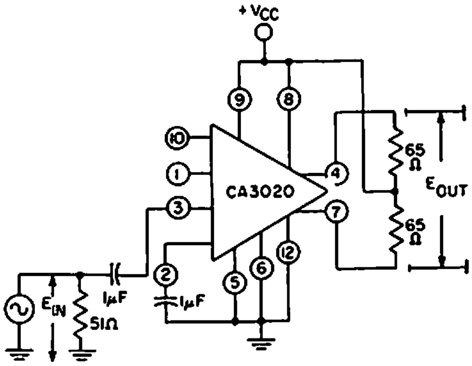
BUFFER—Dual mosfet coupled to complementary transistor pair has excellent thermal stability and almost infinite impedance, for isolating high-impedance circuits. Maximum input current drawn is less than 0.1 pA.—T. H. Lynch, MOS FET Amplifier Provides Almost Infinite Impedance, *Electronics*, July 24, 1967, p 88.


+28V
2N2846
14V
1K
51
50
R_L
C_L
3000
pf
2N2927
DRIVER
LOAD

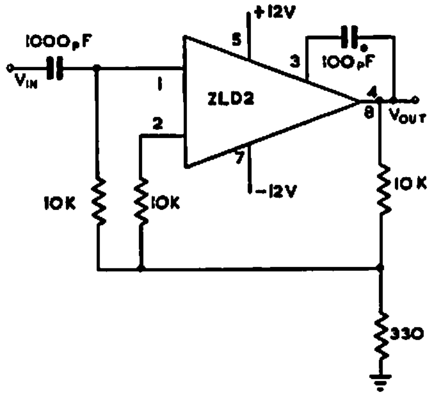
CABLE-DRIVING PULSE AMPLIFIER—Upper transistor is turned on by pulse to drive 50-ohm line, and lower transistor turns on at end of pulse to discharge line capacitance, to improve waveshape and permit driving of longer lines. Area enclosed in dashed lines simulates worst-case line-load situation. With 2N2927 pnp, 14-V pulse decays in 75 ns; if 2N1132 is used instead, decay is 110 ns.—Cable Driver Amplifier, *Electronic Design*, Feb. 3, 1964, p 44.


INPUT (50Ω)
.022
CP651
OUTPUT
2mH
50Ω
200
Ω
.022
120Ω
+20V

POWER-FET FRONT END—Covers 0.5 to 40 MHz. Broadband noise figure is below 3 dB, with sufficient dynamic range to handle signals above 2 V with little distortion. Receiver sensitivity and selectivity are significantly better than that achieved with bipolar devices.—J. Tamosaitis, The Power FET, *Electronics World*, June 1969, p 34–35 and 82.

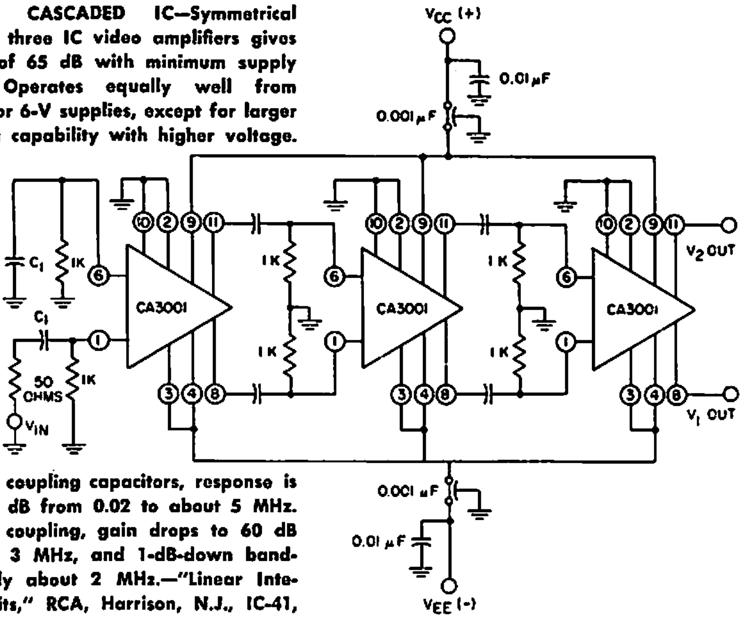

+VCC
CA3020
65 Ω
65 Ω
EOUT
EIN
51Ω
1μF
1μF

WIDEBAND CONTROL AMPLIFIER—Voltage gain is 44 dB at 1 kHz. Highly efficient as power amplifier in control systems requiring a-c amplification.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 274.

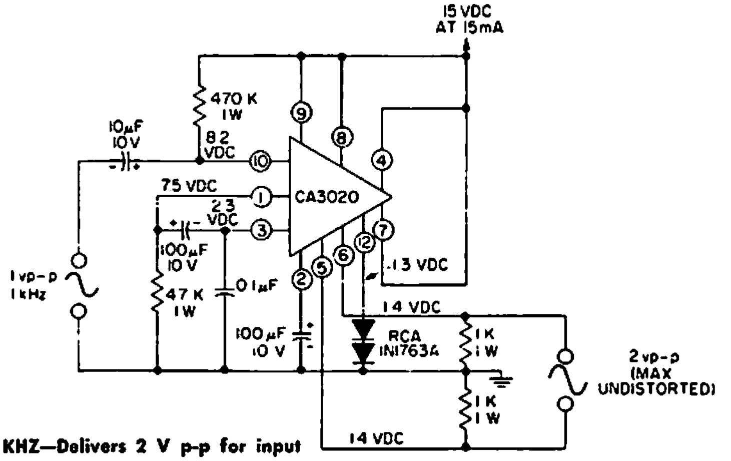

+12V
1000pF
VIN
ZLD2
100pF
VOUT
-12V
10K
10K
10 K
330

HIGH-IMPEDANCE NONINVERTING A-C AMPLIFIER—Arrangement of resistors used with Ferranti ZLD2 IC differential-input d-c amplifier gives high input impedance (400,000 ohms), because feedback is applied to both inputs. Voltage gain is 30. Gives reasonably good low-frequency response without requiring large-value capacitors; gain is 3 dB down at 240 Hz and 440 kHz.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967.

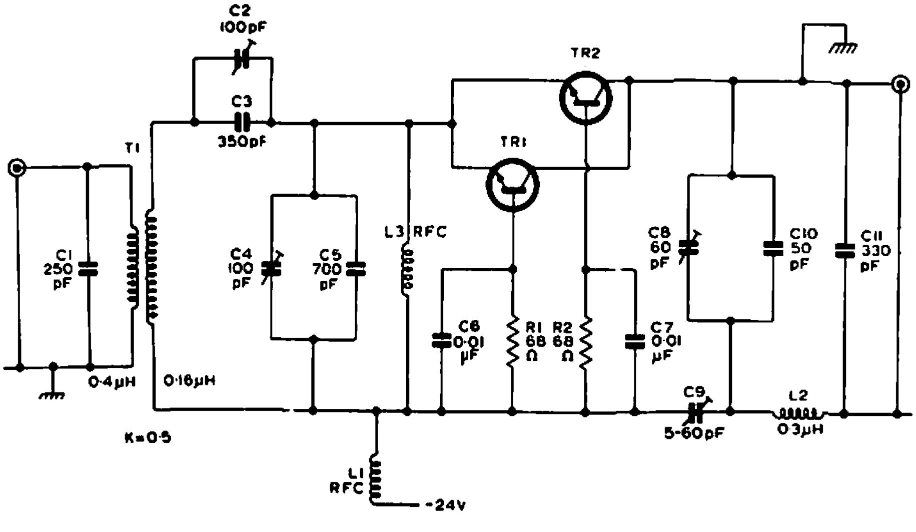
THREE-STAGE CASCADED IC—Symmetrical cascading of three IC video amplifiers gives stable gain of 65 dB with minimum supply decoupling. Operates equally well from either 4.5-V or 6-V supplies, except for larger output swing capability with higher voltage.


VCC (+)
0.01μF
0.001μF
C1
1K
C1
50 OHMS
1K
VIN
CA3001
1K
1K
CA3001
1K
1K
CA3001
V2 OUT
V1 OUT
0.001 μF
0.01 μF
VEE (-)

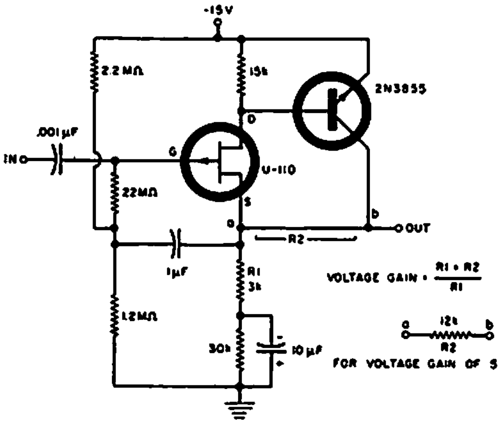
With 0.02-μF coupling capacitors, response is flat within 1 dB from 0.02 to about 5 MHz. With 100-pF coupling, gain drops to 60 dB maximum at 3 MHz, and 1-dB-down bandwidth is only about 2 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 145.


15 VDC AT 15mA
470 K 1W
8.2 VDC
10μF 10V
7.5 VDC
2.3 VDC
CA3020
100μF 10V
47 K 1W
.01μF
1 vp-p 1 kHz
-1.3 VDC
14 VDC
RCA 1N1763A
1 K 1 W
1 K 1 W
100μF 10 V
2 vp-p (MAX UNDISTORTED)
14 VDC

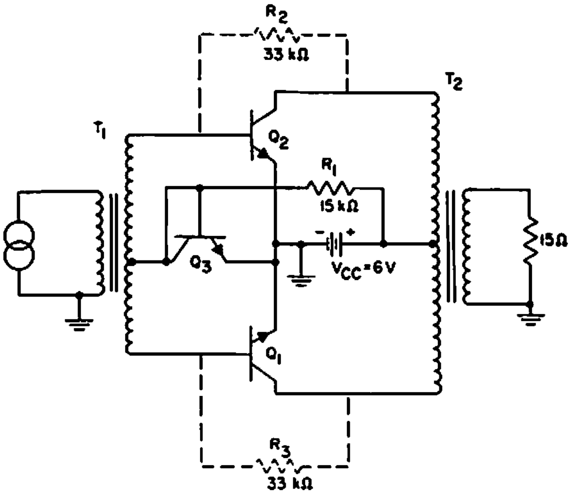
D-C TO 100 KHZ—Delivers 2 V p-p for input of 0.1 V p-p at 1 kHz, and covers entire frequency range from 100 kHz down to d-c.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 276.


C2 100pF
C3 350pF
T1
TR2
TR1
C1 250 pF
C4 100 pF
C5 700 pF
L3 RFC
C8 60 pF
C10 50 pF
C11 330 pF
C6 0·01 μF
R1 68 Ω
R2 68 Ω
C7 0·01 μF
0·4μH
0·16μH
K=0·5
C9 5-60pF
L2 0·3μH
L1 RFC
-24V

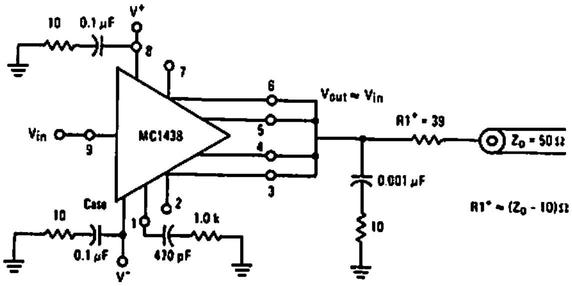
30-MHZ 3-W AMPLIFIER—Provides power gain of 7 dB and 48% efficiency with BFY50 transistors. Input and output impedances are 50 ohms.—Applications of the BFY50, BFY51, and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


-15V
2.2MΩ
15k
2N3855
D
.001µF
IN
G
U-110
22MΩ
S
b
a
OUT
R2
1µF
R1
3k
VOLTAGE GAIN = (R1 + R2)/R1
1.2MΩ
a 12k b
R2
30k
10µF
FOR VOLTAGE GAIN OF 5

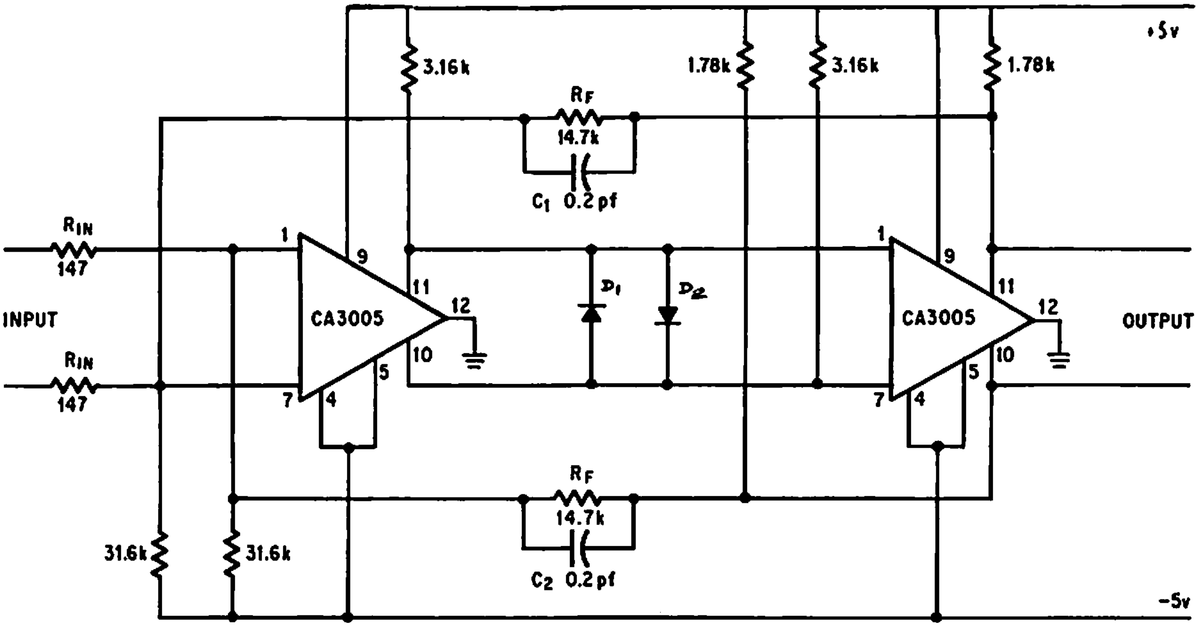
FET WITH TRANSISTOR—Gives very high input impedance and low output impedance. Voltage gain can be made greater than unity by inserting resistor R2 in feedback path. Bandwidth decreases as impedance of driving source increases.—J. H. Wujek, Jr., and M. E. McGee, Field-Effect Transistor Circuits, *Electronics World*, May 1967, p 32–33 and 75.


R2
33 kΩ
T2
T1
Q2
R1
15 kΩ
Q3
VCC=6V
15Ω
Q1
R3
33 kΩ

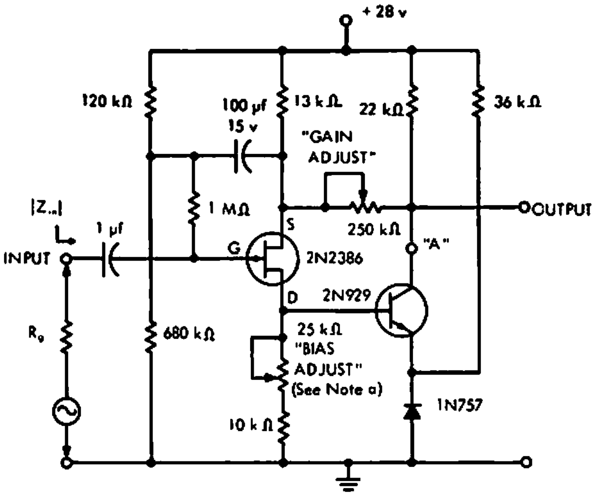
LOW-LEVEL CLASS B—Uses RCA CA3018 transistor array to give maximum output power of 40 mW and total idling current that varies only from 0.5 to 0.6 mA over entire military temperature range. Uses both a-c and d-c feedback. T1 is ADC Products 55X1322, and T2 is Chicago Standard TA-10. R1 is removed when R2 and R3 are added.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 315.


10
0.1µF
V+
8
7
6
Vout ≈ Vin
Vin
9
MC1438
5
4
R1* = 39
Z0 = 50Ω
3
0.001µF
Case
2
10
1
1.0k
R1* ≈ (Z0 - 10)Ω
0.1µF
470pF
10
V-

LINE DRIVER—Uses Motorola IC amplifier providing 70 dB current gain, with unity voltage gain, as either digital or analog driver for 50-ohm line.—Power Booster MC1438R, Motorola, Phoenix, Ariz., ADI-14R1, 1969.

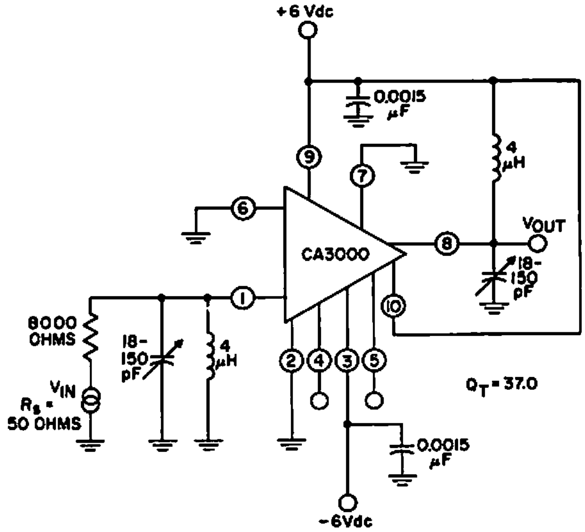

+5v
3.16k
1.78k
3.16k
1.78k
RF
14.7k
C1 0.2pf
RIN
147
1
9
1
9
11
D1
D2
11
INPUT
CA3005
12
CA3005
12
OUTPUT
RIN
147
10
10
5
5
7
4
7
4
RF
14.7k
31.6k
31.6k
C2 0.2pf
-5v

20-MHZ BANDWIDTH—Two IC r-f amplifiers are combined to form stable, reliable wideband differential amplifier. Gain, determined by ratio of RF to RIN, is 100 for values shown. Bandwidth is 20 MHz, and delay time is 20 ns. Clamp diodes D1 and D2 are required if amplifier is overloaded by large differential inputs. Diodes cause output to clip symmetrically and insure fast recovery.—C. J. Ulrick, Differential Amplifier Uses Two IC's, *Electronics*, Nov. 11, 1968, p 120–121.

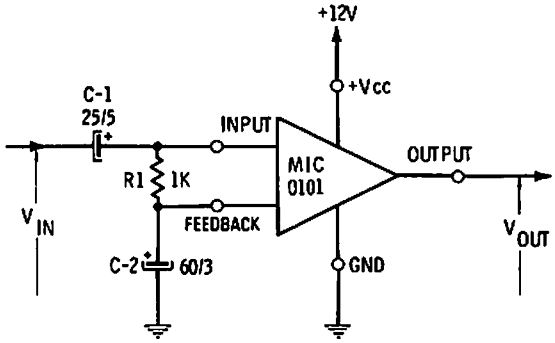

+ 28 v
120 kΩ
100 μf
15 v
13 kΩ
22 kΩ
36 kΩ
"GAIN ADJUST"
1 MΩ
250 kΩ
OUTPUT
|Z_in|
1 μf
INPUT
S
G
2N2386
"A"
D
2N929
R_g
680 kΩ
25 kΩ
"BIAS ADJUST"
(See Note a)
1N757
10 kΩ

NOTES: a. Adjust for + 18 v at Point "A".
b. All resistors ± 5% tolerance, 1/2 watt.

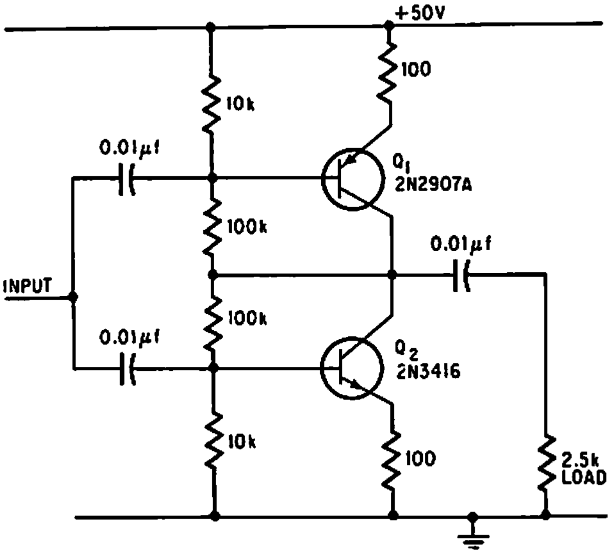
HIGH-Z INPUT—Use of p-channel diffused planar silicon fet gives input impedance of 70 meg up to 100 Hz, 50 meg at 1 kHz, and 10 meg at 10 kHz. Intended for small-signal applications. Voltage gain is adjustable from 1 to 20.—"Preferred Semiconductors and Components," Texas Instruments, Dallas, Texas, CC101, 1968, p 6302.


+6 Vdc
0.0015 μF
9
7
4 μH
6
VOUT
CA3000
8
18-150 pF
1
10
8000 OHMS
18-150 pF
4 μH
2
4
3
5
Q_T = 37.0
VIN
R_s = 50 OHMS
0.0015 μF
-6Vdc

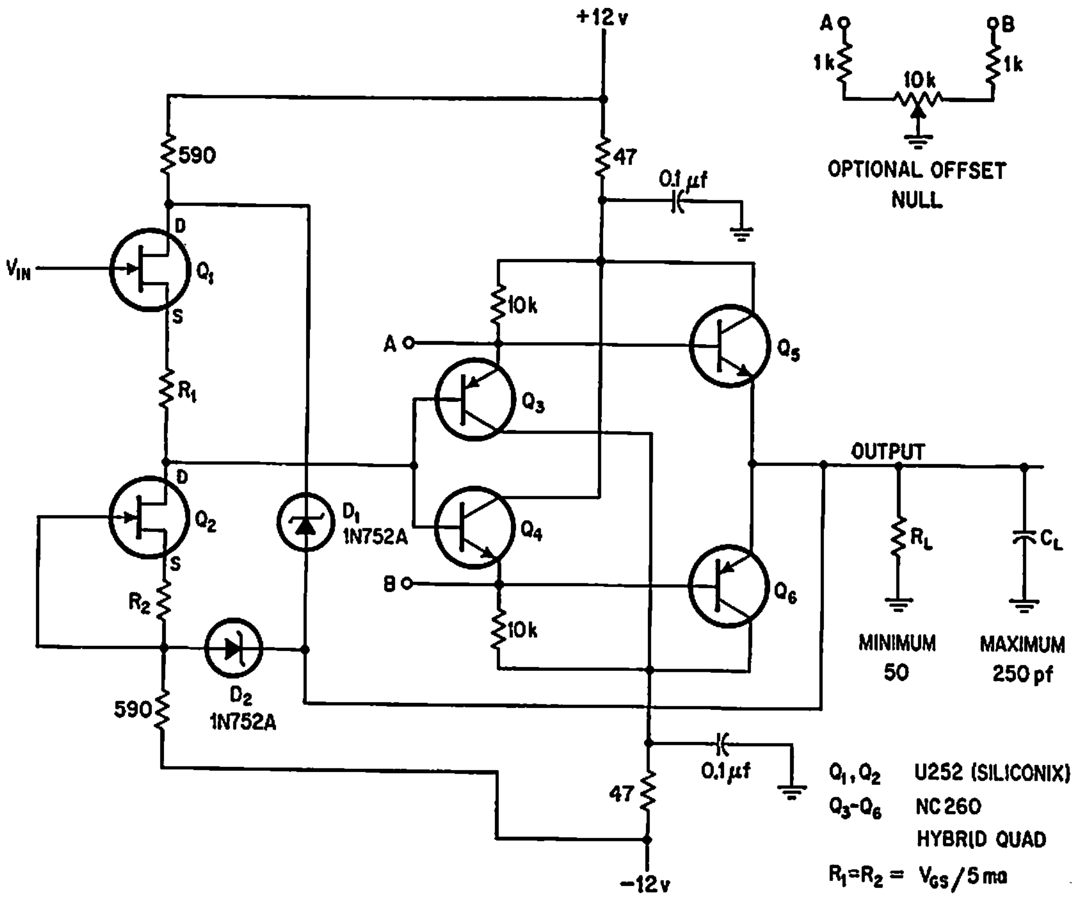
10-MHZ NARROW-BAND—With tuned input and tuned output, IC d-c amplifier provides narrow-band response, with gain dropping from about 30 dB down to 0 dB at about 1.2 MHz off from center frequency in either direction. Can be used in tuned amplifiers up to 30 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 128.


+12V
+Vcc
C-1
25/5
INPUT
MIC
0101
OUTPUT
R1
1K
FEEDBACK
V_{IN}
V_{OUT}
C-2
60/3
GND

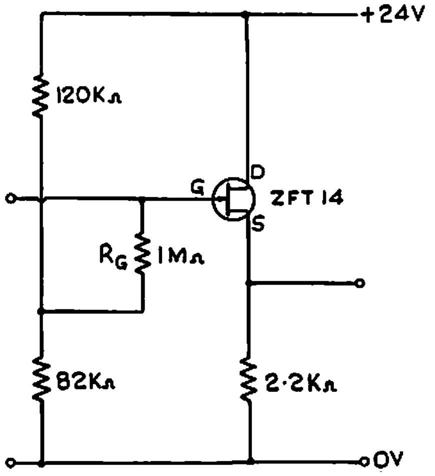
R-C COUPLING—Uses Mallory MIC0101 preamp to provide voltage gains from 57 to 53 dB. 3-dB bandwidth extends up to 700 kHz. Distortion is under 5% for outputs up to 1 V rms.—M. L. Deschler, Integrated Circuit Preamplifiers, Mallory, Indianapolis, Ind., APPN-2, 1968.


+50V
100
10k
0.01μf
Q_1
2N2907A
100k
0.01μf
INPUT
100k
0.01μf
Q_2
2N3416
10k
100
2.5k LOAD

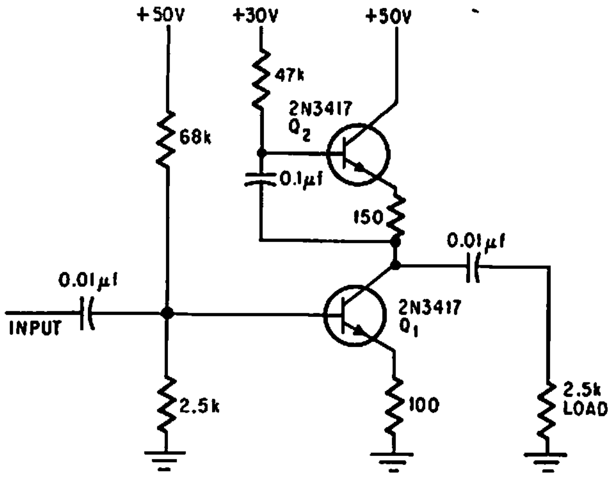
IMPROVING SIGNAL TRANSFER—Complementary arrangement of amplifier transistors, with each operating class A as both amplifier and collector load, improves efficiency and reduces distortion. Each transistor serves as collector impedance for the other. Delivers 0.5 W at 22 V to load.—M. J. Wright, Transistor Replaces Resistor and Improves Amplifier, *Electronics*, Jan. 8, 1968, p 92.


+12v
590
47
0.1 µf
D
V_IN
Q1
S
R1
D
Q2
S
R2
590
D1
1N752A
D2
1N752A
A
10k
Q3
Q4
B
10k
Q5
Q6
OUTPUT
RL
CL
MINIMUM 50
MAXIMUM 250 pf
0.1 µf
47
-12v
A
B
1k
10k
1k
OPTIONAL OFFSET NULL
Q1, Q2 U252 (SILICONIX)
Q3-Q6 NC260 HYBRID QUAD
R1=R2= VGS/5 ma

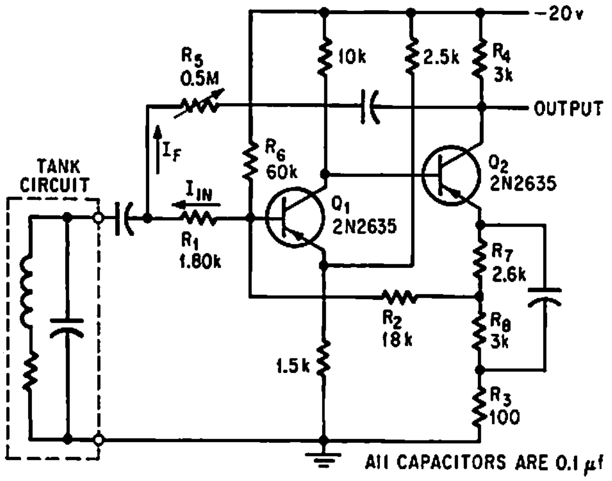
FAST-SETTLING BUFFER—Simple transistor circuit outperforms high-speed fet opamps used in sampling circuits and analog memories by settling to 0.1% of final value in 50 ns. Circuit is stable with moderate capacitive loading and will slew at up to 300 V per µs. Potentiometer can be connected to A and B to null the offset voltage. Bode plot is flat from d-c to 40 MHz.—D. Atlas, FET Buffer Boasts High Speed and Performance, *Electronics*, July 21, 1969, p 82–83.


+24V
120KΩ
G
D
ZFT 14
S
RG
1MΩ
82KΩ
2·2KΩ
0V

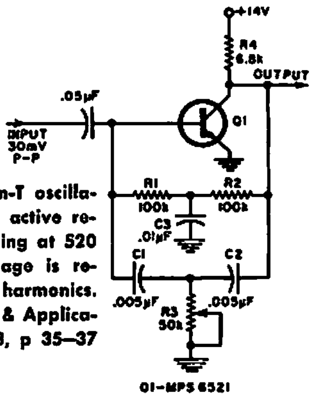
FET SOURCE FOLLOWER—Uses voltage divider to provide bias for gate. Input impedance is 1 meg.—Field Effect Transistors and Applications, Ferranti Ltd., Oldham, Lancs., England, No. 22, 1965.


+50V
+30V
+50V
68k
47k
2N3417
Q2
0.1µf
150
0.01µf
0.01µf
INPUT
2N3417
Q1
2.5k
100
2.5k
LOAD

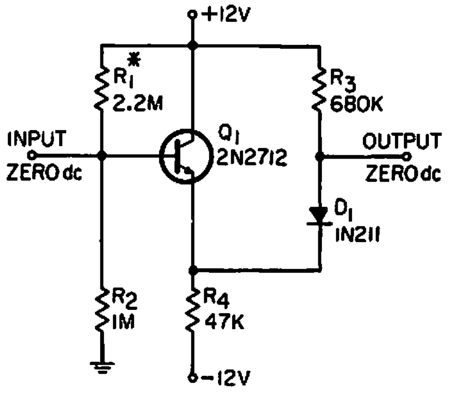
CONSTANT-CURRENT SOURCE—Q2 offers high impedance to amplifier, and requires only bias current to develop output voltage. Practically all of collector-current modulation of Q1 is delivered to load; thus, collector current of 2 mA p-p produces 1-mA p-p in load, whereas 2.5K resistor in place of Q2 would require 4-mA p-p input for same output. Maximum output power is over 0.2 W at 22 V.—M. J. Wright, Transistor Replaces Resistor and Improves Amplifier, *Electronics*, Jan. 8, 1968, p 92.


-20v
R5
0.5M
10k
2.5k
R4
3k
OUTPUT
IF
R6
60k
Q2
2N2635
TANK CIRCUIT
IIN
R1
1.80k
Q1
2N2635
R7
2.6k
R2
18k
R8
3k
1.5k
R3
100
All CAPACITORS ARE 0.1 µf

INFINITE IMPEDANCE—Simple two-stage amplifier with both positive and negative feedback can serve either as Q multiplier or infinite-impedance amplifier, by appropriate adjustment of interstage feedback. Basically, this circuit is a negative-impedance converter. Article gives design equations.—G. Marosi, Negative Impedance Converter Does Double Duty, *Electronics*, July 24, 1967, p 87–88.

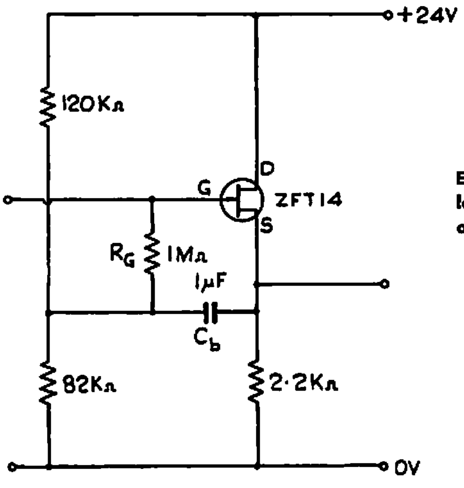

+14V
R4
6.8k
OUTPUT
.05µF
INPUT
30mV
P-P
Q1
R1
100k
R2
100k
C3
.01µF
C1
C2
.005µF
R3
50k
.005µF
Q1—MPS 6521

TWIN-T—Adjusting R3 in basic twin-T oscillator for operation well in quiescent active region gives resonant amplifier peaking at 520 Hz, with Q of 15. Chief advantage is response only to fundamental, not harmonics. —F. B. Maynard, Twin T's: Designs & Applications, *Electronics World*, Aug. 1968, p 35–37 and 64.

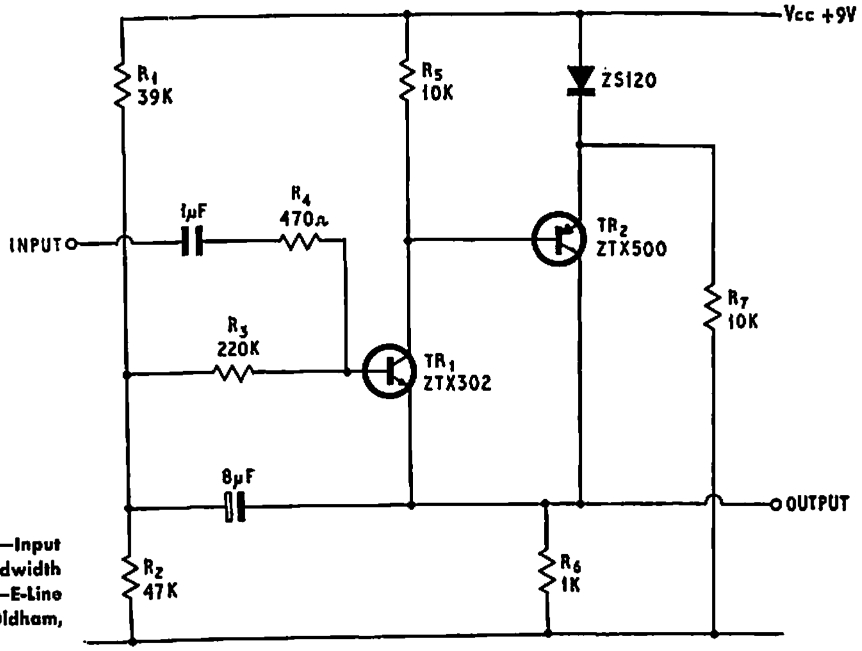

+12V
*
R1
2.2M
R3
680K
INPUT
ZERO dc
Q1
2N2712
OUTPUT
ZERO dc
D1
IN211
R2
1M
R4
47K
-12V

* SELECTED TO GIVE ZERO VOLTS AT THE BASE

EMITTER-FOLLOWER WITHOUT OFFSET—D-c levels at input and output are equal, with offset eliminated by diode. Suitable for both d-c and a-c applications.—A. C. Caggiano, Modified Emitter Follower Has No Offset, *EEE*, March 1967, p 164.

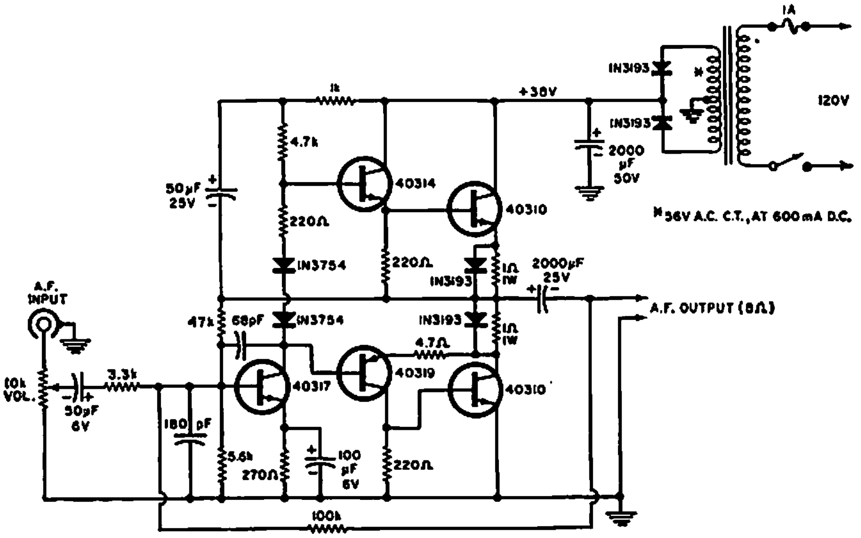

+24V
120KΩ
D
G
ZFT14
S
RG
1MΩ
1µF
Cb
82KΩ
2·2KΩ
0V

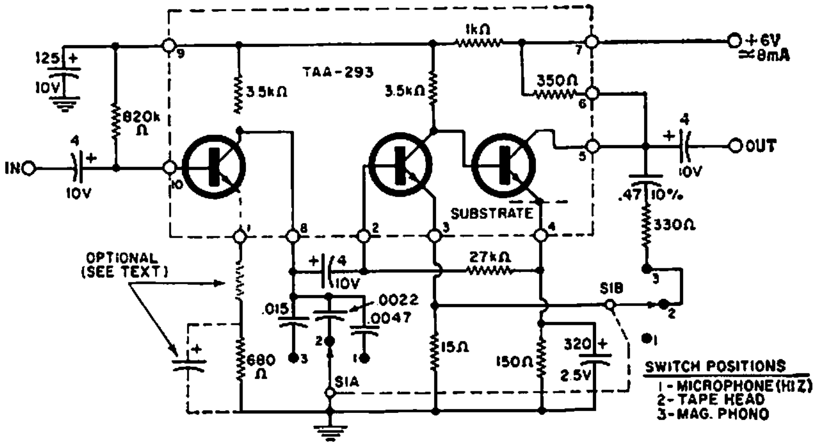
BOOTSTRAPPED FET SOURCE FOLLOWER—Bootstrapping increases input impedance to 5.5 meg as compared to 1 meg for conventional source follower using same resistor values, for improved performance stability.—Field Effect Transistors and Applications, Ferranti Ltd., Oldham, Lancs., England, No. 22, 1965.


Vcc +9V
R1
39K
R5
10K
ZS120
R4
470Ω
1µF
INPUT
TR2
ZTX500
R7
10K
R3
220K
TR1
ZTX302
8µF
OUTPUT
R2
47K
R6
1K

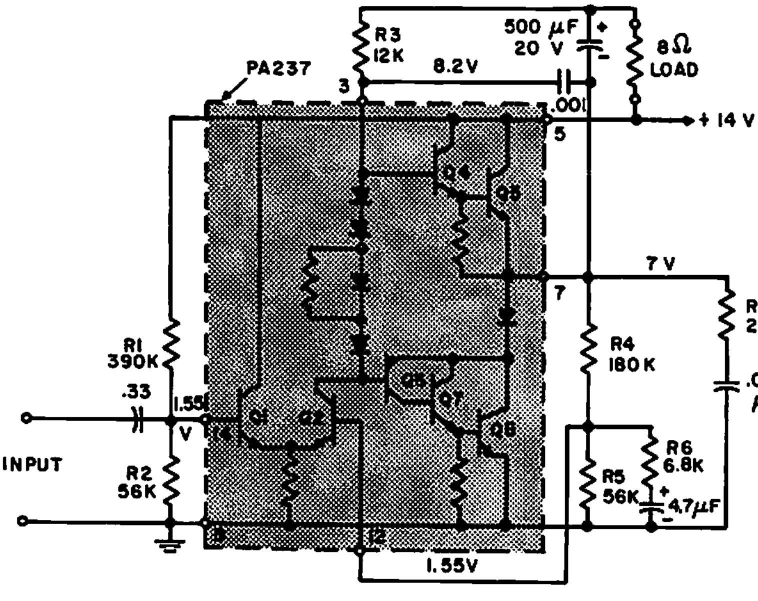
UNITY GAIN AT HIGH IMPEDANCE—Input impedance is at least 1 meg and bandwidth is above 1 MHz at 1 V rms output.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 31.

10-W HI-FI—Quasi-complementary circuit uses 1N3754 diodes in input of driver to compensate for effect of high-temperature variations of output transistors. Diodes shunting 1-ohm resistors in output stage reduce losses when operating at rated power, while resistors provide degeneration for circuit stability. Response is flat within 1 dB from 15 to 20,000 Hz.—R. D. Gold and J. C. Sondermeyer, Designing Silicon-Transistor Hi-Fi Amplifiers, *Electronics World*, Nov. 1966, p 47–50 and 80–81.

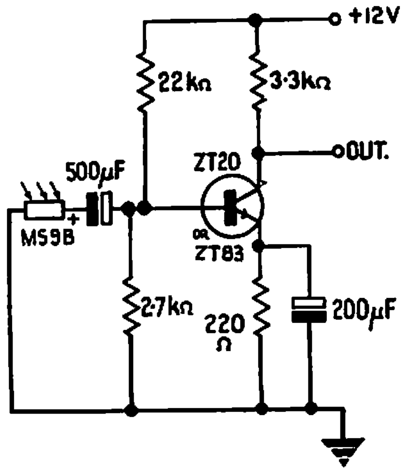

1A
120V
IN3193
IN3193
*
+38V
1k
4.7k
50μF 25V
40314
40310
2000 μF 50V
*36V A.C. C.T., AT 600mA D.C.
220Ω
IN3754
220Ω
IN3193
1Ω 1W
2000μF 25V
A.F. INPUT
47k
68pF
IN3754
IN3193
1Ω 1W
4.7Ω
A.F. OUTPUT (8Ω)
10k VOL.
3.3k
50μF 6V
40317
40319
40310
180 pF
5.6k
270Ω
100 μF 6V
220Ω
100k


125 10V
+
9
TAA-293
1kΩ
7
+6V ≃8mA
3.5kΩ
3.5kΩ
350Ω
6
820k Ω
4
IN
10V
10
4
+
OUT
5
10V
SUBSTRATE
.47 10%
330Ω
1
8
2
3
4
OPTIONAL (SEE TEXT)
+ 4 10V
27kΩ
S1B
3
2
.015
.0022
.0047
2
1
3
1
680 Ω
15Ω
150Ω
320 2.5V
S1A
SWITCH POSITIONS
1-MICROPHONE (HI Z)
2-TAPE HEAD
3-MAG. PHONO

IC PREAMP—Uses Amperex TAA-293 integrated circuit containing three transistors and four resistors, priced under $3. S1 gives choice of three types of equalization. To obtain higher gain for tape playback, add 125-μF capacitor across 560-ohm resistor used in place of 680 ohms, and insert 180-ohm unbypassed series resistor as per dotted lines. Output is 0.5 V.—D. R. Pryce, Integrated Circuit Equalized Preamplifier, *Electronics World*, July 1968, p 29 and 73.

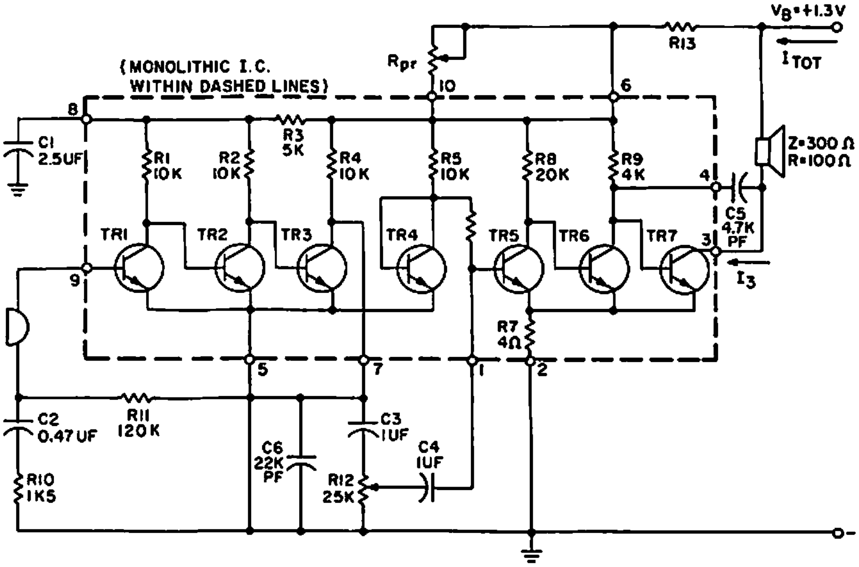

R3 12K
500 μF 20 V
8Ω LOAD
PA237
3
8.2V
.001
+14 V
5
Q4
Q5
7 V
7
R7 22
R1 390K
R4 180 K
.047 μF
.33
1.55
V
Q6
Q7
Q1
Q2
Q8
INPUT
R2 56K
14
R6 6.8K
R5 56K
4.7μF
9
12
1.55V

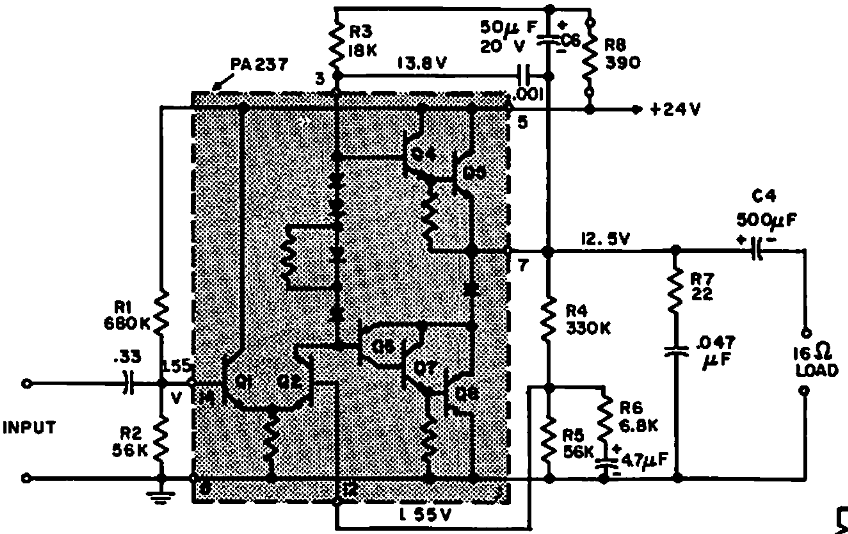
1-W IC AMPLIFIER—Uses GE PA-237 monolithic integrated circuit with external components shown. Can drive 8-ohm speaker directly. With 22-V supply, will deliver 1.5 W into 22-ohm load. Total harmonic distortion is 1% at 1 kHz.—Dwight V. Jones, Monolithic 2 Watt Integrated Amplifier—Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.73, 1968, p 10.


+12V
22kΩ
3·3kΩ
OUT.
500μF
ZT20
OR
ZT83
MS9B
2·7kΩ
220 Ω
200μF

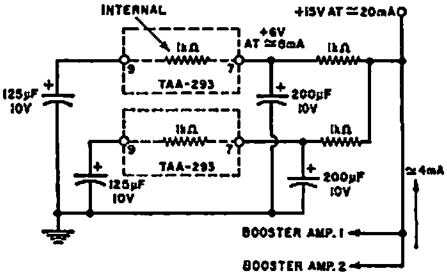
MOVIE SOUND PICKUP—Silicon photocell and single-transistor amplifier give essentially flat frequency response from d-c to well above 20,000 Hz for sound-on-film track of movie projector.—Silicon Photocell Applications, Ferranti Ltd., Oldham, Lancs., England, No. 9, 5/67, p 16.

IC HEARING AID—Uses TAA370 IC developed especially for body and behind-the-ear hearing aids. Heavy negative feedback keeps spread in gain very small for battery aging and other factors. Output power is 1 mW. Frequency response is determined largely by values of C2, C5, and C6; for those shown, response is flat within 3 dB from 200 Hz to above 9,000 Hz. R10 is 1.5K.—The Amperex TAA 370 as a Hearing Aid Amplifier, Amperex, Slatersville, R.I., S-139, 1968.

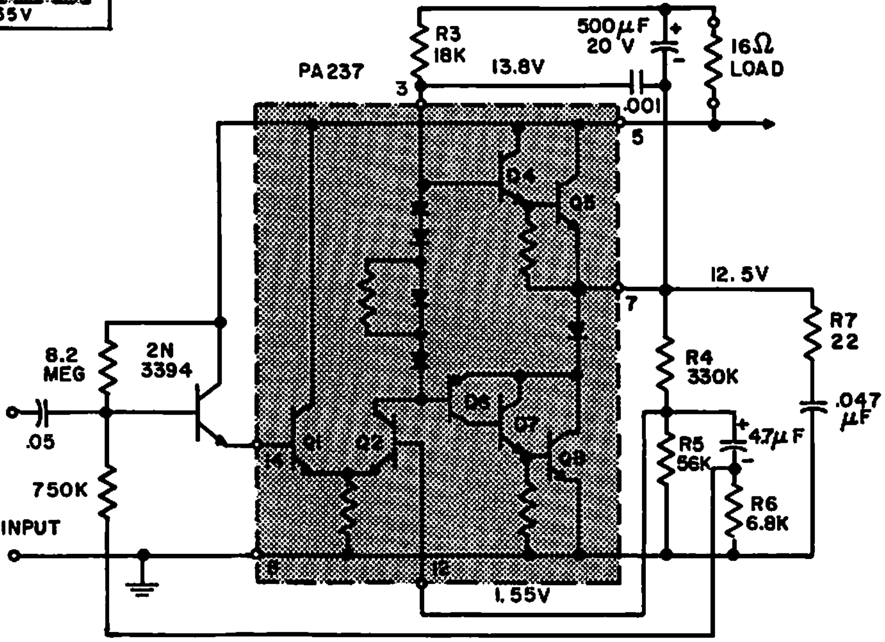

(MONOLITHIC I.C. WITHIN DASHED LINES)
Rpr
V_B=+1.3V
R13
I_{TOT}
Z=300 Ω
R=100 Ω
C1 2.5UF
R1 10K
R2 10K
R3 5K
R4 10K
R5 10K
R8 20K
R9 4K
C5 4.7K PF
TR1
TR2
TR3
TR4
TR5
TR6
TR7
I_3
R7 4Ω
8
10
6
4
3
9
5
7
1
2
C2 0.47UF
R11 120K
C6 22K PF
C3 1UF
C4 1UF
R12 25K
R10 1K5


PA237
R3 18K
13.8V
50μF 20 V
C6
R8 390
.001
+24V
3
5
Q4
Q5
7
12.5V
C4 500μF
R7 22
.047 μF
16Ω LOAD
R4 330K
R1 680K
.33
1.55 V
14
Q1
Q2
Q6
Q7
Q8
INPUT
R2 56K
R6 6.8K
R5 56K
4.7μF
8
12
1.55V

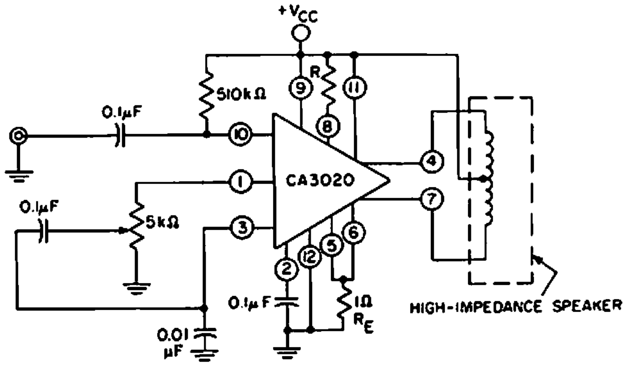
2-W IC AMPLIFIER—Uses GE PA-237 integrated circuit for driving 16-ohm load that is returned to ground. Total harmonic distortion is 1% at 1 kHz.—Dwight V. Jones, Monolithic 2 Watt Integrated Amplifier—Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.73, 1968, p 11.


INTERNAL
+15V AT ≃20mA
+6V AT ≃6mA
1kΩ
1kΩ
1kΩ
1kΩ
9
7
TAA-293
9
7
TAA-293
125μF 10V
125μF 10V
200μF 10V
200μF 10V
≃4mA
BOOSTER AMP. 1
BOOSTER AMP. 2

DECOUPLER—Used to prevent feedback and crosstalk problems when two preamps, with or without booster amplifiers, are used in stereo system having Amperex TAA-293 IC in each channel. Only power supply connections for IC's are shown here.—D. R. Pryce, Integrated Circuit Equalized Preamplifier, *Electronics World*, July 1968, p 29 and 73.

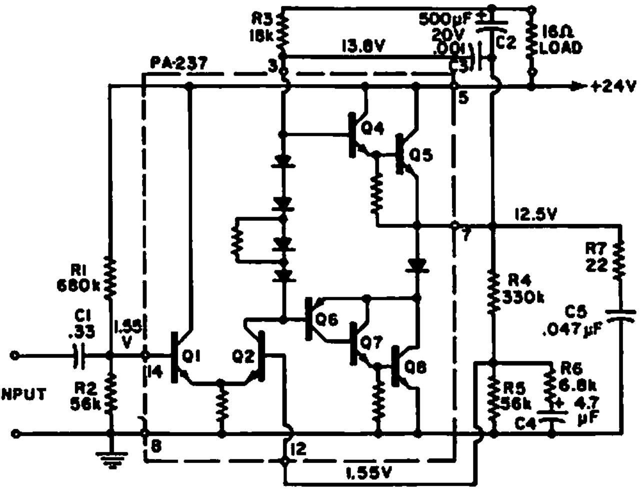

R3 18K
13.8V
500μF 20 V
16Ω LOAD
PA237
3
.001
5
Q4
Q5
12.5V
7
R7 22
R4 330K
.047 μF
8.2 MEG
2N 3394
.05
14
Q1
Q2
Q6
Q7
Q8
R5 56K
4.7μF
R6 6.8K
750K
INPUT
8
12
1.55V

2-W IC WITH 2-MEG INPUT—Uses GE PA-237 integrated circuit with additional transistor at input to give input impedance between 2 and 3 meg.—Dwight V. Jones, Monolithic 2 Watt Integrated Amplifier—Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.73, 1968, p 13.

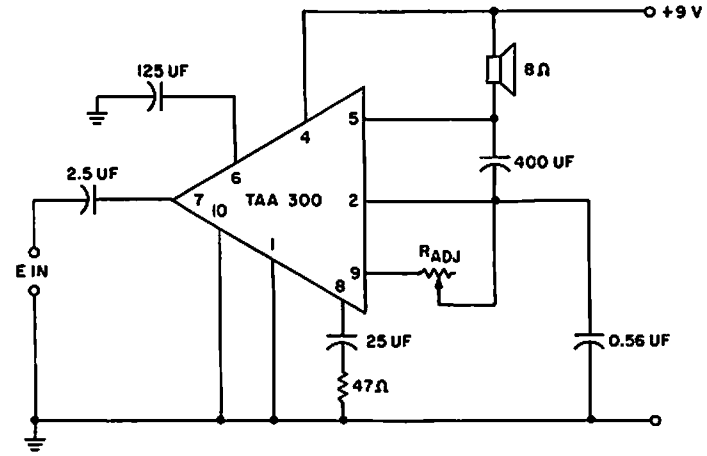

+Vcc
510kΩ
R
0.1μF
9
11
8
10
1
CA3020
4
7
0.1μF
5kΩ
3
6
5
12
2
0.1μF
1Ω
R_E
0.01 μF
HIGH-IMPEDANCE SPEAKER

Supply Voltage Vcc (V)	Idling Current I_{do} (mA)	Resistor between Terminals 8 and 11 (ohms)	Power Output P_{out} (mW)	Total Harmonic Distortion (%)
3	10	220	50	2.0
6	21	1000	200	2.0
9	24	∞	400	2.5

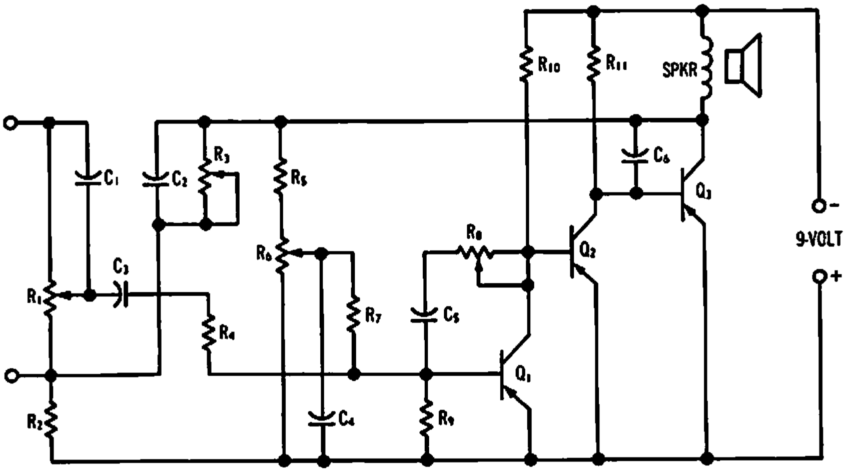
LOW-DISTORTION IC AMPLIFIER—Table gives optimum value of resistor R, connected between wideband IC amplifier terminals 8 and 11, for minimizing total harmonic distortion. —"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 270.


R3 18k
13.8V
500μF 20V
C2
16Ω LOAD
.001
C3
PA-237
3
5
+24V
Q4
Q5
12.5V
7
R7 22
R1 680k
R4 330k
C1 .33
1.55 V
C5 .047μF
Q6
Q7
Q1
Q2
Q8
14
INPUT
R2 56k
R5 56k
R6 6.8k
4.7 μF
C4
8
12
1.55V

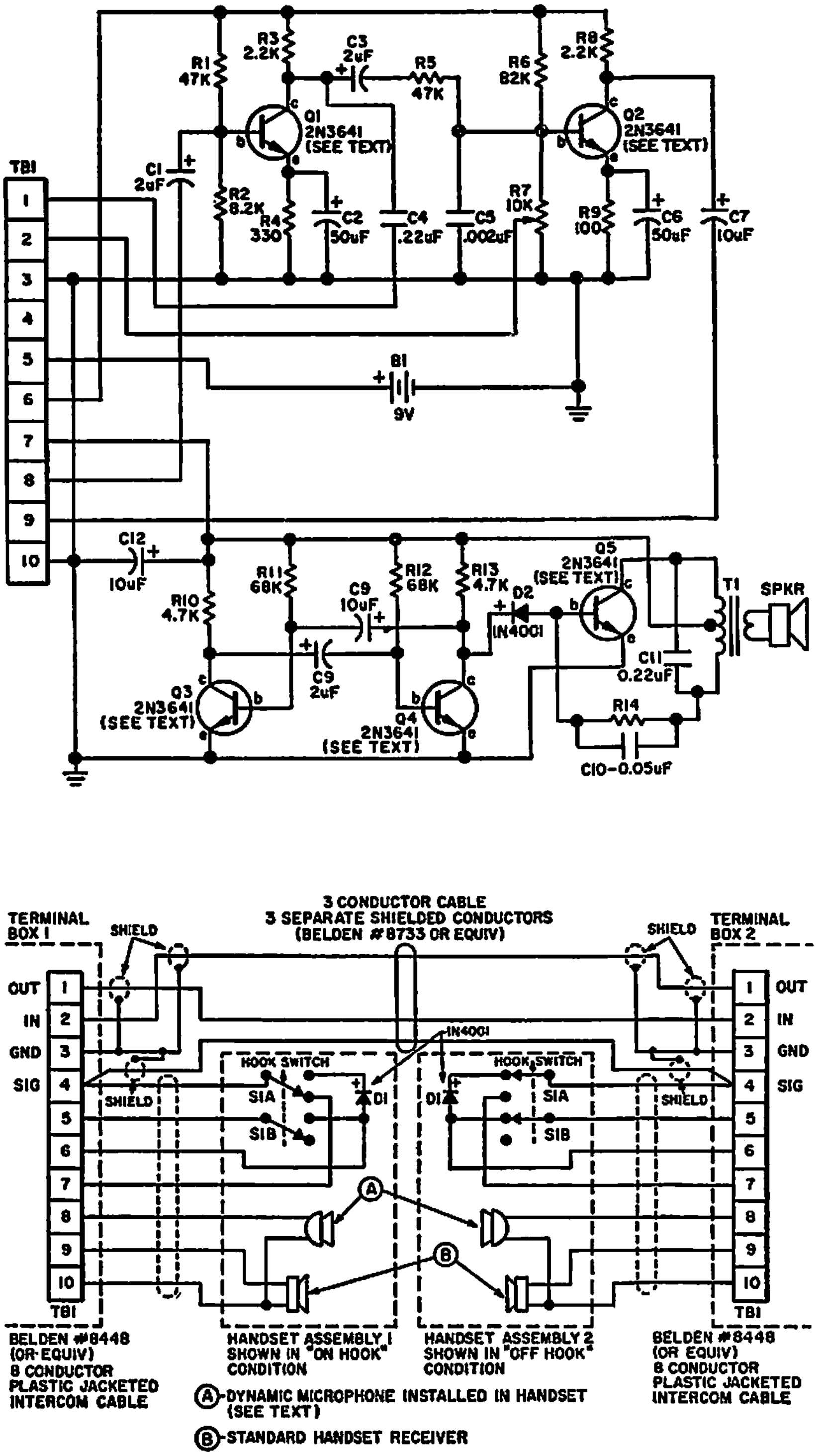
2-W AUDIO IC—G-E monolithic amplifier has quasi-complementary output circuit, shown inside dashed square, to give push-pull output. Input is differential amplifier.—D. V. Jones, Audio-Frequency Integrated Circuits, *Electronics World*, July 1968, p 54–56.


+9 V
125 UF
8Ω
5
4
400 UF
2.5 UF
6
7
10
TAA 300
2
E IN
1
RADJ
9
8
25 UF
0.56 UF
47Ω

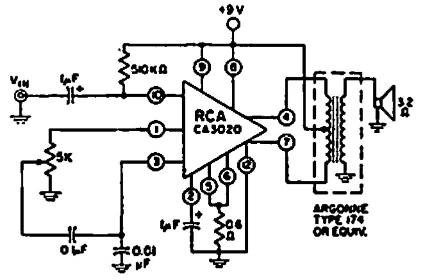
1-W IC AUDIO AMP—Gives high gain and low current consumption for portable radios, phonographs, TV sets, tape cassette systems, and walkie-talkies. Uses Amperex TAA300 IC. Frequency response is down 3 dB at 120 and 23,000 Hz with feedback. Select R-adj for 8-mA no-signal total current drain. —The Amperex TAA 300 Monolithic Integrated Circuits Used as a Complete Audio Amplifier, Amperex, Slatersville, R.I., S-138, 1968.


R_{10}
R_{11}
SPKR
C_1
C_2
R_3
R_5
C_6
Q_3
9-VOLT
-
+
R_6
R_8
Q_2
C_3
R_1
R_4
R_7
C_5
Q_1
C_4
R_9
R_2

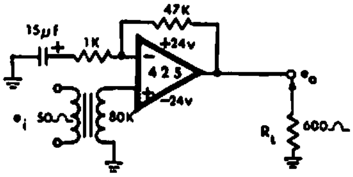
0.5-W AMPLIFIER—Serves as center of inexpensive mono hi-fi system. Uses external 9-V supply for power, and a-m/f-m tuner or ceramic cartridge phonograph as program source feeding into 32-ohm speaker. Article gives construction details. Parts values are: R1 2.5 meg; R2 270; R3 10K bass pot; R4 200K; R5, R9 10K; R6-R7-R8 100K; R10 22K; R11 1.2K; C1 75 μμF; C2 0.1 μF; C3 0.02 μF; C4 15 μF; C5 0.01 μF; C6 0.05 μF; Q1 HEP-253; Q2 HEP254; Q3 HEP230.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 37.


TB1
1
2
3
4
5
6
7
8
9
10
R1 47K
R3 2.2K
C3 2uF
R5 47K
R6 82K
R8 2.2K
Q1 2N3641 (SEE TEXT)
Q2 2N3641 (SEE TEXT)
C1 2uF
R2 8.2K
R4 330
C2 50uF
C4 .22uF
C5 .002uF
R7 10K
R9 100
C6 50uF
C7 10uF
B1 9V
C12 10uF
R10 4.7K
R11 68K
C9 10uF
R12 68K
R13 4.7K
D2 1N4001
Q5 2N3641 (SEE TEXT)
T1
SPKR
C9 2uF
C11 0.22uF
Q3 2N3641 (SEE TEXT)
Q4 2N3641 (SEE TEXT)
R14
C10-0.05uF
3 CONDUCTOR CABLE
3 SEPARATE SHIELDED CONDUCTORS
(BELDEN #8733 OR EQUIV)
TERMINAL BOX 1
TERMINAL BOX 2
SHIELD
OUT
IN
GND
SIG
1N4001
HOOK SWITCH
S1A
S1B
D1
D1
A
B
TB1
BELDEN #8448 (OR EQUIV) 8 CONDUCTOR PLASTIC JACKETED INTERCOM CABLE
HANDSET ASSEMBLY 1 SHOWN IN "ON HOOK" CONDITION
HANDSET ASSEMBLY 2 SHOWN IN "OFF HOOK" CONDITION
Ⓐ-DYNAMIC MICROPHONE INSTALLED IN HANDSET (SEE TEXT)
Ⓑ-STANDARD HANDSET RECEIVER

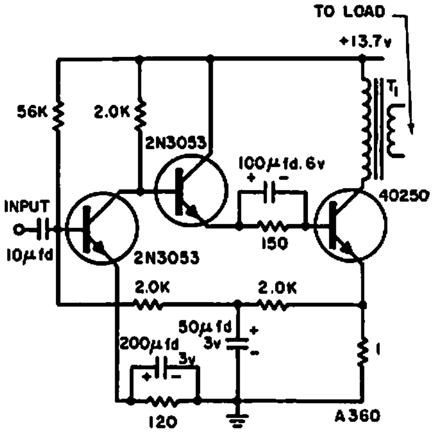
TWO-STATION INTERCOM WITH PRIVACY—Has no on-off or talk-listen switches yet neither party can listen in on room conversations at other station when handset at one station is hung up. When one party picks up handset, beep tone at other station calls other party. When that handset is picked up, tone stops and normal two-way conversation can take place, with both parties talking and listening just as with standard telephone. Cost of parts for two stations is about $50. Any equivalent transistor can be used, such as 2N697, 2N3705, SK3020, GE21, or HEP54. Article tells where to buy handset, cradle, and dynamic microphone to be used in place of handset transmitter cartridge in each of the identical stations or terminals.—E. A. Morris, Phonecom—The Hot Line Intercom, *Elementary Electronics*, Mar.–Apr. 1970, p 35–40 and 99–100.


+9V
V_{IN}
1μF
510KΩ
RCA CA3020
10
1
3
9
8
4
7
2
5
6
12
5K
1μF
0.6 Ω
0 μF
0.01 μF
3.2 Ω
ARGONNE TYPE 174 OR EQUIV.

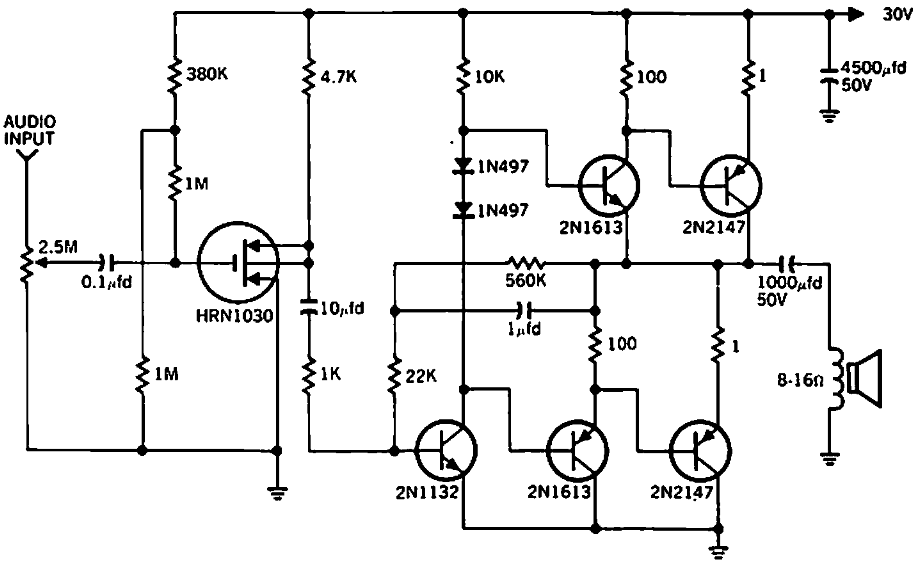
IC AUDIO OUTPUT—Delivers up to 1 W, either to center-tapped speaker or to output transformer and ordinary speaker as shown. Same integrated circuit can also drive higher-power audio amplifiers. Power gain is 58 dB.—D. E. Lancaster, Audio Integrated Circuits—What's Available?, *Electronics World*, Oct. 1967, p 34–36.


47K
15μf
1K
+24v
425
−24v
e_o
e_i
50Ω
80K
R_L
600Ω

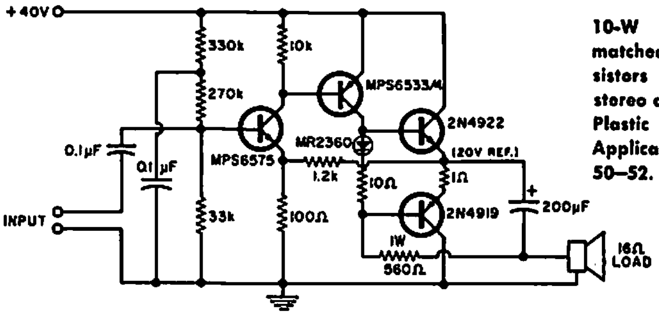
OPAMP PREAMP—Input transformer for microphone provides voltage step-up for Model 425 d-c opamp. Serves to reduce overall noise, because total noise becomes equal to noise of transformer plus noise of IC, divided by transformer gain. Low-frequency cutoff is 10 Hz. Output level of IC is +22 dBm and overall gain is 1,000 (60 dB). May also be used as tape preamp.—B. J. Losmandy, Operational Amplifier Applications for Audio Systems, Op-amp Labs, Los Angeles, Cal., 1968.


TO LOAD
+13.7v
T_1
56K
2.0K
2N3053
100μfd. 6v
40250
INPUT
10μfd
2N3053
150
2.0K
2.0K
50μfd 3v
200μfd 3v
1
120
A360

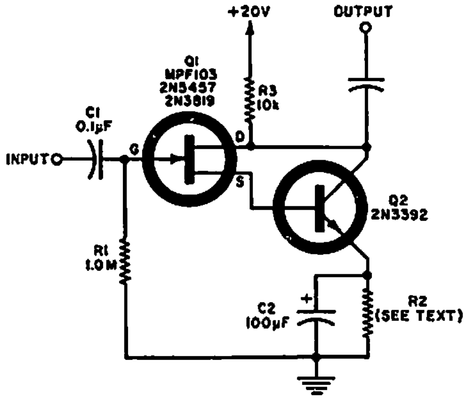
12-V OUTPUT STAGE—Provides medium power for audio applications. Converter and inverter applications for 40250 are given in RCA Application Note SMA-35.—Amplifiers and Converters, *Electronic Design*, March 15, 1965, p 217.


30V
380K
4.7K
10K
100
1
4500μfd 50V
AUDIO INPUT
1M
1N497
1N497
2N1613
2N2147
2.5M
0.1μfd
HRN1030
560K
1000μfd 50V
10μfd
1μfd
100
1
1M
1K
22K
8-16Ω
2N1132
2N1613
2N2147

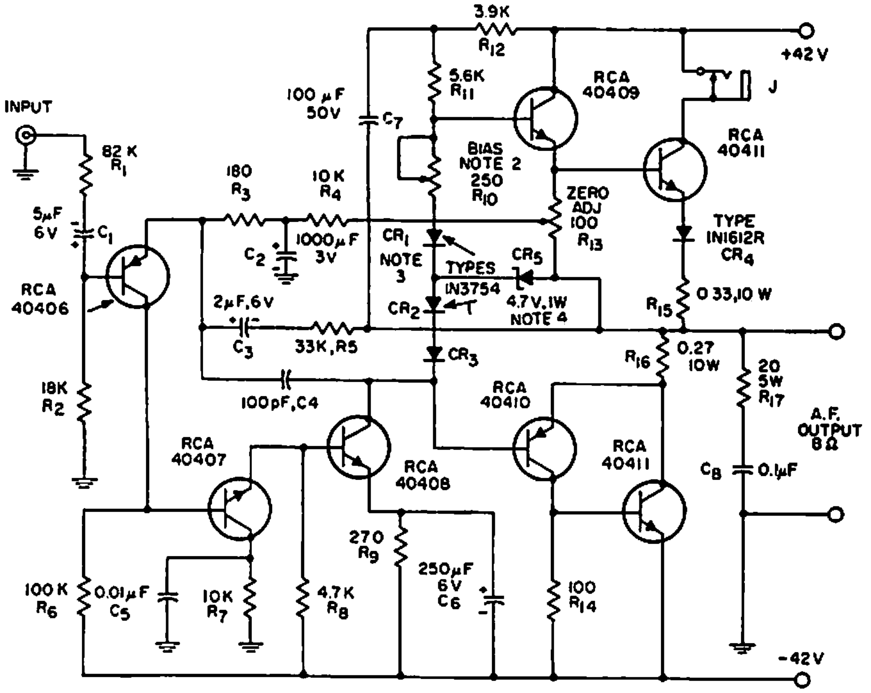
5-W HI-FI AMPLIFIER—Uses single mosfet input stage, for which two-mosfet tone control circuit may be substituted if desired.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 8.


+40V
330k
10k
270k
MPS6533/4
2N4922
0.1μF
0.1 μF
MPS6575
MR2360
(20V REF.)
1.2k
10Ω
1Ω
INPUT
33k
100Ω
2N4919
200μF
1W
560Ω
16Ω LOAD

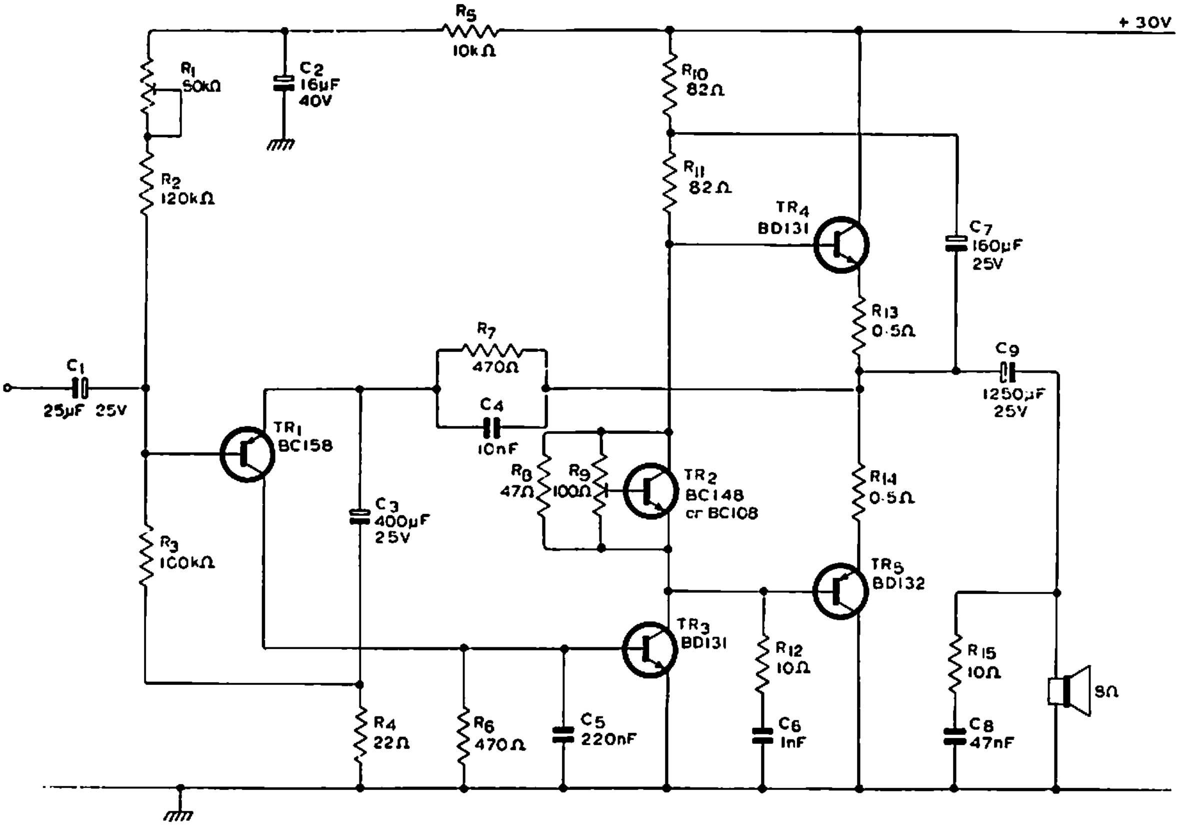
10-W COMPLEMENTARY AMPLIFIER—Uses matched pair of pnp and npn Motorola transistors to give high-fidelity performance for stereo and other applications.—D. E. Lancaster, Plastic Power Transistors—Advantages and Applications, *Electronics World*, Feb. 1968, p 50–52.


+20V
OUTPUT
Q1 MPF103 2N5457 2N3819
R3 10k
C1 0.1μF
INPUT
G
D
S
Q2 2N3392
R1 1.0M
C2 100μF
R2 (SEE TEXT)

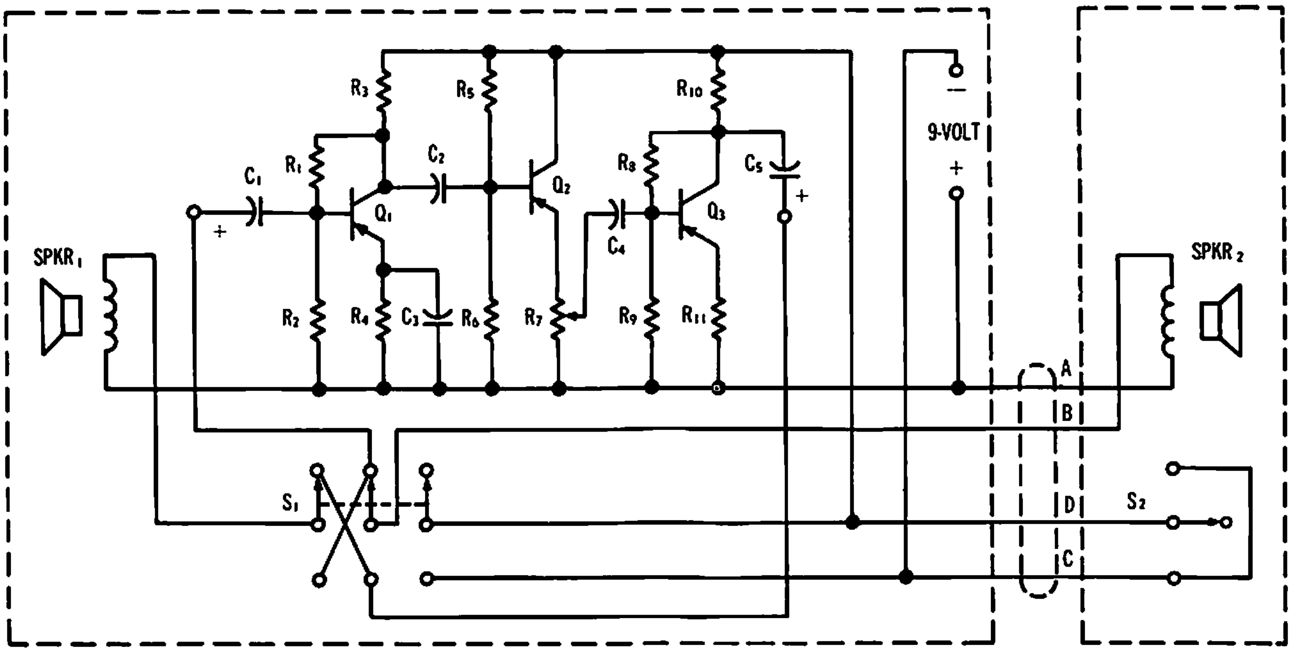
FET INPUT—Used when high audio voltage gain is more important than hi-fi quality. Signal voltage gain is 120, and frequency response is down 2 dB at 30 Hz and 10,000 Hz. R2 is between 560 and 1,200 ohms, selected to produce d-c stage current of 1 mA at 20 V.—F. H. Tooker, High-Gain Audio Input Stage, *Electronics World*, July 1969, p 77.


3.9K R12
+42V
J
5.6K R11
RCA 40409
INPUT
100 μF 50V
C7
RCA 40411
82 K R1
BIAS NOTE 2 250 R10
180 R3
10 K R4
ZERO ADJ 100 R13
5μF 6V C1
C2
1000μF 3V
CR1 NOTE 3
TYPES 1N3754
CR5
TYPE 1N1612R CR4
RCA 40406
CR2
4.7V, 1W NOTE 4
0 33,10 W R15
2μF, 6V
C3
33K, R5
CR3
R16 0.27 10W
20 5W R17
18K R2
100pF, C4
RCA 40410
A.F. OUTPUT 8Ω
RCA 40407
RCA 40408
RCA 40411
C8 0.1μF
270 R9
250μF 6V C6
100 K R6
0.01μF C5
10K R7
4.7K R8
100 R14
-42V

70-W 20-HZ QUASI-COMPLEMENTARY—Developed for amplifying 20-Hz sine-wave input and feeding 225-W peak power into 8-ohm load. Zener CR5 is 1M1519.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-5, p 100.

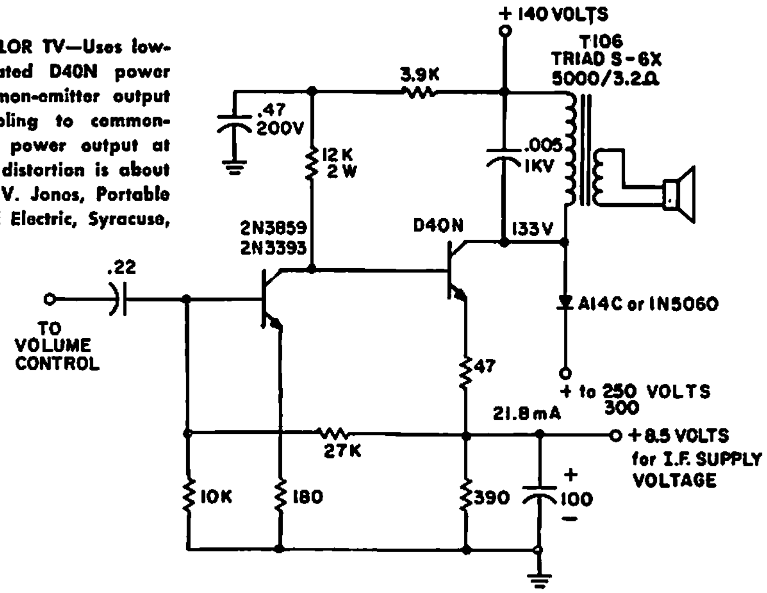

R5
10kΩ
+30V
R1
50kΩ
C2
16μF
40V
R2
120kΩ
R10
82Ω
R11
82Ω
TR4
BD131
C7
160μF
25V
R13
0·5Ω
R7
470Ω
C9
1250μF
25V
C1
25μF 25V
C4
10nF
TR1
BC158
R8
47Ω
R9
100Ω
TR2
BC148
or BC108
C3
400μF
25V
R14
0·5Ω
R3
100kΩ
TR5
BD132
TR3
BD131
R12
10Ω
R15
10Ω
8Ω
R4
22Ω
R6
470Ω
C5
220nF
C6
1nF
C8
47nF

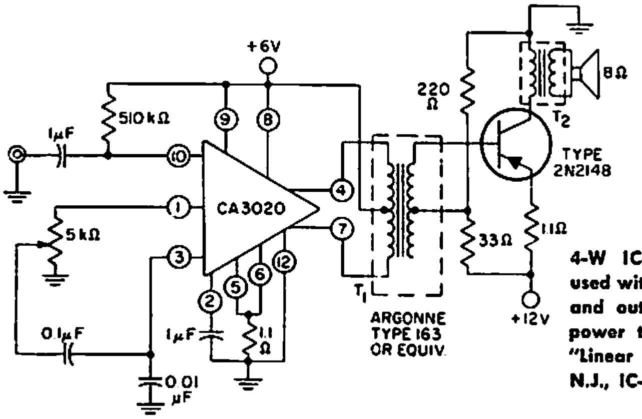
10-W HI-FI AMPLIFIER—Response is flat within 3 dB from 20 to 35,000 Hz for 2-W output. Distortion at rated output is less than 0.1%. Complementary pair of output transistors drives 8-ohm speaker directly. Book gives recommendations for layout of components to ensure high quality without hum.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 102.


R3
R5
R10
−
9-VOLT
+
C1
R1
C2
Q2
R8
C5
+
Q1
Q3
+
C4
SPKR1
SPKR2
R2
R4
C3
R6
R7
R9
R11
A
B
S1
D
S2
C

TWO-STATION INTERCOM—Can provide communication over distance of 100 feet, using 9 to 12 V voltage source. Circuit draws power only when message is being sent, thereby increasing battery life. Article gives construction details. Both speakers are 45 ohms. Parts values are: R1 100K; R2, R5, R6 10K; R3, R7 2K; R4 51; R8 1.5K; R9 100; R10 56; R11 0.47; C1, C2 5 μF; C3 25 μF; C4, C5 10 μF; Q1 HEP253; Q2 HEP254; Q3 HEP230.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 45–50.

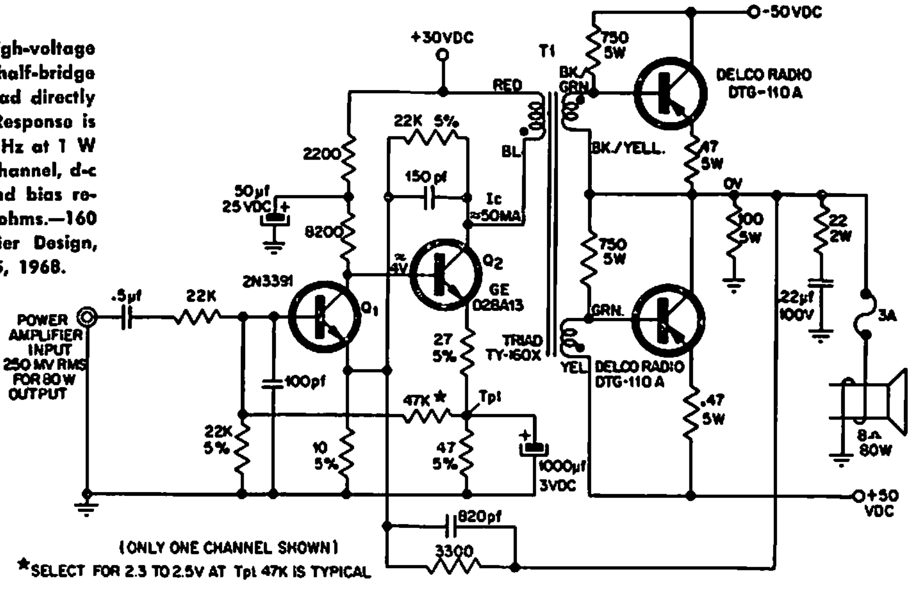
AUDIO FOR PORTABLE COLOR TV—Uses low-cost high-voltage glassivated D40N power transistor in class A common-emitter output stage having direct coupling to common-emitter driver. Maximum power output at 400 Hz is 2 W. At 1 W, distortion is about 10%.—E. L. Haas and D. V. Jones, Portable TV Sound System, General Electric, Syracuse, N.Y., No. 90.78, 1969.


+ 140 VOLTS
T106
TRIAD S-6X
5000/3.2Ω
3.9K
.47
200V
12K
2 W
.005
1KV
2N3859
2N3393
D40N
133V
.22
TO
VOLUME
CONTROL
A14C or 1N5060
47
+ to 250 VOLTS
300
21.8mA
+8.5 VOLTS
for I.F. SUPPLY
VOLTAGE
27K
10K
180
390
+
100
-


+6V
510kΩ
1μF
9
8
10
1
CA3020
4
7
5kΩ
3
2
5
6
12
0.1μF
1μF
1.1
Ω
0.01
μF
T1
ARGONNE
TYPE 163
OR EQUIV.
220
Ω
33Ω
8Ω
T2
TYPE
2N2148
11Ω
+12V

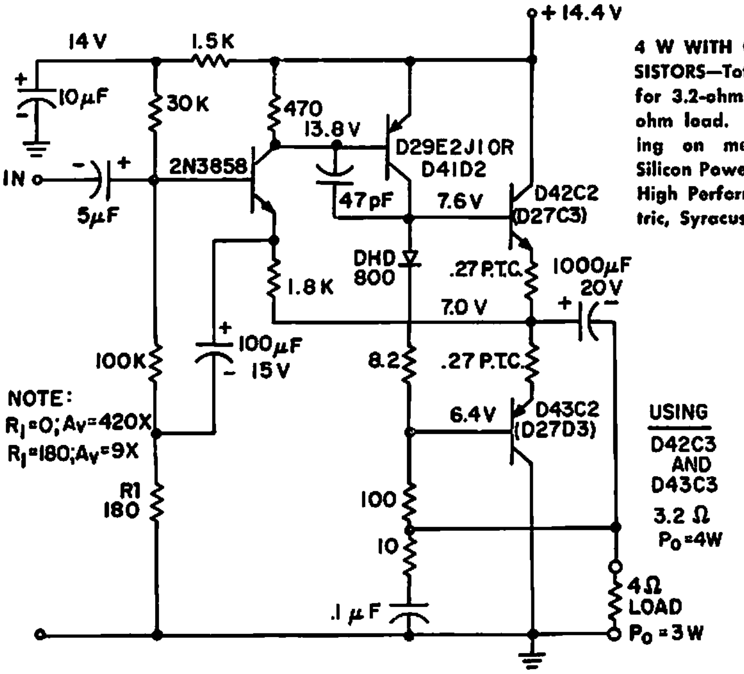
4-W IC-TRANSISTOR—Wideband IC is here used with driver transformer, power transistor, and output transformer to deliver full rated power to speaker for 18-mV audio input.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 274.

80-W POWER AMPLIFIER—Uses high-voltage high-power audio transistors in half-bridge push-pull output to drive 8-ohm load directly from balanced 50-V d-c supply. Response is flat within 1 dB from 20 to 20,000 Hz at 1 W and 20 W output. For 50 W per channel, d-c supply can be reduced to 35 V and bias resistor changed from 750 to 550 ohms.—160 Watt Stereo Audio Power Amplifier Design, Delco Radio, Kokomo, Ind., No. 35, 1968.

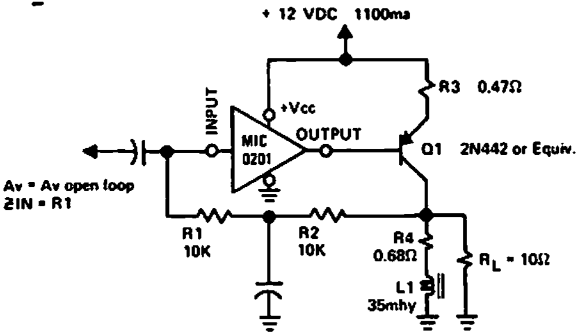

+30VDC
T1
-50VDC
750
5W
BK/
GRN
RED
DELCO RADIO
DTG-110A
22K 5%
BL
BK./YELL.
2200
150pf
Ic
≈50MA
.47
5W
0V
50μf
25VDC
+
8200
≈
4V
Q2
GE
028A13
100
5W
22
2W
750
5W
2N3391
Q1
.5μf
22K
POWER
AMPLIFIER
INPUT
250 MV RMS
FOR 80 W
OUTPUT
100pf
27
5%
TRIAD
TY-160X
GRN.
YEL
DELCO RADIO
DTG-110 A
22μf
100V
3A
47K ★
Tpl
.47
5W
22K
5%
10
5%
47
5%
+
1000μf
3VDC
8Ω
80W
+50
VDC
820pf
3300

(ONLY ONE CHANNEL SHOWN)

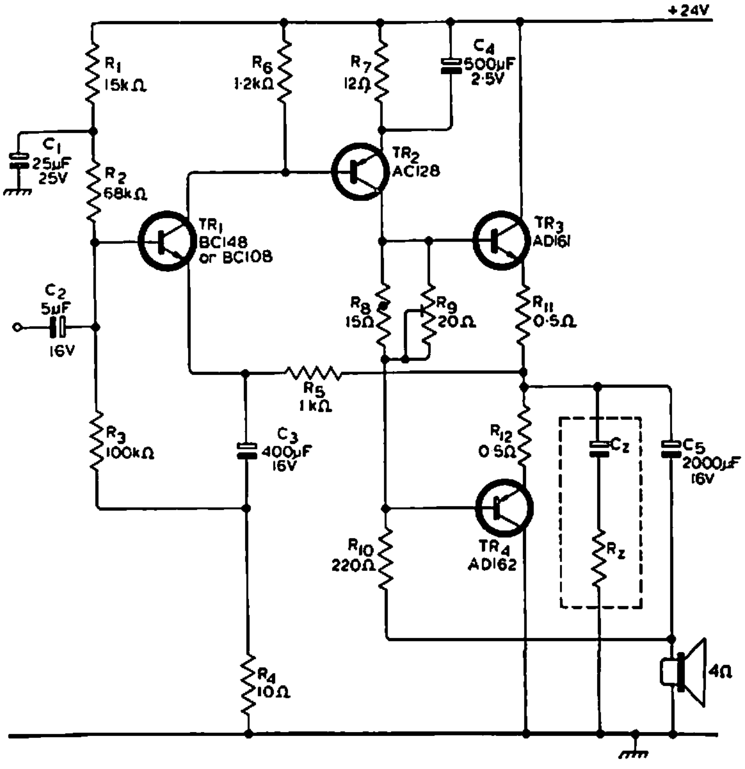
*SELECT FOR 2.3 TO 2.5V AT Tpl 47K IS TYPICAL


+14.4V
14V
1.5K
+
10µF
30K
470
13.8V
D29E2J10R
D41D2
IN
5µF
2N3858
47pF
7.6V
D42C2
(D27C3)
DHD
800
.27P.T.C.
1000µF
20V
1.8K
7.0 V
100K
+
100µF
15V
8.2
.27P.T.C.
NOTE:
R1=0;Av=420X
R1=180;Av=9X
6.4V
D43C2
(D27D3)
USING
D42C3
AND
D43C3
3.2 Ω
Po=4W
R1
180
100
10
.1 µF
4Ω
LOAD
Po=3W

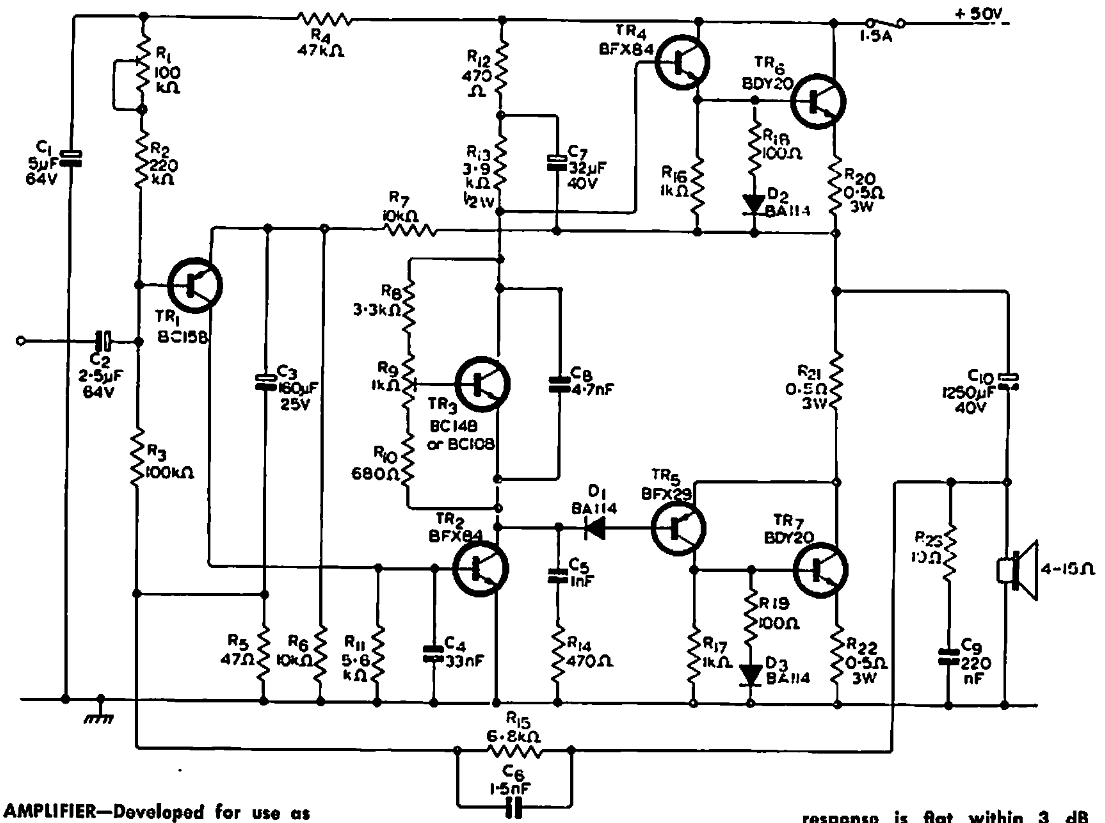
4 W WITH COMPLEMENTARY OUTPUT TRANSISTORS—Total harmonic distortion is 1.6% for 3.2-ohm load, and slightly higher for 4-ohm load. Driver transistor requires mounting on metal surface.—Dwight V. Jones, Silicon Power Transistor Amplifier Circuits with High Performance at Low Cost, General Electric, Syracuse, N.Y., No. 90.79, 1969.


+ 12 VDC 1100ma
R3 0.47Ω
INPUT
+Vcc
MIC
0201
OUTPUT
Q1 2N442 or Equiv.
Av = Av open loop
ZIN = R1
R1
10K
R2
10K
R4
0.68Ω
RL = 10Ω
L1
35mhy

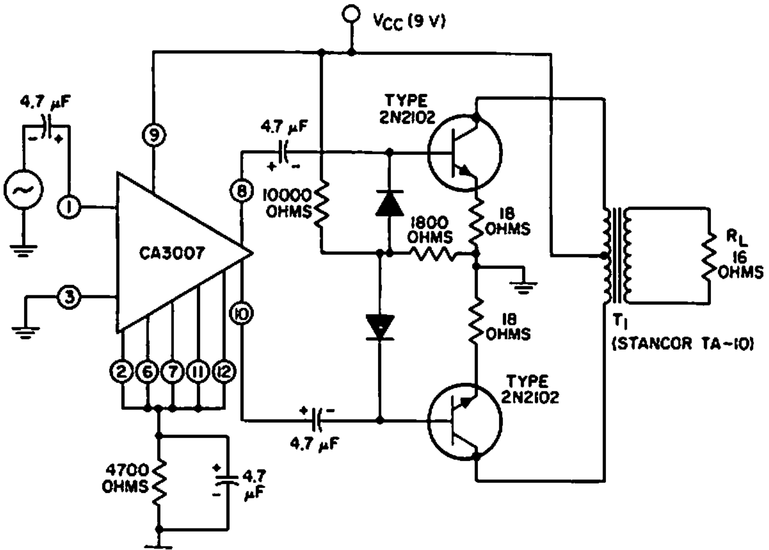
6-W IC WITHOUT A-C FEEDBACK—Provides high gain, with distortion still less than 10% at full power. Feeds 10-ohm speaker. Used in auto radios, tape players, and mobile power amplifiers. IC is Mallory MIC0201.—M. L. Deschler, Integrated Circuit Audio Driver Amplifier, Mallory, Indianapolis, Ind., APPN-1, 1968.


+24V
R1
15kΩ
R6
1·2kΩ
R7
12Ω
C4
500µF
2·5V
C1
25µF
25V
R2
68kΩ
TR2
AC128
TR1
BC148
or BC108
TR3
AD161
C2
5µF
16V
R8
15Ω
R9
20Ω
R11
0·5Ω
R5
1kΩ
R3
100kΩ
C3
400µF
16V
R12
0·5Ω
Cz
C5
2000µF
16V
TR4
AD162
R10
220Ω
Rz
R4
10Ω
4Ω

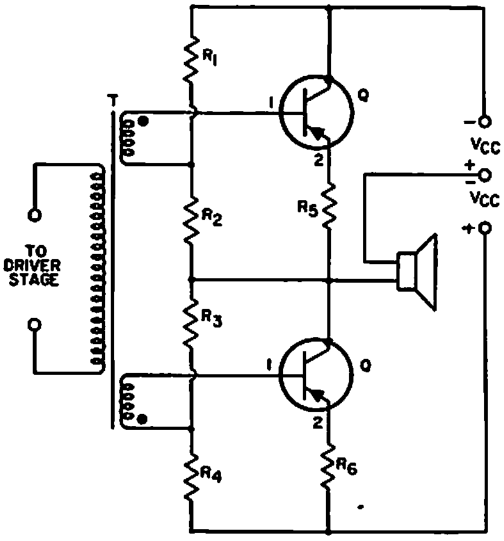
10-W AUDIO AMP WITH ZOBEL NETWORK—Output transistors are protected from energy stored in inductance of speaker by Zobel network RZ-CZ whose values are chosen to make speaker present purely resistive load to transistors. RZ should be equal to equivalent resistance of speakers, and CZ should be equal to speaker inductance divided by square of its resistance. For 4-ohm speaker with inductance of 200 µH, RZ should be 4 ohms and CZ 12.5 µF. Distortion is less than 3% and response is flat within 3 dB from 40 to 20,000 Hz.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 39.


+50V
1·5A
R4 47kΩ
R1 100 kΩ
R2 220 kΩ
C1 5μF 64V
C2 2·5μF 64V
TR1 BC158
R3 100kΩ
R12 470 Ω
R13 3·9 kΩ ½W
C7 32μF 40V
R7 10kΩ
R8 3·3kΩ
R9 1kΩ
TR3 BC148 or BC108
R10 680Ω
C3 160μF 25V
C8 4·7nF
TR2 BFX84
R5 47Ω
R6 10kΩ
R11 5·6 kΩ
C4 33nF
D1 BA114
C5 1nF
R14 470Ω
R15 6·8kΩ
C6 1·5nF
TR4 BFX84
TR6 BDY20
R16 1kΩ
R18 100Ω
D2 BA114
R20 0·5Ω 3W
R21 0·5Ω 3W
TR5 BFX29
TR7 BDY20
R17 1kΩ
R19 100Ω
D3 BA114
R22 0·5Ω 3W
C10 1250μF 40V
R23 10Ω
C9 220 nF
4-15Ω

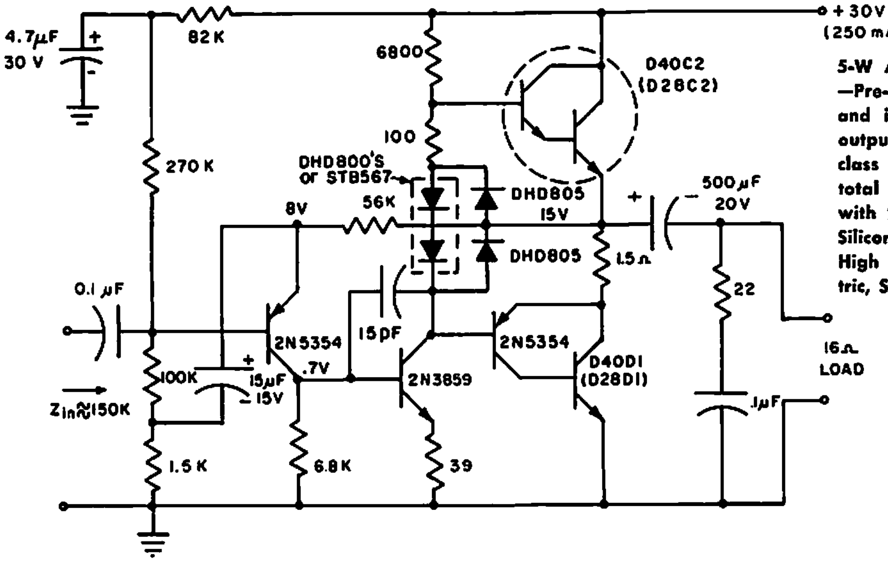
25-W HI-FI AMPLIFIER—Developed for use as one channel of stereo system. Matched output transistors are driven by matched complementary pair. Three diodes ensure that distortion in crossover region (at low output power) is very low. R1 is preset for symmetrical clipping in output stage. Frequency response is flat within 3 dB from 10 to 30,000 Hz, and distortion at full output is only 0.2%.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 106.


VCC (9 V)
4.7 μF
9
1
3
CA3007
8
10
2 6 7 11 12
4700 OHMS
4.7 μF
4.7 μF
10000 OHMS
1800 OHMS
4.7 μF
TYPE 2N2102
18 OHMS
18 OHMS
TYPE 2N2102
RL 16 OHMS
T1 (STANCOR TA-10)

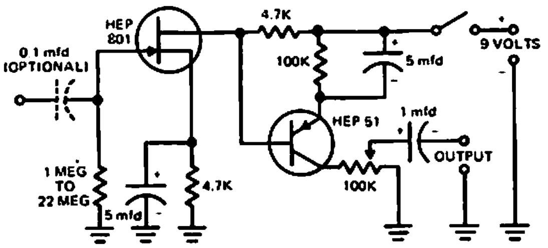
30-MW IC DRIVER—Audio input of 6.5 mV rms gives 30-mW audio output when IC a-f amplifier is used as single-supply audio driver in capacitor-coupled amplifier. Neither a-c nor d-c feedback loops are used.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 135.


T
R1
1
Q
2
R2
R5
TO DRIVER STAGE
R3
1
Q
2
R4
R6
−VCC
+VCC
+

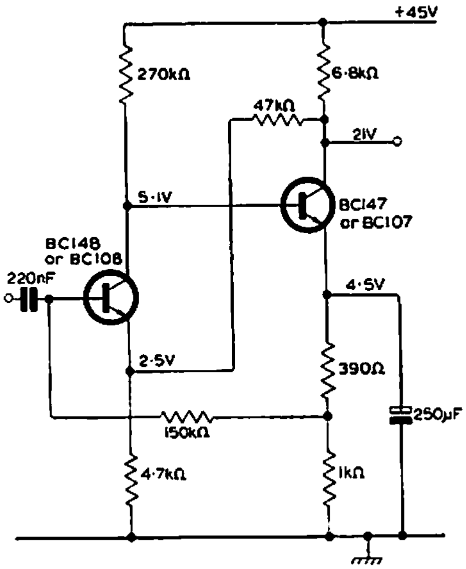
SINGLE-ENDED PUSH-PULL CLASS B—With 2N2147 power transistors, EIA music power output rating is 45 W and power gain 33 dB. Chief drawback is need for driver transformer. Values: R1, R3 330; R2, R4 3.9; R5, R6 0.27; Vcc 22 V.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 192.


4.7µF
30 V
82 K
6800
D40C2
(D28C2)
+30V
(250 mA)
100
270 K
DHD800'S
or STB567
DHD805
15V
8V
56K
500µF
20V
DHD805
1.5Ω
0.1µF
15pF
2N5354
2N5354
D40D1
(D28D1)
.7V
2N3859
22
16Ω
LOAD
100K
15µF
15V
Zin≈150K
.1µF
1.5 K
6.8 K
39

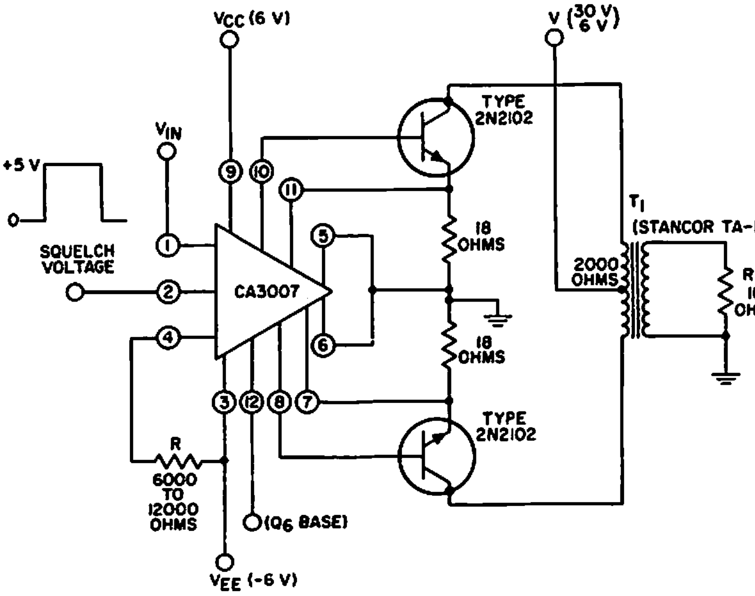
5-W AMPLIFIER WITH DARLINGTON OUTPUT—Pre-driver stage increases both sensitivity and input impedance. Power Darlington in output eliminates need for bootstrapping class A drive load resistor. At rated output, total harmonic distortion at 1 kHz is 1.5% with 280-mV input signal.—Dwight V. Jones, Silicon Power Transistor Amplifier Circuits with High Performance at Low Cost, General Electric, Syracuse, N.Y., No. 90.79, 1969.


HEP
801
0.1 mfd
(OPTIONAL)
4.7K
100K
5 mfd
9 VOLTS
HEP 51
1 mfd
OUTPUT
100K
1 MEG
TO
22 MEG
5 mfd
4.7K

VERSATILE FET—Amplifies low-level audio signals over frequency range of 10 Hz to 30 kHz. Current drain is only 200 to 400 µA. Typical gain is 200 to 400. Has high input impedance and low output impedance.—"Tips on Using FET's," HMA-33, Motorola Semiconductor Products Inc., Phoenix, Ariz., 1969.

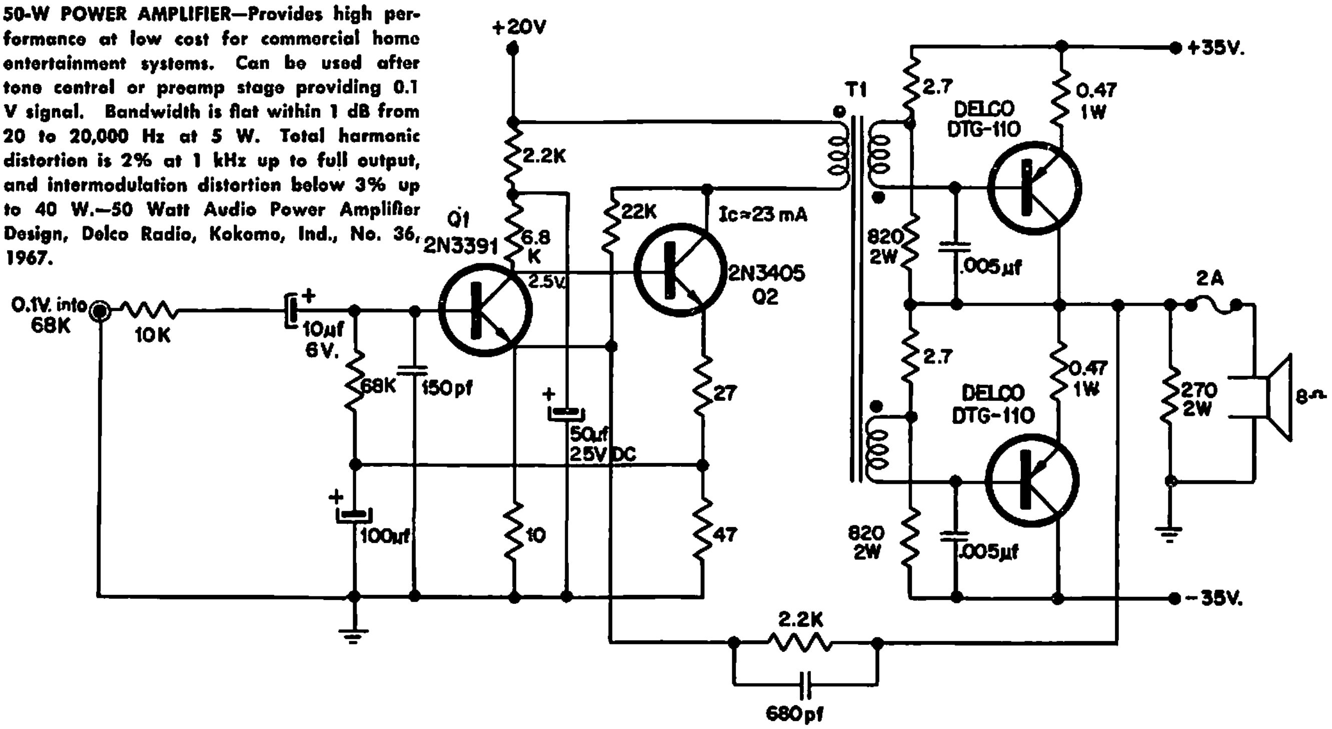

+45V
270kΩ
6·8kΩ
47kΩ
21V
5·1V
BC147
or BC107
BC148
or BC108
220nF
4·5V
2·5V
390Ω
250µF
150kΩ
4·7kΩ
1kΩ

AMPLIFIER WITH HIGH VOLTAGE OUTPUT—Voltage gain is 20 dB and maximum output voltage 10 V, with 45-V supply. Input impedance is 140K and output impedance is 200 ohms. Response is flat within 3 dB from 20 to 20,000 Hz.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 127.

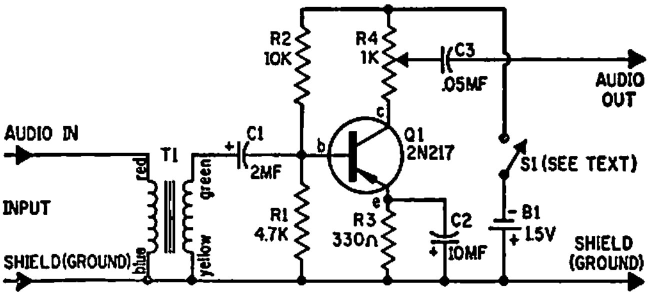

VCC (6 V)
V (30 V / 6 V)
TYPE
2N2102
VIN
+5 V
0
SQUELCH
VOLTAGE
9
10
11
1
2
4
5
6
3
12
8
7
CA3007
18
OHMS
18
OHMS
T1
(STANCOR TA-10)
2000
OHMS
RL
16
OHMS
R
6000
TO
12000
OHMS
(Q6 BASE)
VEE (-6 V)
TYPE
2N2102

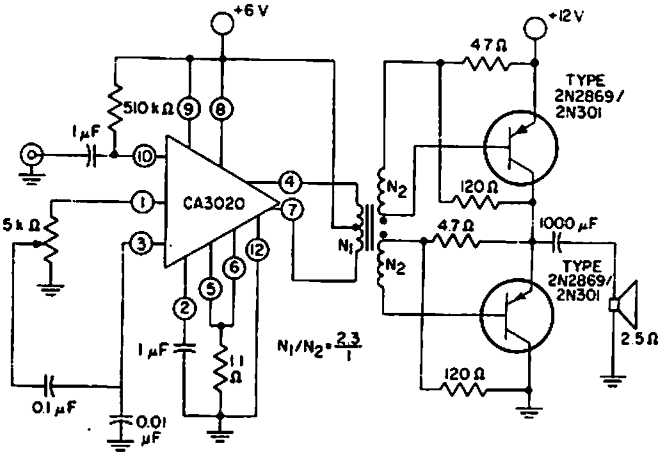
300-MW IC DRIVER—IC a-f amplifier is used as dual-supply audio driver in direct-coupled audio amplifier delivering 300 mW for audio input of 0.3 V rms with 30-V supply for output stage, and about 100 mW for 6-V supply. If audio squelch is not desired, terminal 2 must be grounded.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 133.

50-W POWER AMPLIFIER—Provides high performance at low cost for commercial home entertainment systems. Can be used after tone control or preamp stage providing 0.1 V signal. Bandwidth is flat within 1 dB from 20 to 20,000 Hz at 5 W. Total harmonic distortion is 2% at 1 kHz up to full output, and intermodulation distortion below 3% up to 40 W.—50 Watt Audio Power Amplifier Design, Delco Radio, Kokomo, Ind., No. 36, 1967.

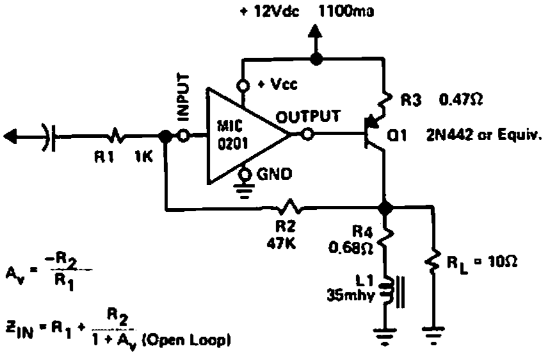

+20V
+35V.
T1
2.7
DELCO
DTG-110
0.47
1W
2.2K
22K
Ic≈23 mA
Q1
2N3391
6.8
K
2.5V
2N3405
Q2
820
2W
.005μf
2A
0.1V into
68K
10K
10μf
6V.
68K
150pf
50μf
25V DC
27
2.7
DELCO
DTG-110
0.47
1W
270
2W
8Ω
100μf
10
47
820
2W
.005μf
-35V.
2.2K
680pf

AUDIO BOOSTER—Single-transistor audio amplifier operating from 1.5-V alkaline cell can be mounted in base of desk-stand microphone for use as preamp, to give more modulation for any transmitter and less hum pickup even when using long microphone cable. T1 is miniature audio transformer having 100,000-ohm primary (for use with high-impedance mike) and 1,000-ohm secondary. For low-impedance mike, omit T1 and connect directly to C1. Book gives construction details.—E. A. Morris, Modulation Booster, "Bench-Tested Communications Projects," Hayden Book Co., N.Y., p 51–54.


R2
10K
R4
1K
C3
.05MF
AUDIO OUT
AUDIO IN
INPUT
T1
red
green
blue
yellow
C1
2MF
Q1
2N217
b
c
e
S1 (SEE TEXT)
R1
4.7K
R3
330Ω
C2
10MF
B1
1.5V
SHIELD(GROUND)
SHIELD (GROUND)


+6 V
+12V
510kΩ
9
8
1μF
10
CA3020
4
7
1
3
5kΩ
2
5
6
12
1μF
11 Ω
0.1μF
0.01 μF
N1/N2 = 2.3/1
47Ω
TYPE 2N2869/ 2N301
N2
N1
N2
120Ω
47Ω
1000μF
TYPE 2N2869/ 2N301
2.5Ω
120Ω

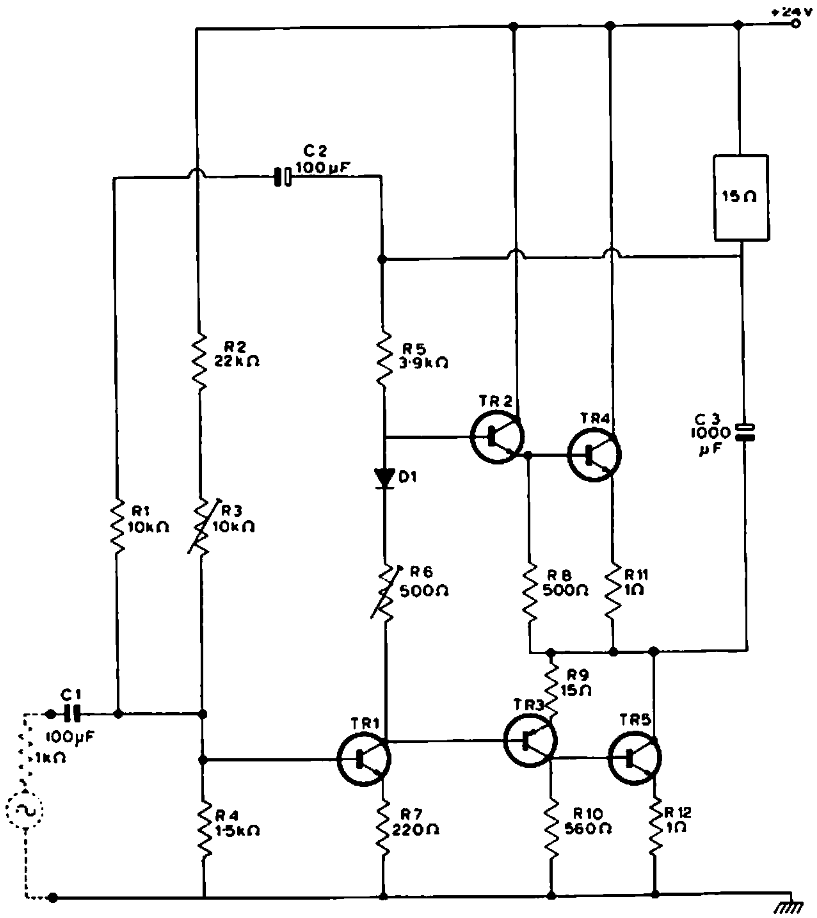
7-W SINGLE-ENDED CLASS B—Two power transistors in single-ended output stage drive 2.5-ohm speaker directly with full rated power for input of 14.2 mV to IC wideband amplifier.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 274.


+ 12Vdc 1100ma
+ Vcc
INPUT
MIC 0201
OUTPUT
GND
R1 1K
R3 0.47Ω
Q1 2N442 or Equiv.
R2 47K
R4 0.68Ω
L1 35mhy
R_L = 10Ω

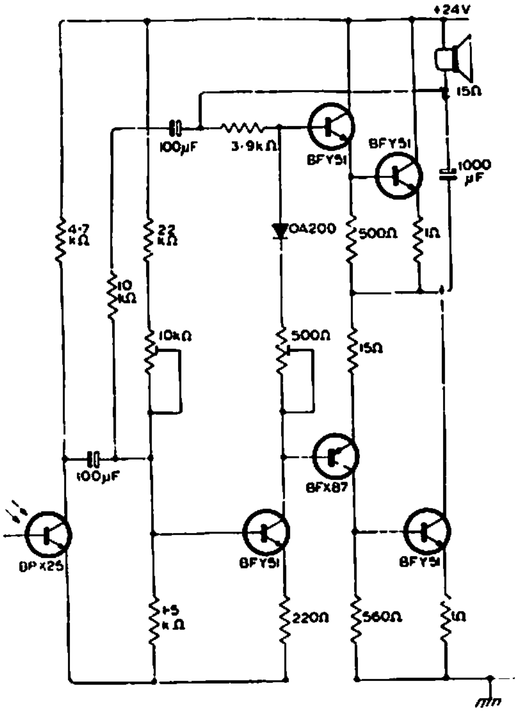
$$A_v = \frac{-R_2}{R_1}$$

$$Z_{IN} = R_1 + \frac{R_2}{1 + A_v} \text{ (Open Loop)}$$

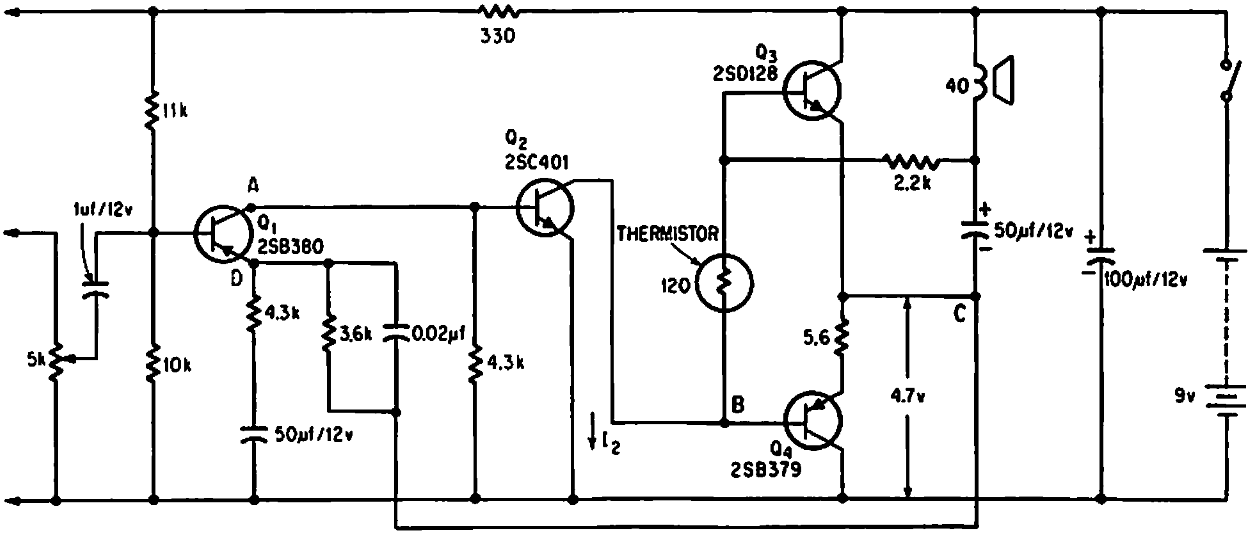
6-W IC WITH SHUNT A-C FEEDBACK—Uses Mallory MIC0201 audio driver IC with minimum number of external components. Distortion is less than 1% for outputs up to 3.5 W. Distortion increases to 10% for outputs above 6 W. Used in auto radios, tape players, and mobile power amplifiers.—M. L. Deschler, Integrated Circuit Audio Driver Amplifier, Mallory, Indianapolis, Ind., APPN-1, 1968.


+24V
C2
100μF
15Ω
R2
22kΩ
R5
3·9kΩ
TR2
TR4
C3
1000
μF
D1
R1
10kΩ
R3
10kΩ
R6
500Ω
R8
500Ω
R11
1Ω
R9
15Ω
C1
100μF
1kΩ
TR1
TR3
TR5
R4
1·5kΩ
R7
220Ω
R10
560Ω
R12
1Ω

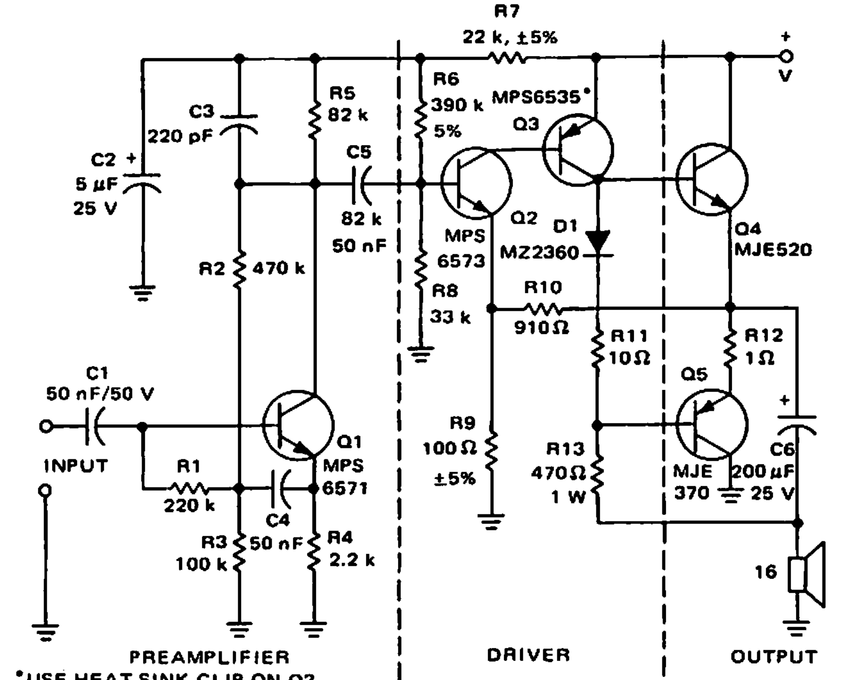
3-W UTILITY AMPLIFIER—Power gain is 38 dB, voltage gain 20 dB, and response is flat within 3 dB from 15 Hz to 50,000 Hz. Will drive loudspeaker directly. TR3 is BCY32 and other transistors are BFY51. Diode is OA200. —Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


+24V
15Ω
100μF
3·9kΩ
BFY51
BFY51
1000
μF
4·7
kΩ
22
kΩ
OA200
500Ω
1Ω
10
kΩ
10kΩ
500Ω
15Ω
100μF
BFX87
BPX25
BFY51
BFY51
1·5
kΩ
220Ω
560Ω
1Ω

OPTICAL SOUND HEAD—Will give output of 50 mW with optical modulation of only 50 lux from sound track on movie film. Maximum output is 3 W, and frequency response extends from 15 to 6,000 Hz at 100 lux. Required intensity through 0.08 × 0.01-inch slot, for bandwidth of 6 Hz and full output, can be obtained by focusing 1-W miniature lamp on slot.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.

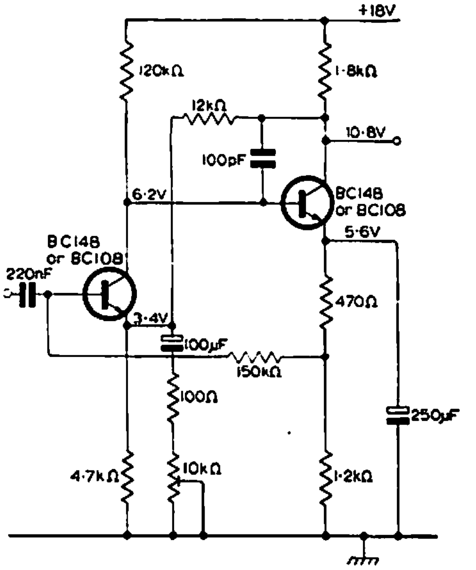

330
Q3
2SD128
40
11k
Q2
2SC401
2.2k
A
1uf/12v
Q1
2SB380
THERMISTOR
50μf/12v
D
120
100μf/12v
C
4.3k
3.6k
0.02μf
4.3k
5.6
5k
10k
B
4.7v
9v
I2
50μf/12v
Q4
2SB379

DIRECT-COUPLED OUTPUT—Direct coupling in Sony model 2R-27 a-m portable radio eliminates two coupling transformers and reduces no-signal battery drain to 5.5 mA, thus increasing battery life 30%. First two stages use complementary-symmetry cascade connection, while output stage is class B push-pull complementary symmetry. High stability is obtained by 100% d-c negative feedback from output stage through 3.6K resistor to Q1.—Ceramic Filters Edge Out Costly I-F Transformers, *Electronics*, Nov. 14, 1966, p 160–163.

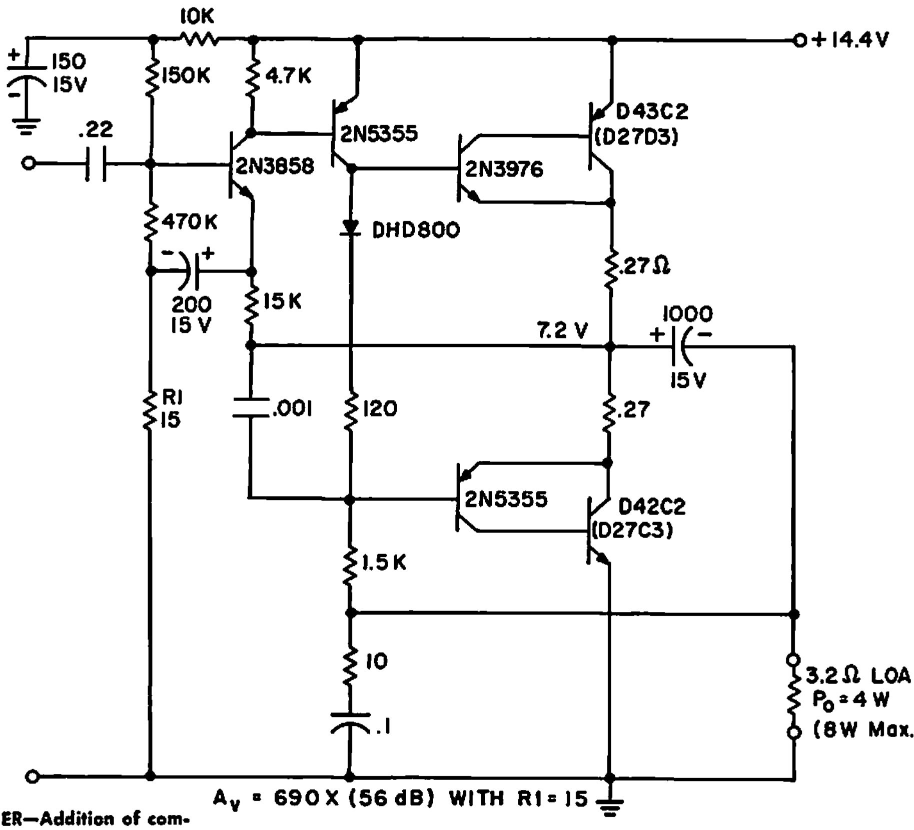

R7
22 k, ±5%
+
V
C3
220 pF
R5
82 k
R6
390 k
5%
MPS6535*
Q3
C2 +
5 µF
25 V
C5
82 k
50 nF
Q2
D1
MPS
6573
MZ2360
Q4
MJE520
R2
470 k
R8
33 k
R10
910 Ω
R11
10 Ω
R12
1 Ω
C1
50 nF/50 V
Q5
+
Q1
MPS
6571
INPUT
R1
220 k
C4
50 nF
R9
100 Ω
±5%
R13
470 Ω
1 W
MJE
370
C6
200 µF
25 V
R3
100 k
R4
2.2 k
16
PREAMPLIFIER
DRIVER
OUTPUT

*USE HEAT SINK CLIP ON Q3.

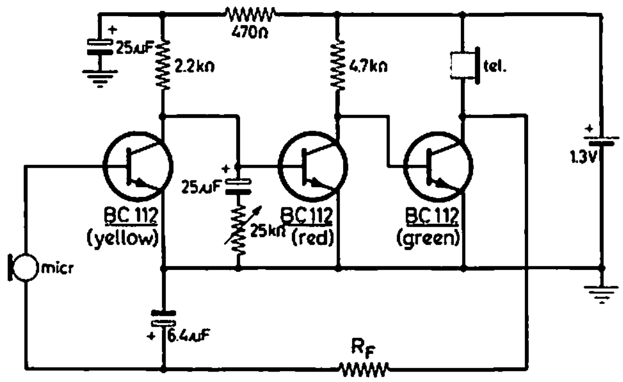
5 W FOR 16 OHMS—Simple and economical audio power amplifier delivers rated output for input of 0.1 V rms. Response is down 3 dB at 40 Hz and well above 20 kHz. Book gives changes needed for 10-W output.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–34.


+18V
120kΩ
1·8kΩ
12kΩ
10·8V
100pF
6·2V
BC148
or BC108
5·6V
BC148
or BC108
220nF
3·4V
100µF
150kΩ
470Ω
100Ω
250µF
4·7kΩ
10kΩ
1·2kΩ

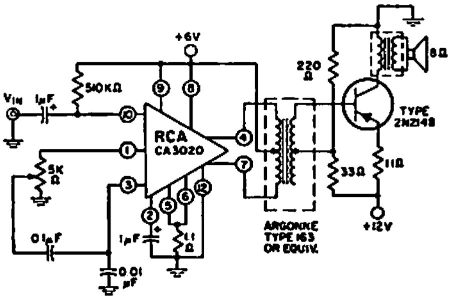
MICROPHONE AMPLIFIER—Voltage gain is adjustable between 13 and 40 dB by varying feedback with 10K pot. Distortion at maximum gain is 0.75% for 2-V output, input impedance is 120K, and output impedance is 120 ohms.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 124.


10K
+14.4V
+
150
15V
150K
4.7K
D43C2
(D27D3)
.22
2N5355
2N3858
2N3976
470K
DHD800
-
+
.27Ω
200
15 V
15K
1000
7.2 V
+
-
15V
R1
15
.001
120
.27
2N5355
D42C2
(D27C3)
1.5K
10
3.2 Ω LOAD
P_O = 4 W
(8W Max.)
.1
A_V = 690X (56 dB) WITH R1 = 15

4-W HIGH-GAIN AMPLIFIER—Addition of complementary push-pull drive stage to basic complementary output transistor arrangement permits class A drive stage to be operated at lower current and power dissipation. This gives higher voltage gain and permits use of lower-cost transistors. Added sensitivity reduces distortion. Total harmonic distortion at 1 kHz is 1.8% for 5.4-mV input signal.—Dwight V. Jones, Silicon Power Transistor Amplifier Circuits with High Performance at Low Cost, General Electric, Syracuse, N.Y., No. 90.79, 1969.

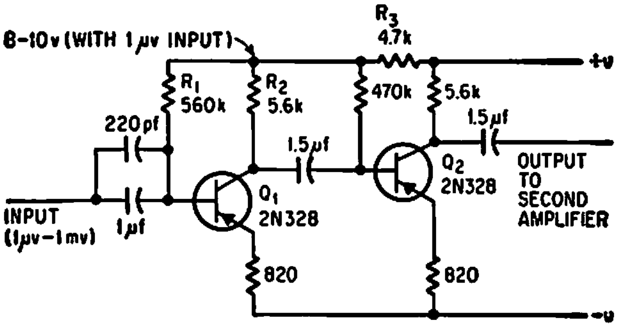

25µF
2.2kΩ
470Ω
4.7kΩ
tel.
1.3V
BC112
(yellow)
25µF
25kΩ
BC112
(red)
BC112
(green)
micr
6.4µF
R_F

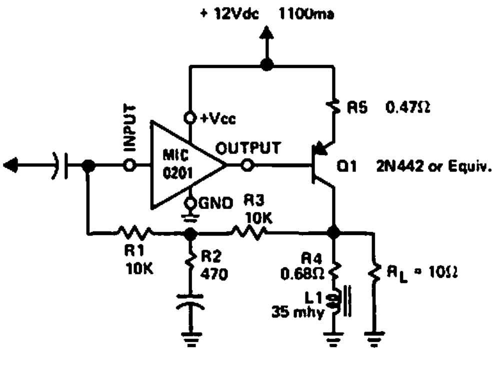
1-MW HEARING AID—Three-transistor circuit provides adequate power for conventional behind-the-ear hearing aid. Requires only 25K volume control, low enough to be reliable as miniature pot. Input can range from 100 µV to 5 mV. Value of RF depends on transistor currents; average value is 350K.—A. M. Aelbers and A. M. Peters, The Microminiature Transistor BC112 Employed in a Direct Coupled Hearing Aid Amplifier with 1 mW Output, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 135, 1966.


+6V
V_{IN}
1µF
510KΩ
9
8
10
1
3
2
5
6
12
4
7
RCA
CA3020
5K
Ω
0.1µF
1µF
1.1
Ω
0.01
µF
ARGONNE
TYPE 163
OR EQUIV.
220
Ω
8Ω
TYPE
2N2148
33Ω
11Ω
+12V

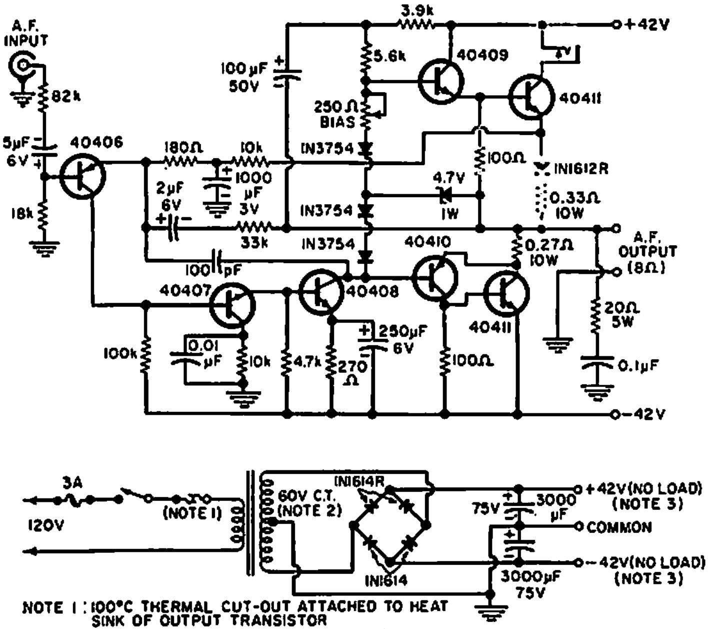
4-W CLASS-A AMPLIFIER WITH IC—Integrated circuit provides 58 dB power gain in driving transistor output stage through coupling transformer.—D. E. Lancaster, Audio Integrated Circuits—What's Available?, *Electronics World*, Oct. 1967, p 34–36.

SEISMIC AMPLIFIER—Can amplify faint echoes of distant explosive charge without being saturated by direct sound of underground explosion used in geophysical prospecting. Gain is about 25 for microvolt inputs, and decreases automatically as input increases to millivolt levels. Only first stage is shown; five stages give maximum overall gain of 1,000,000 and input dynamic range of 60 dB from 1-µV minimum signal. Third stage has manual level control that adjusts gain without affecting frequency response or dynamic range.—G. S. Lehsten, Audio Amplifier Adjusts Gain to Input Levels, *Electronics*, May 29, 1967, p 86–87.


8-10v (WITH 1µv INPUT)
R_3
4.7k
+v
R_1
560k
R_2
5.6k
470k
5.6k
220pf
1.5µf
1.5µf
Q_1
2N328
Q_2
2N328
OUTPUT
TO
SECOND
AMPLIFIER
INPUT
(1µv–1mv)
1µf
820
820
-v

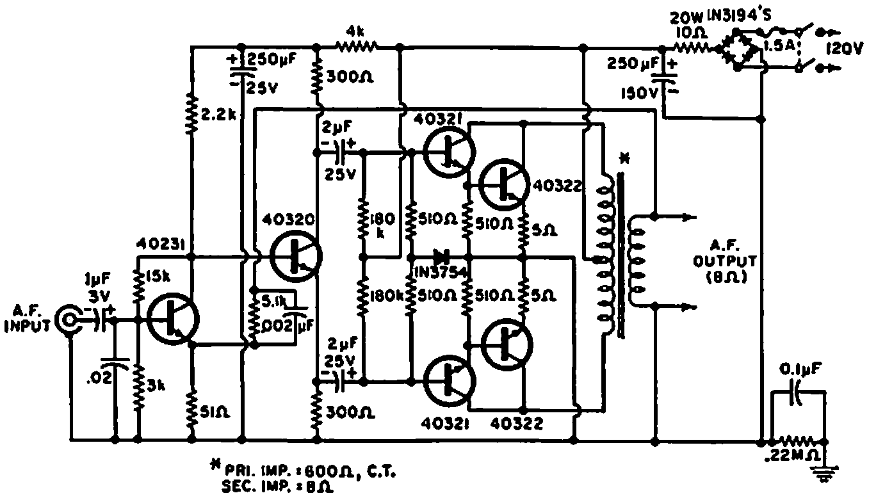

+ 12Vdc 1100ma
INPUT
+Vcc
MIC
0201
OUTPUT
GND
R5 0.47Ω
Q1 2N442 or Equiv.
R3
10K
R1
10K
R2
470
R4
0.68Ω
L1
35 mhy
R_L = 10Ω

6-W IC WITH SERIES-SHUNT A-C FEEDBACK—Input impedance is 1K but circuit retains high sensitivity (20 mV input for 2 W output) even with feedback from output transistor to Mallory MIC0201 IC input. Distortion is about 10% for 6 W but less than 5% up to 4.5 W. —M. L. Deschler, Integrated Circuit Audio Driver Amplifier, Mallory, Indianapolis, Ind., APPN-1, 1968.

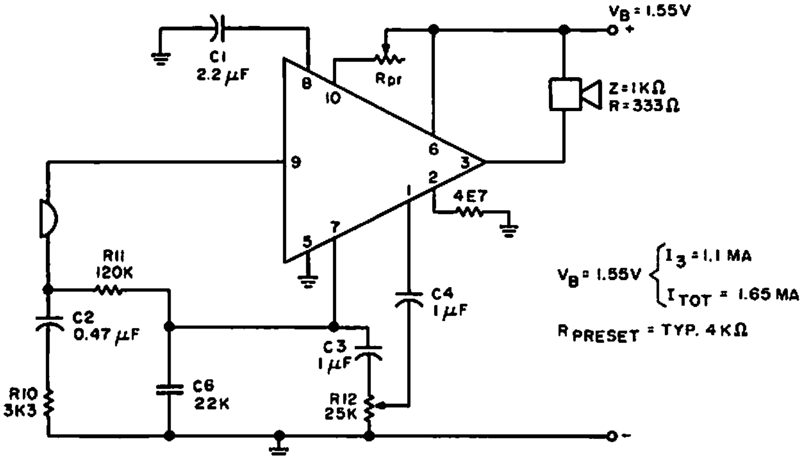

A.F.
INPUT
82k
5µF
6V
40406
18k
100µF
50V
180Ω
10k
2µF
6V
1000
µF
3V
33k
100pF
3.9k
+42V
5.6k
40409
40411
250Ω
BIAS
1N3754
1N3754
1N3754
100Ω
4.7V
1W
1N1612R
0.33Ω
10W
40410
0.27Ω
10W
A.F.
OUTPUT
(8Ω)
40407
40408
40411
0.01
µF
100k
10k
4.7k
270
Ω
250µF
6V
100Ω
20Ω
5W
0.1µF
-42V
3A
120V
(NOTE 1)
60V C.T.
(NOTE 2)
1N1614R
1N1614
75V
3000
µF
+42V(NO LOAD)
(NOTE 3)
COMMON
-42V(NO LOAD)
(NOTE 3)
3000µF
75V

NOTE 1: 100°C THERMAL CUT-OUT ATTACHED TO HEAT SINK OF OUTPUT TRANSISTOR
2: AT 1.5A D.C.; 62V C.T. FOR OPEN CIRCUIT
3: 39V AT FULL LOAD

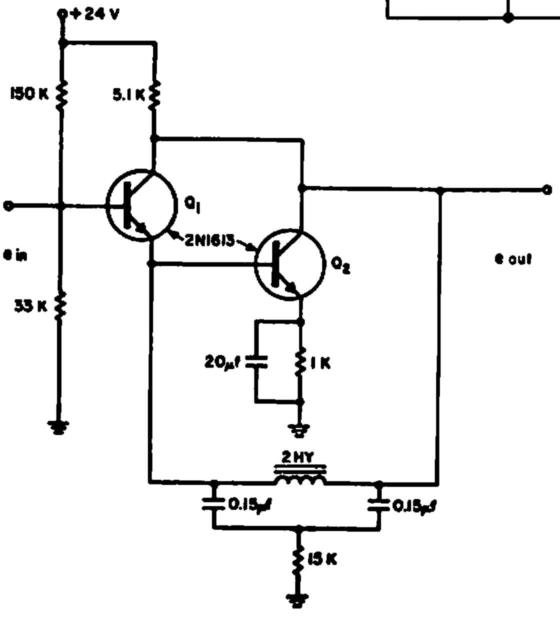
70-W HI-FI—Response is flat within 1 dB from 5 to 25,000 Hz. Diodes in driver stage are thermally connected to output transistor heat sinks, to maintain preset 20 mA of quiescent output current at case temperatures up to 100 C. Other circuit features contribute to stability and reliability.—R. D. Gold and J. C. Sondermeyer, Designing Silicon-Transistor Hi-Fi Amplifiers, *Electronics World*, Nov. 1966, p 47–50 and 80–81.


20W 1N3194'S
10Ω
1.5A
120V
4k
250μF
25V
300Ω
2.2k
250μF
150V
2μF
25V
40321
40322
40320
180k
510Ω
510Ω
5Ω
40231
1μF
3V
15k
A.F. INPUT
1N3754
180k
510Ω
510Ω
5Ω
5.1k
.002μF
A.F. OUTPUT (8Ω)
.02
3k
51Ω
2μF
25V
300Ω
40321
40322
0.1μF
.22MΩ
*PRI. IMP.: 600Ω, C.T.
SEC. IMP.: 8Ω

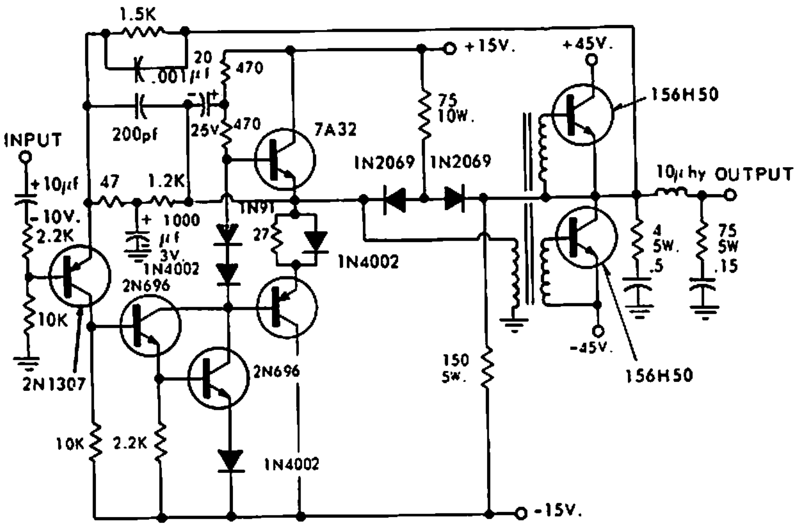
25-W PUBLIC ADDRESS—Transformer-coupled a-c/d-c class-AB audio amplifier provides output impedance flexibility. Drivers use Darlington arrangement to output transistors. Input impedance is 2,500 ohms. Response is flat within 3 dB from about 30 to 10,000 Hz.—R. D. Gold and J. S. Sondermeyer, Designing Silicon-Transistor Hi-Fi Amplifiers, *Electronics World*, Nov. 1966, p 47–50 and 80–81.


VB = 1.55V
+
C1
2.2μF
8
10
Rpr
Z = 1KΩ
R = 333Ω
9
6
3
2
1
4E7
5
7
R11
120K
C4
1μF
C2
0.47μF
C3
1μF
C6
22K
R10
3K3
R12
25K
VB = 1.55V
I3 = 1.1 MA
ITOT = 1.65 MA
RPRESET = TYP. 4KΩ
−

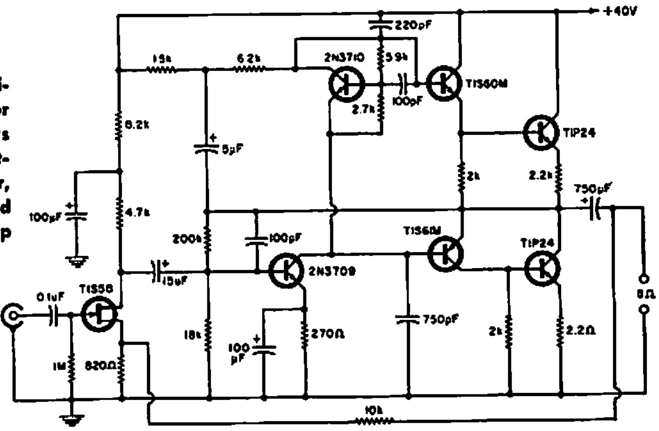
0.8-MW IC HEARING AID—Uses TAA370 IC driving 1,000-ohm earpiece. Total current drain is 1.65 mA from 1.55-V silver oxide cell. R10 is 3.3K. Report gives performance curves.—The Amperex TAA 370 as a Hearing Aid Amplifier, Amperex, Slatersville, R.I., S-139, 1968.


+24 V
150 K
5.1 K
Q1
2N1613
Q2
e in
e out
33 K
20μf
1 K
2 HY
0.15μf
0.15μf
15 K

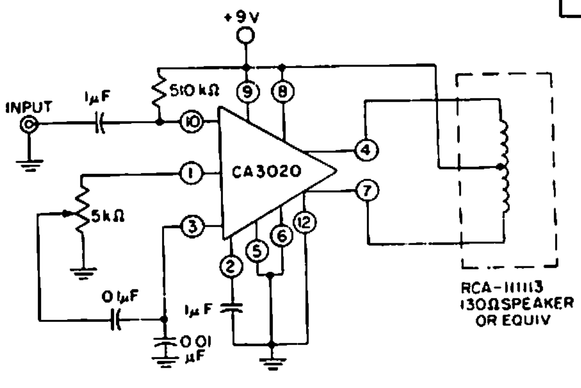
10-HZ BANDWIDTH AT 400 HZ—Darlington connection of Q1 and Q2 is combined with bridged-T network to give bandpass amplifier in audio range. Gain is over 30 dB.—P. Fung, Audio Frequency Amplifier Responds over 10-Cps Bandwidth, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 21–22.


1.5K
20
.001μf
470
200pf
25V
470
7A32
+15V.
+45V.
75
10W.
156H50
INPUT
+10μf
-10V.
2.2K
47
1.2K
+ 1000
μf
3V.
1N4002
2N696
1N91
27
1N2069
1N2069
10μhy OUTPUT
1N4002
4
5W.
.5
75
5W
.15
10K
2N1307
2N696
150
5W.
-45V.
156H50
10K
2.2K
1N4002
-15V.

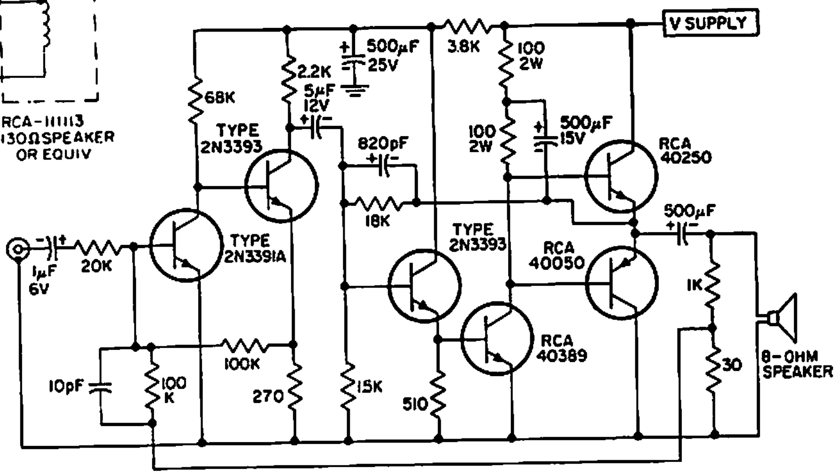
100 W PER CHANNEL—Intermodulation distortion is below 0.3% at any power level, and total harmonic distortion below 0.5% from 20 to 20,000 Hz. Latching diode circuit is used ahead of power stage to disconnect it from driver when instantaneous voltage across output terminals is greater than 15-V supply voltage of driver. Power stage efficiency is 78%.—"Silicon Power Transistor Handbook," Westinghouse, Youngwood, Pa., p 6–17.


+40V
220pF
15k
62k
2N3710
5.9k
TIS60M
100pF
2.7k
6.2k
5μF
TIP24
2k
2.2k
750pF
100μF
4.7k
200k
100pF
TIS60M
TIP24
15μF
2N3709
0.1μF
TIS58
8Ω
18k
100μF
270Ω
750pF
2k
2.2Ω
1M
820Ω
10k

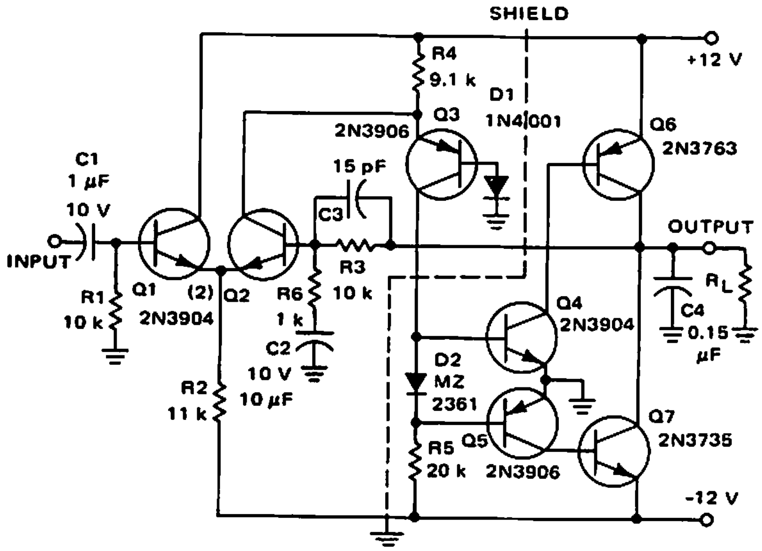
15-W QUASI-COMPLEMENTARY—Provides hi-fi performance for mono or in pairs for stereo, while requiring only npn transistors in output stage. Fet serves as high-input-impedance preamplifier.—D. E. Lancaster, Plastic Power Transistors—Advantages and Applications, *Electronics World*, Feb. 1968, p 50–52.


+9V
INPUT
1μF
510kΩ
⑨
⑧
⑩
①
CA3020
④
⑦
5kΩ
③
②
⑤
⑥
⑫
0.1μF
1μF
0.01
μF
RCA-11113
130Ω SPEAKER
OR EQUIV

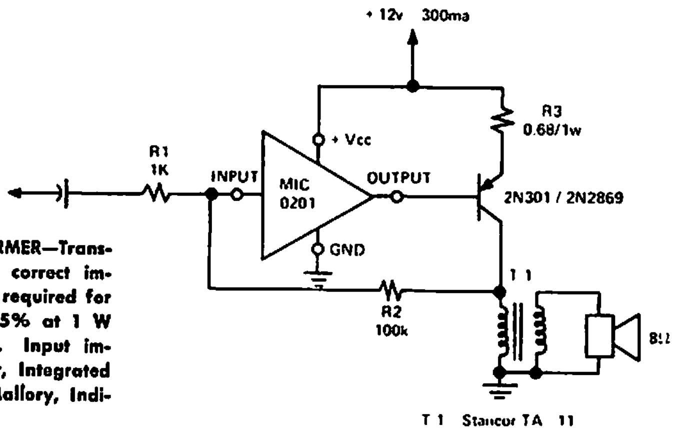
310-MW IC TRANSFORMERLESS—Can be used with most a-m and f-m detectors, because full power is developed for 45-mV input voltage. Total harmonic distortion is only 1%.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 272.


V SUPPLY
500μF
25V
3.8K
100
2W
2.2K
5μF
12V
68K
TYPE
2N3393
820pF
100
2W
500μF
15V
RCA
40250
18K
500μF
1μF
6V
20K
TYPE
2N3391A
TYPE
2N3393
RCA
40050
1K
RCA
40389
8-OHM
SPEAKER
10pF
100
K
100K
270
15K
510
30

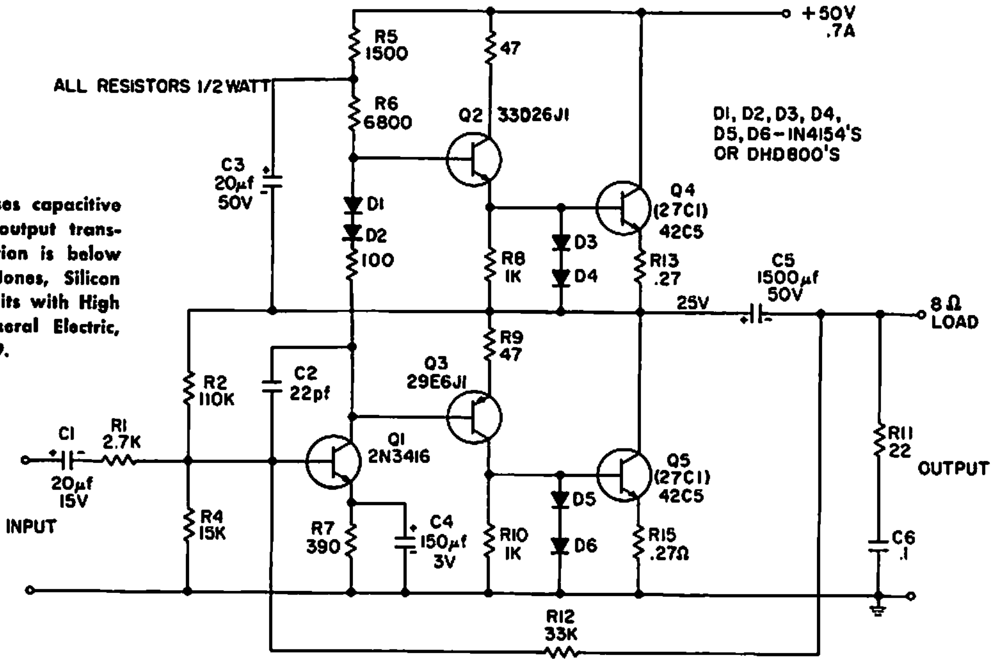
CLASS-B COMPLEMENTARY-SYMMETRY POWER AMPLIFIER—Book gives detailed design procedure for overcoming bias dissipation. Storage effects are reduced as result of reverse bias provided for OFF transistor by ON transistor in complementary symmetry.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 402.


SHIELD
+12 V
R4
9.1 k
D1
1N4001
Q3
2N3906
Q6
2N3763
C1
1 μF
10 V
15 pF
C3
OUTPUT
INPUT
R3
10 k
R1
10 k
Q1
2N3904
(2)
Q2
R6
1 k
R_L
C4
0.15 μF
Q4
2N3904
C2
10 V
10 μF
D2
MZ
2361
R2
11 k
R5
20 k
Q5
2N3906
Q7
2N3735
-12 V

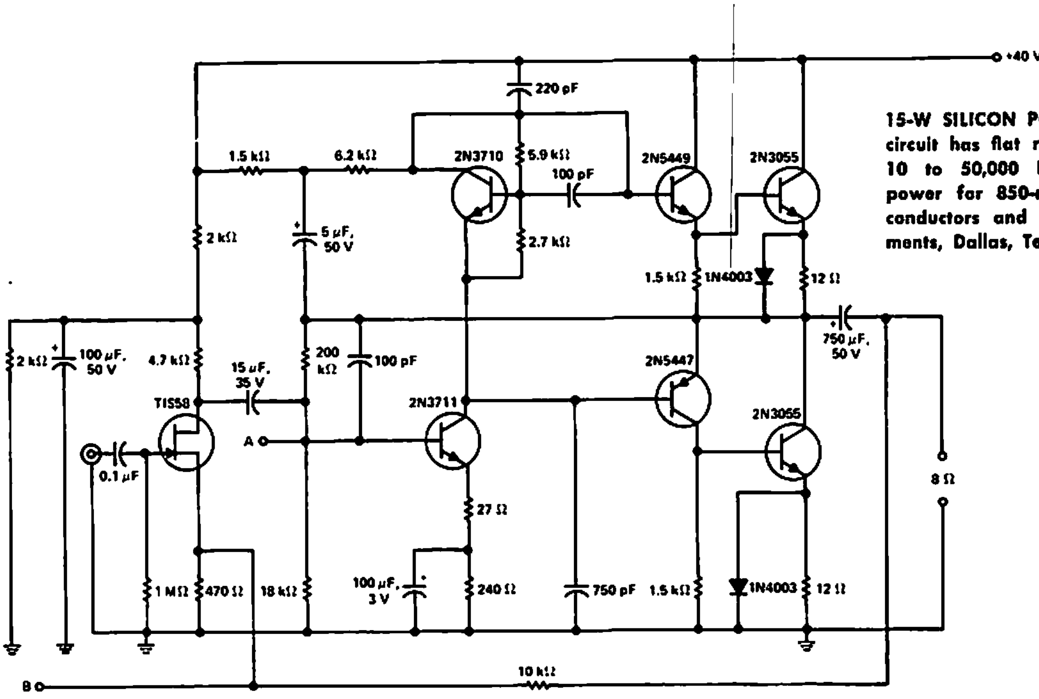
4-W WIDEBAND AMPLIFIER—Bandwidth is 100 kHz and minimum power output 2 W. Beta product of Q4-Q6 and Q5-Q7 complementary pairs should be matched to give low d-c offset at amplifier output and minimize distortion. At 4-W output, response is flat within — 1 dB from 45 Hz to 100 kHz. Distortion limits are more than adequate for hi-fi applications. Can be used as d-c amplifier with excellent stability if C1 and C2 are shorted out.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–30.


+ 12v 300ma
R3
0.68/1w
+ Vcc
R1
1K
INPUT
MIC
0201
OUTPUT
2N301 / 2N2869
GND
T 1
R2
100k
8Ω
T 1 Stancor TA 11

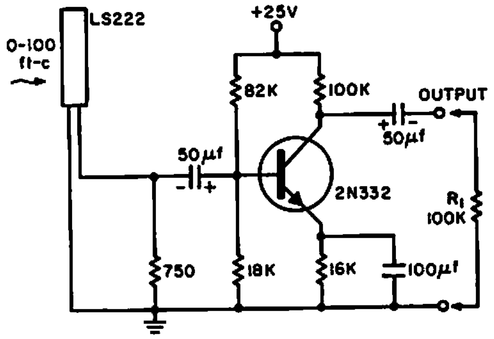
1-W IC WITH OUTPUT TRANSFORMER—Transformer was selected to provide correct impedance ratio and d-c resistance required for biasing. Harmonic distortion is 5% at 1 W and much less at lower output. Input impedance is 1.1K.—M. L. Deschler, Integrated Circuit Audio Driver Amplifier, Mallory, Indianapolis, Ind., APPN-1, 1968.


+50V
.7A
R5
1500
47
ALL RESISTORS 1/2 WATT
R6
6800
Q2
33026J1
D1, D2, D3, D4,
D5, D6–1N4154'S
OR DHD800'S
C3
20μf
50V
D1
D2
100
Q4
(27C1)
42C5
D3
D4
R8
1K
R13
.27
C5
1500μf
50V
25V
8 Ω
LOAD
R9
47
Q3
29E6J1
R2
110K
C2
22pf
C1
R1
2.7K
Q1
2N3416
Q5
(27C1)
42C5
R11
22
OUTPUT
20μf
15V
INPUT
R4
15K
D5
R7
390
C4
150μf
3V
R10
1K
D6
R15
.27Ω
C6
.1
R12
33K

20-W PUSH-PULL CLASS AB—Uses capacitive coupling to load in place of output transformer. Intermodulation distortion is below 1.5% at 20 W.—Dwight V. Jones, Silicon Power Transistor Amplifier Circuits with High Performance at Low Cost, General Electric, Syracuse, N.Y., No. 90.79, 1969.

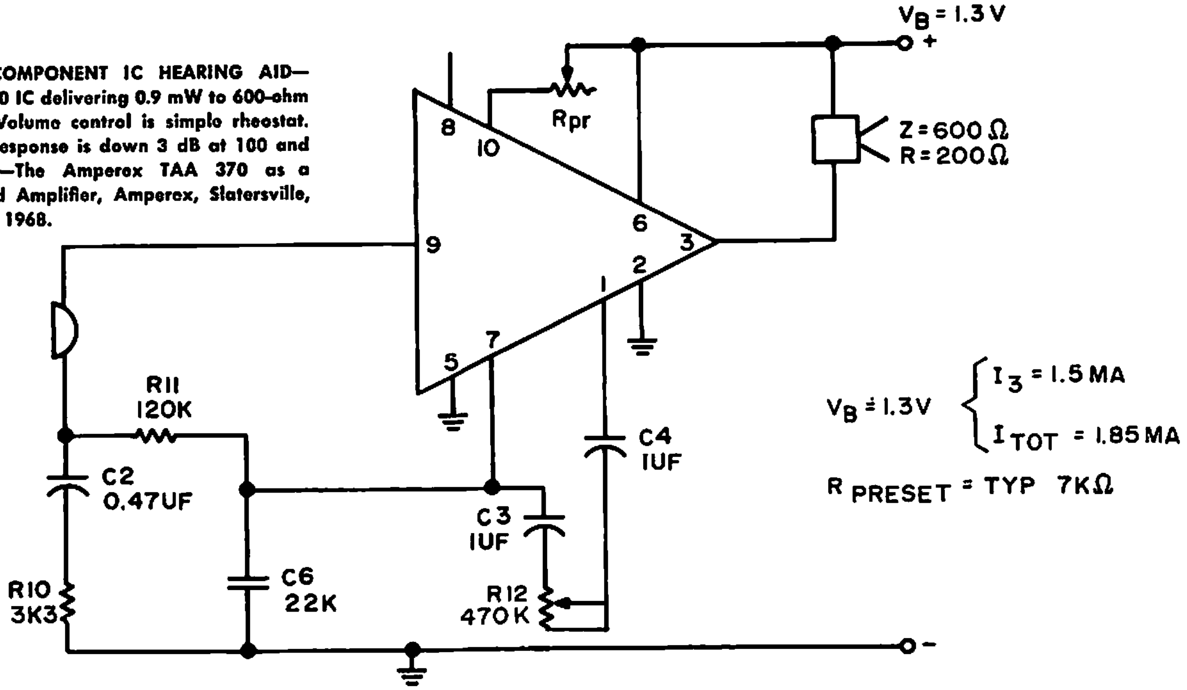

+40 V
220 pF
1.5 kΩ
6.2 kΩ
2N3710
5.9 kΩ
100 pF
2N5449
2N3055
2 kΩ
5 µF, 50 V
2.7 kΩ
1.5 kΩ
1N4003
12 Ω
2 kΩ
100 µF, 50 V
4.7 kΩ
15 µF, 35 V
200 kΩ
100 pF
2N5447
750 µF, 50 V
TIS58
2N3711
A
2N3055
0.1 µF
8 Ω
27 Ω
1 MΩ
470 Ω
18 kΩ
100 µF, 3 V
240 Ω
750 pF
1.5 kΩ
1N4003
12 Ω
B
10 kΩ

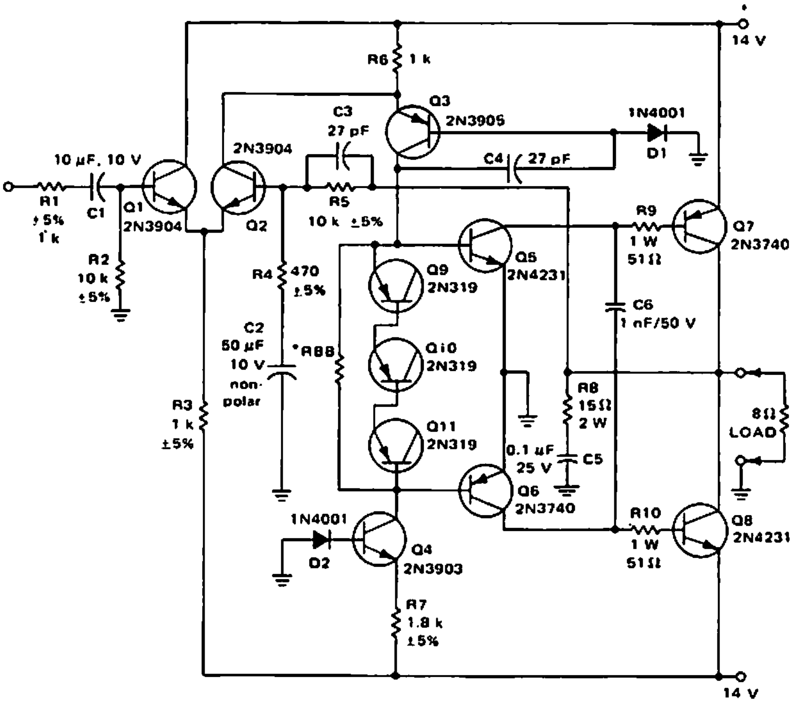
15-W SILICON POWER—Quasi-complementary circuit has flat response within 0.5 dB from 10 to 50,000 Hz. Provides rated output power for 850-mV input.—"Preferred Semiconductors and Components," Texas Instruments, Dallas, Texas, CC101, 1968, p 1702A.


LS222
0-100 ft-c
+25V
82K
100K
OUTPUT
50µf
50µf
2N332
R$_l$ 100K
750
18K
16K
100µf

SOUND-ON-FILM HEAD—Uses silicon photovoltaic sensor producing 26.7 µA output at 0 Hz and 21.3 µA at 20 kHz, boosted by preamp to 1.8 V p-p at 20 Hz and 1.2 V p-p at 10 kHz. Output is linear within 3 dB from — 40 to 75 C.—Light Sensor and Preamplifier, *Electronic Design*, Feb. 3, 1964, p 44.

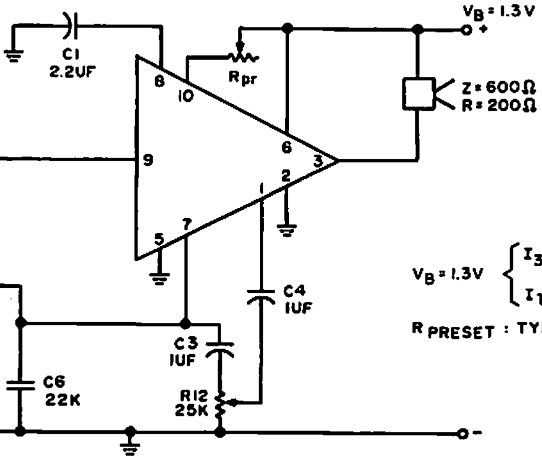
MINIMUM-COMPONENT IC HEARING AID—Uses TAA370 IC delivering 0.9 mW to 600-ohm earpiece. Volume control is simple rheostat. Frequency response is down 3 dB at 100 and 20,000 Hz.—The Amperex TAA 370 as a Hearing Aid Amplifier, Amperex, Slatersville, R.I., S-139, 1968.


V$_B$ = 1.3 V
+
Rpr
8
10
Z = 600 Ω
R = 200 Ω
6
3
9
2
1
7
5
R11
120K
C4
1UF
C2
0.47UF
C3
1UF
R10
3K3
C6
22K
R12
470 K
−
V$_B$ ≐ 1.3V
I$_3$ = 1.5 MA
I$_{TOT}$ = 1.85 MA
R$_{PRESET}$ = TYP 7KΩ


14 V
R6 1 k
Q3
2N3905
C3
27 pF
1N4001
D1
2N3904
C4 27 pF
10 μF, 10 V
R1
±5%
1 k
C1
Q1
2N3904
Q2
R5
10 k ±5%
R9
1 W
51 Ω
Q7
2N3740
Q5
2N4231
R2
10 k
±5%
R4 470
±5%
Q9
2N319
C6
1 nF/50 V
C2
50 μF
10 V
non-polar
*RBB
Q10
2N319
R3
1 k
±5%
R8
15 Ω
2 W
8 Ω
LOAD
Q11
2N319
0.1 μF
25 V
C5
Q6
2N3740
1N4001
D2
Q4
2N3903
R10
1 W
51 Ω
Q8
2N4231
R7
1.8 k
±5%
14 V

*RBB – AS REQUIRED TO GIVE 15-30 MILLIAMPS QUIESCENT CURRENT IN Q7 AND Q8.

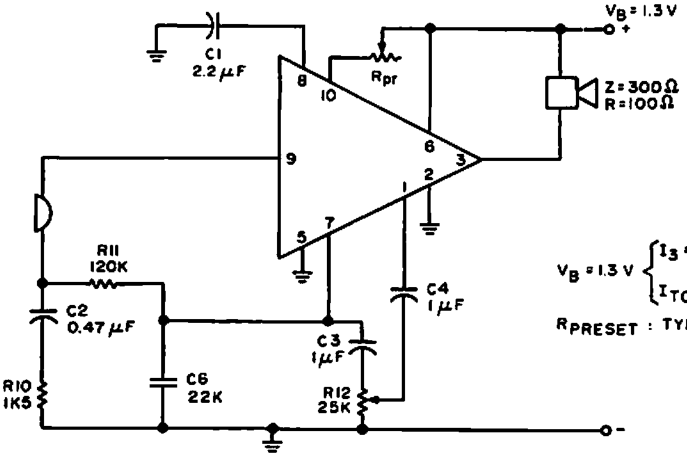
10 W FOR 8 OHMS—Direct-coupled class-B complementary-output amplifier has less than 1% distortion from 20 to 20,000 Hz, with response no more than 0.3 dB down over this frequency range at 1-W output level. Input impedance is about 10K.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–37.


$V_B = 1.3V$
+
C1
2.2UF
8
10
Rpr
Z = 600 Ω
R = 200 Ω
9
6
2
3
1
5
7
R11
120K
C2
0.47UF
C4
1UF
C3
1UF
R10
3K3
C6
22K
R12
25K
-

$V_B = 1.3V$ $\begin{cases} I_3 = 1.5MA \\ I_{TOT} = 1.85MA \end{cases}$

R_{PRESET} : TYP 7KΩ

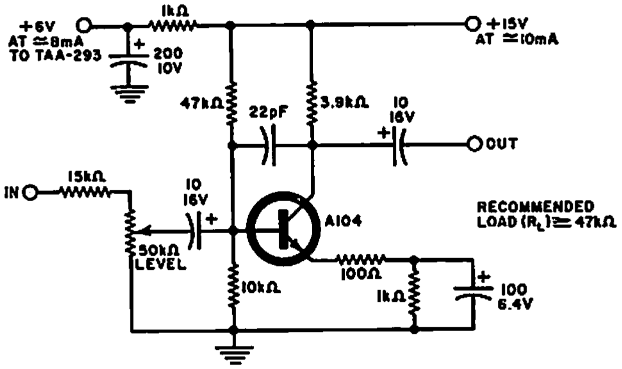
0.9-MW IC HEARING AID—Uses TAA370 IC driving 600-ohm earpiece. Frequency response is flat within 3 dB from 150 to 30,000 Hz. R10 is 3.3K.—The Amperex TAA 370 as a Hearing Aid Amplifier, Amperex, Slatersville, R.I., S-139, 1968.


$V_B = 1.3V$
+
C1
2.2μF
8
10
Rpr
Z = 300 Ω
R = 100 Ω
9
6
2
3
1
5
7
R11
120K
C2
0.47μF
C4
1μF
C3
1μF
R10
1K5
C6
22K
R12
25K
-

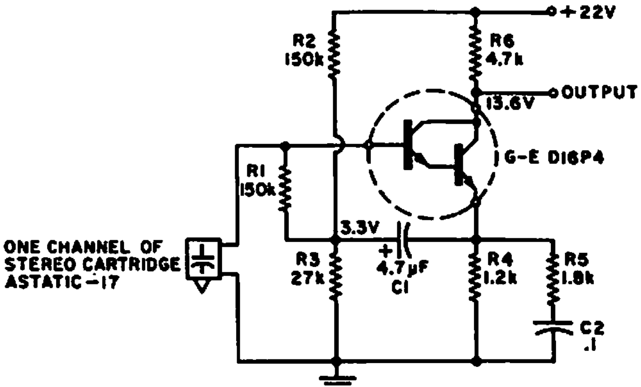
$V_B = 1.3 V$ $\begin{cases} I_3 = 2.5 MA \\ I_{TOT} = 2.85 MA \end{cases}$

R_{PRESET} : TYP 4KΩ

1.5-MW IC HEARING AID—Uses TAA370 IC driving 300-ohm earpiece. Total battery drain at 1.3 V is 2.85 mA. Volume control is conventional continuous type. Report includes graphs showing how performance varies with voltage and temperature.—The Amperex TAA 370 as a Hearing Aid Amplifier, Amperex, Slatersville, R.I., S-139, 1968.

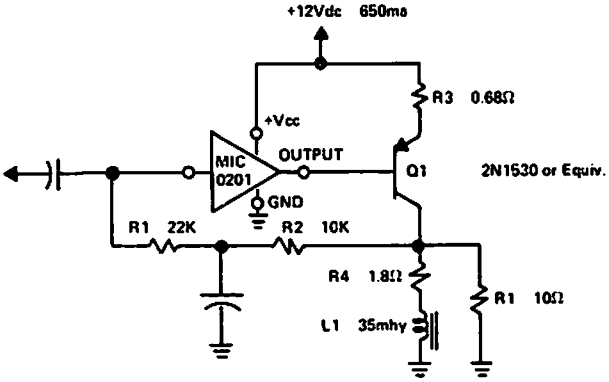

+6V
AT ≈8mA
TO TAA-293
1kΩ
+15V
AT ≈10mA
+ 200
10V
47kΩ
22pF
3.9kΩ
10
16V
OUT
IN
15kΩ
10
16V
A104
RECOMMENDED
LOAD (RL) ≥ 47kΩ
50kΩ
LEVEL
10kΩ
100Ω
1kΩ
100
6.4V

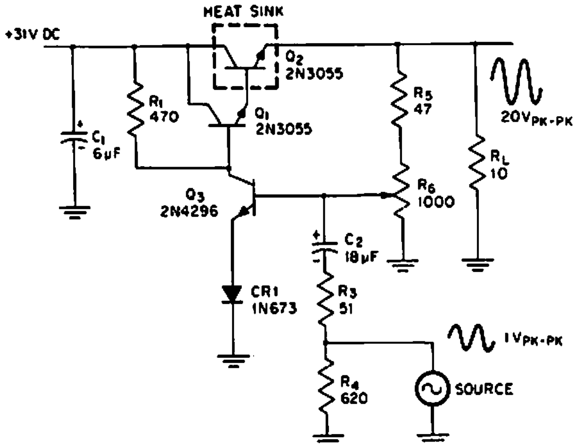
BOOSTER FOR PREAMP—Provides additional 18 dB of gain, or about 4 V output for input of 0.5 V from preamp. Amperex A104 transistor may be replaced by any silicon npn type with beta over 150.—D. R. Pryce, Integrated Circuit Equalized Preamplifier, *Electronics World*, July 1968, p 29 and 73.


+22V
R2
150k
R6
4.7k
OUTPUT
13.6V
G-E D16P4
R1
150k
3.3V
ONE CHANNEL OF
STEREO CARTRIDGE
ASTATIC-17
R3
27k
4.7μF
C1
R4
1.2k
R5
1.8k
C2
.1

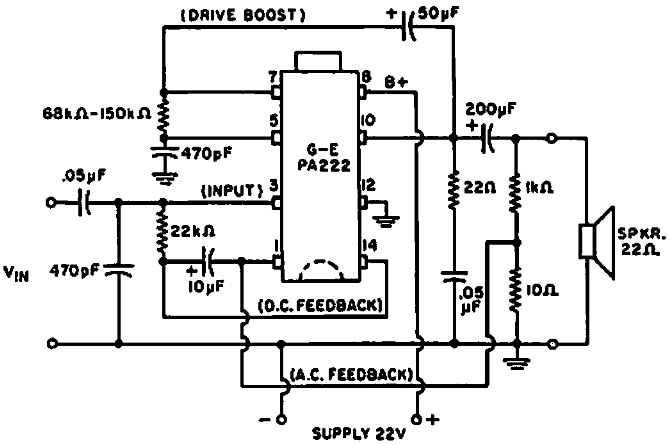
DARLINGTON IC AUDIO PREAMP—Response is flat within 2 dB from 40 to 12,000 Hz. High input impedance makes circuit ideal for ceramic cartridges or microphones. Output reference level is 1.9 V.—D. V. Jones, Audio-Frequency Integrated Circuits, *Electronics World*, July 1968, p 54–56.

4.5-W IC WITHOUT A-C FEEDBACK—Uses Mallory MIC0201 IC audio driver with output transistor. Input impedance goes up to 18K without a-c feedback, in tradeoff for reduced bandwidth of 30 to 10,000 Hz. Used in low-cost auto radios and tape players.—M. L. Deschler, Integrated Circuit Audio Driver Amplifier, Mallory, Indianapolis, Ind., APPN-1, 1968.

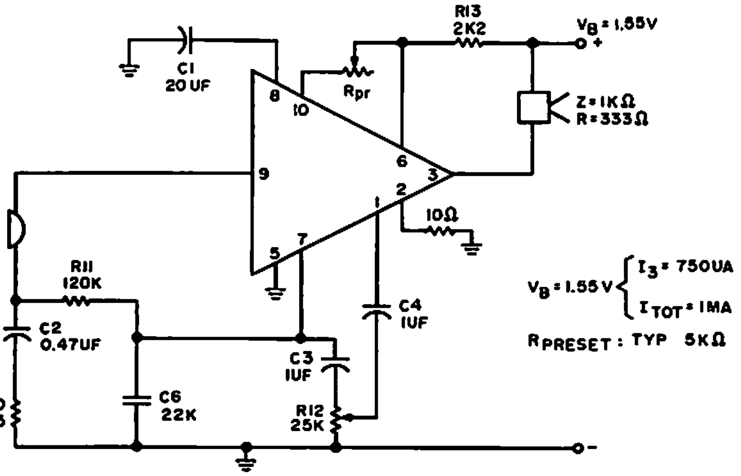

+12Vdc 650ma
R3 0.68Ω
+Vcc
MIC
0201
OUTPUT
Q1
2N1530 or Equiv.
GND
R1 22K
R2 10K
R4 1.8Ω
L1 35mhy
R1 10Ω


HEAT SINK
+31V DC
Q2
2N3055
R1
470
Q1
2N3055
R5
47
20VPK-PK
C1
6μF
RL
10
Q3
2N4296
R6
1000
C2
18μF
CR1
1N673
R3
51
1VPK-PK
R4
620
SOURCE

MODULATED SERIES REGULATOR—With C2, R3, R4, and 600-ohm source added, basic series regulator for d-c output of power supply becomes audio amplifier providing gain of 20, with cutoff at 20 kHz. Frequency response falls off below 1 kHz because of C2, but can be extended to d-c if C2 is shorted, R3 is made larger, and larger modulating voltage is used for base drive to Q3.—R. L. Starliper and R. D. Clement, Modulated DC Voltage Regulator, *EEE*, Feb. 1970, p 114.

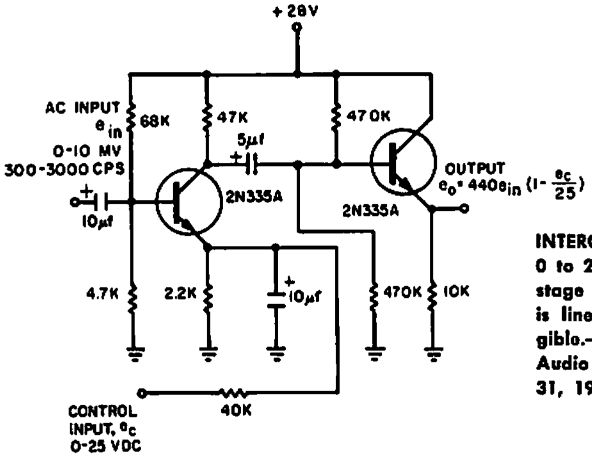

(DRIVE BOOST)
50μF
7
8
B+
68kΩ-150kΩ
5
10
200μF
470pF
G-E
PA222
.05μF
(INPUT) 3
12
22Ω
1kΩ
22kΩ
1
14
SPKR.
22Ω
VIN
470pF
10μF
(D.C. FEEDBACK)
.05
μF
10Ω
(A.C. FEEDBACK)
SUPPLY 22V

1-W IC OUTPUT—Delivers 1 W into 22-ohm load at 10% distortion, fom 55 to 15,000 Hz. Can deliver up to 2 W but with lower fidelity, provided external heatsinking is added to heatsink tab on IC. External components shown serve chiefly to prevent parasitic oscillation. Ideal for intercoms and other average-fidelity applications.—D. E. Lancaster, Audio Integrated Circuits—What's Available?, *Electronics World*, Oct. 1967, p 34–36.



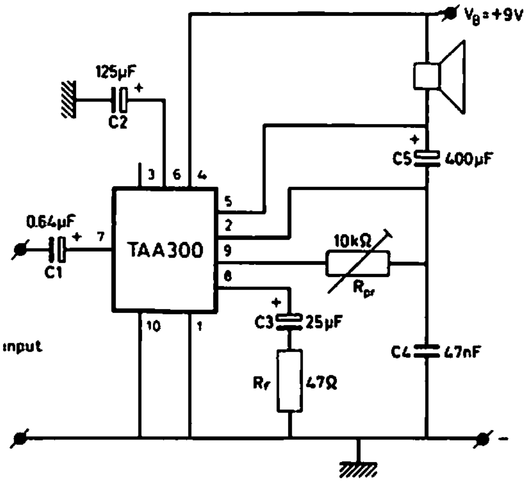
R13
2K2
V_B = 1.55V
+
C1
20 UF
8
10
Rpr
Z = 1KΩ
R = 333Ω
6
9
3
2
1
10Ω
5
7
R11
120K
C2
0.47UF
C4
1UF
C3
1UF
C6
22K
R10
1K5
R12
25K
−
V_B = 1.55V
I_3 = 750UA
I_{TOT} = 1MA
RPRESET : TYP 5KΩ

0.5-MW IC HEARING AID—Uses TAA370 IC driving 1,000-ohm earpiece, and circuit components giving frequency response that is down 3 dB at 200 and 8,000 Hz. R13 is 2.2K and R10 is 1.5K.—The Amperex TAA 370 as a Hearing Aid Amplifier, Amperex, Slatersville, R.I., S-139, 1968.



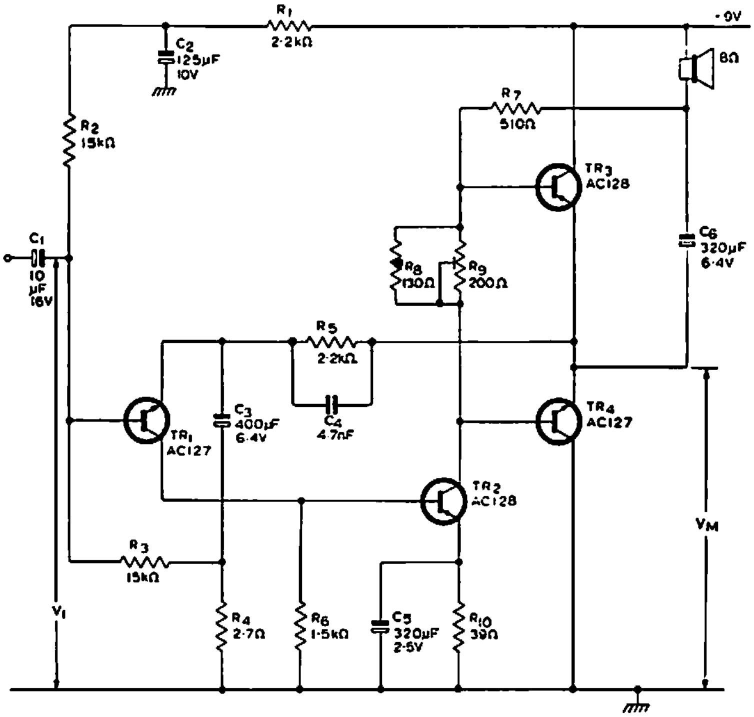
+28V
AC INPUT
e_{in}
0-10 MV
300-3000 CPS
10μf
68K
47K
5μf
470K
2N335A
2N335A
OUTPUT
$e_o = 440e_{in}(1-\frac{e_c}{25})$
4.7K
2.2K
10μf
470K
10K
CONTROL
INPUT, e_c
0-25 VDC
40K

INTERCOM REMOTE GAIN—Control signal of 0 to 25 V d-c changes voltage gain of two-stage audio amplifier from 440 to 0. Control is linear within 2% and distortion is negligible.—P. Cooper, External Signal Controls Audio Voltage Gain, *Electronic Design*, Aug. 31, 1964, p 48.



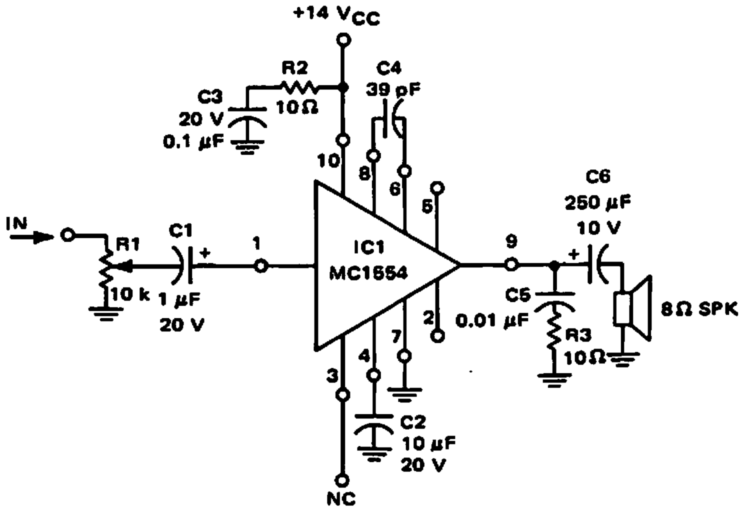
V_B = +9V
125μF
C2
3
6
4
5
2
9
6
10
1
C5
400μF
0.64μF
7
C1
TAA300
10kΩ
R_{pr}
C3
25μF
R_f
47Ω
C4
47nF
input
−

1-W IC AMPLIFIER—IC drives speaker directly, with minimum number of additional components. Input may be from ceramic phono pickup or from detector in portable radio. Total battery drain is 150 mA just before clipping, and 180 mA at full output with 10% distortion.—A. M. Peters, TAA300 Integrated 1 W Class B A. F. Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 136, 1969.

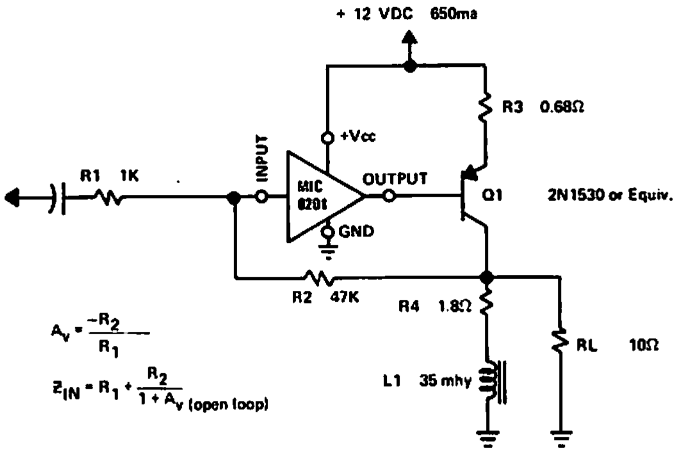


R_1
2·2kΩ
-9V
C_2
125μF
10V
8Ω
R_2
15kΩ
R_7
510Ω
TR_3
AC128
C_1
10μF
16V
R_8
130Ω
R_9
200Ω
C_6
320μF
6·4V
R_5
2·2kΩ
TR_1
AC127
C_3
400μF
6·4V
C_4
4·7nF
TR_4
AC127
TR_2
AC128
V_M
R_3
15kΩ
V_I
R_4
2·7Ω
R_6
1·5kΩ
C_5
320μF
2·5V
R_{10}
39Ω

1-W TRANSFORMERLESS AUDIO AMP—Frequency response is flat within 3 dB from 100 to 20,000 Hz. Has good d-c stability while using minimum number of components.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 35.


+14 VCC
R2
10Ω
C4
39 pF
C3
20 V
0.1 µF
10
8
6
5
C6
250 µF
10 V
IN
R1
10 k
C1
1 µF
20 V
1
IC1
MC1554
9
C5
0.01 µF
R3
10Ω
8Ω SPK
2
7
4
3
C2
10 µF
20 V
NC

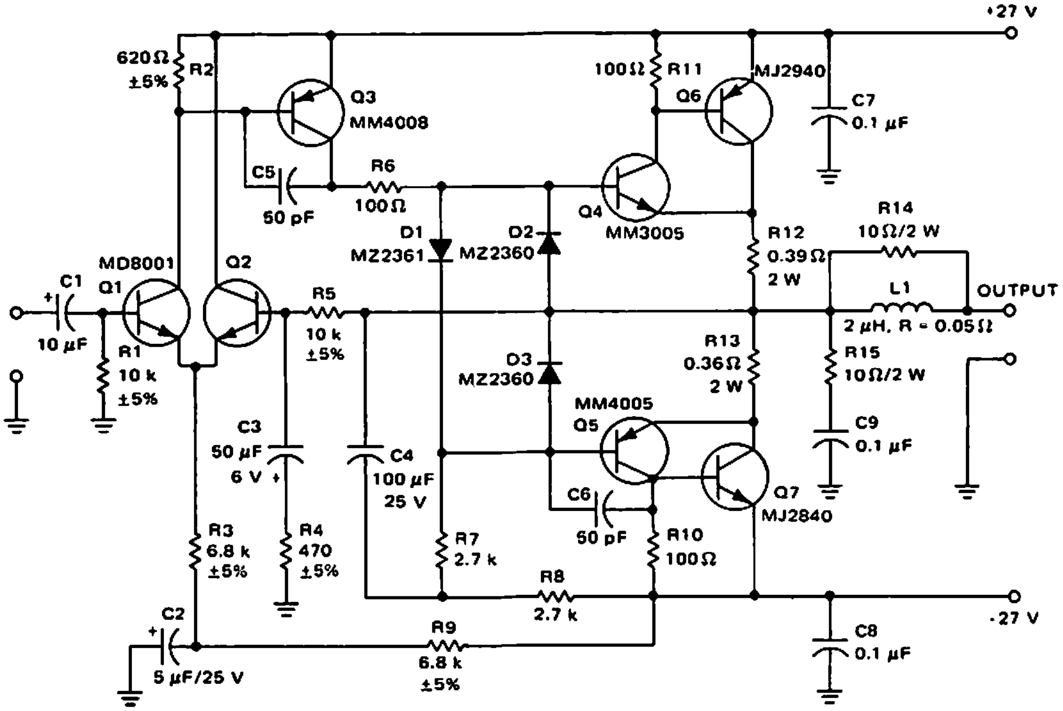
1-W IC AMPLIFIER—Will amplify signals up to 300 kHz. Total harmonic distortion from 20 to 20,000 Hz for 1 W into 16-ohm load, with voltage gain of 10, is typically 0.4%, and for 8-ohm speaker is 1% at 1,000 Hz.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–28.


+ 12 VDC 650ma
R3 0.68Ω
+Vcc
INPUT
R1 1K
MIC 0201
OUTPUT
GND
Q1
2N1530 or Equiv.
R2 47K
R4 1.8Ω
RL 10Ω
L1 35 mhy

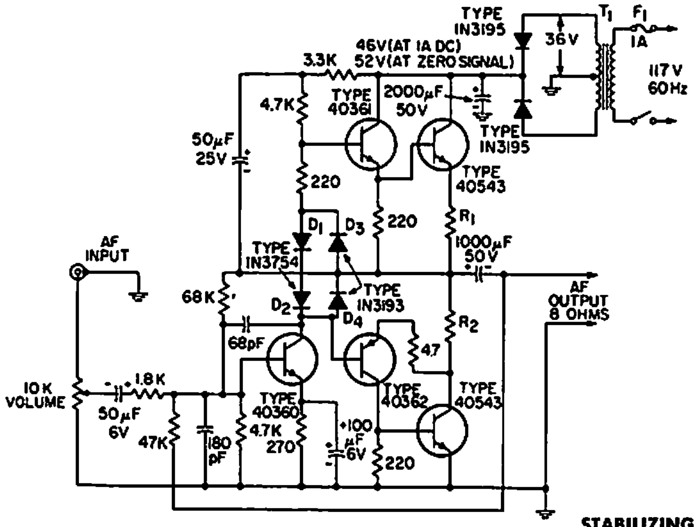
$$A_v = \frac{-R_2}{R_1}$$

$$Z_{IN} = R_1 + \frac{R_2}{1 + A_{v\,(\text{open loop})}}$$

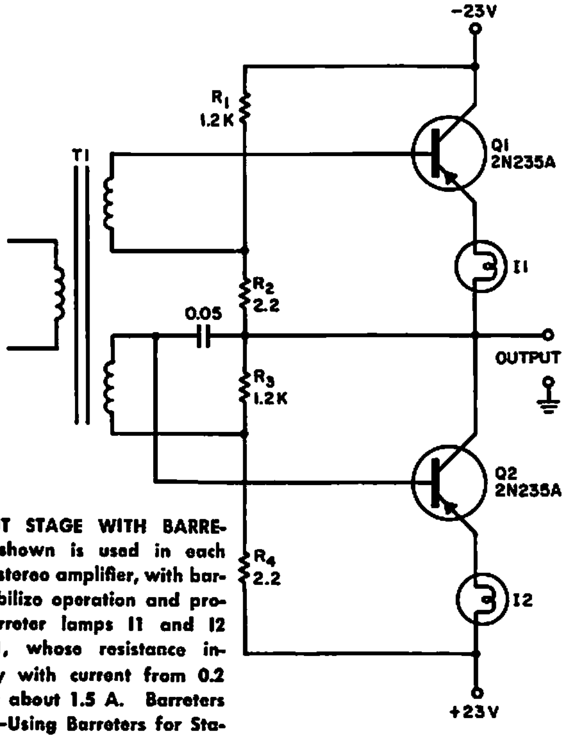
4.5-W IC WITH SHUNT FEEDBACK—Uses Mallory MIC0201 IC audio driver with power output transistor to deliver rated output at 10% distortion, for use in low-cost auto radios, tape players, and other mobile equipment. Response is 3 dB down from 30 to 20,000 Hz at 3 W output.—M. L. Deschler, Integrated Circuit Audio Driver Amplifier, Mallory, Indianapolis, Ind., APPN-1, 1968.


+27 V
620Ω ±5%
R2
Q3
MM4008
100Ω
R11
Q6
MJ2940
C7
0.1 µF
C5
50 pF
R6
100Ω
D1
MZ2361
D2
MZ2360
Q4
MM3005
R14
10Ω/2 W
R12
0.39Ω
2 W
MD8001
Q1
Q2
C1
10 µF
R5
10 k ±5%
L1
2 µH, R = 0.05Ω
OUTPUT
R1
10 k ±5%
D3
MZ2360
R13
0.36Ω
2 W
R15
10Ω/2 W
MM4005
Q5
C9
0.1 µF
C3
50 µF
6 V
C4
100 µF
25 V
Q7
MJ2840
C6
50 pF
R3
6.8 k ±5%
R4
470 ±5%
R7
2.7 k
R10
100Ω
R8
2.7 k
-27 V
C2
5 µF/25 V
R9
6.8 k ±5%
C8
0.1 µF

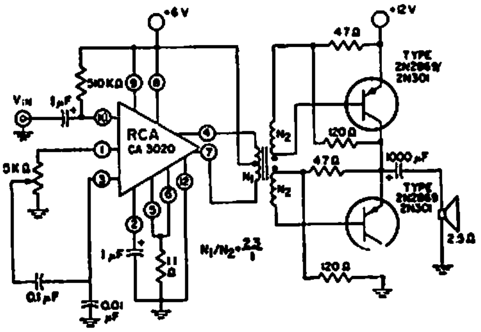
35 W FOR 8 OHMS—Has less than 0.1% total harmonic distortion and less than 0.2% intermodulation distortion at full power output, with 3-dB bandwidth of 10 Hz to 100 kHz. Book gives changes required in values to boost output to 60 W. Diodes provide load-fault protection.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–45.


TYPE 1N3195
46V(AT 1A DC)
52V(AT ZERO SIGNAL)
3.3K
T1
F1
1A
36V
117V 60Hz
2000µF 50V
TYPE 40361
TYPE 1N3195
TYPE 40543
4.7K
50µF 25V
220
220
R1
1000µF 50V
D1
D3
AF INPUT
TYPE 1N3754
TYPE 1N3193
D2
D4
AF OUTPUT 8 OHMS
68K
68pF
R2
47
10K VOLUME
1.8K
50µF 6V
47K
180 pF
TYPE 40360
4.7K
270
100 µF 6V
TYPE 40362
TYPE 40543
220

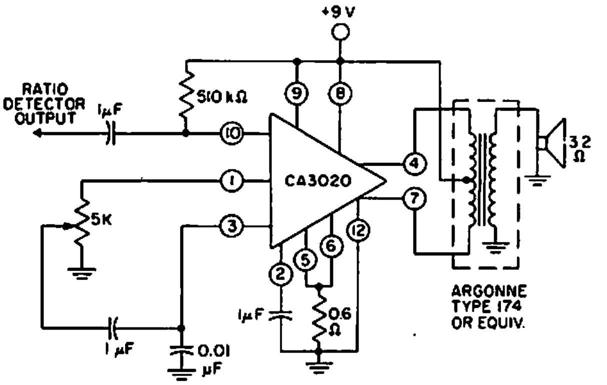
25-W AMPLIFIER WITH CURRENT LIMITING—Diode biasing network establishes fixed current limit on driver and output transistors of quasi-complementary amplifier.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 409.


-23V
R1 1.2K
T1
Q1 2N235A
I1
R2 2.2
0.05
OUTPUT
R3 1.2K
Q2 2N235A
R4 2.2
I2
+23V

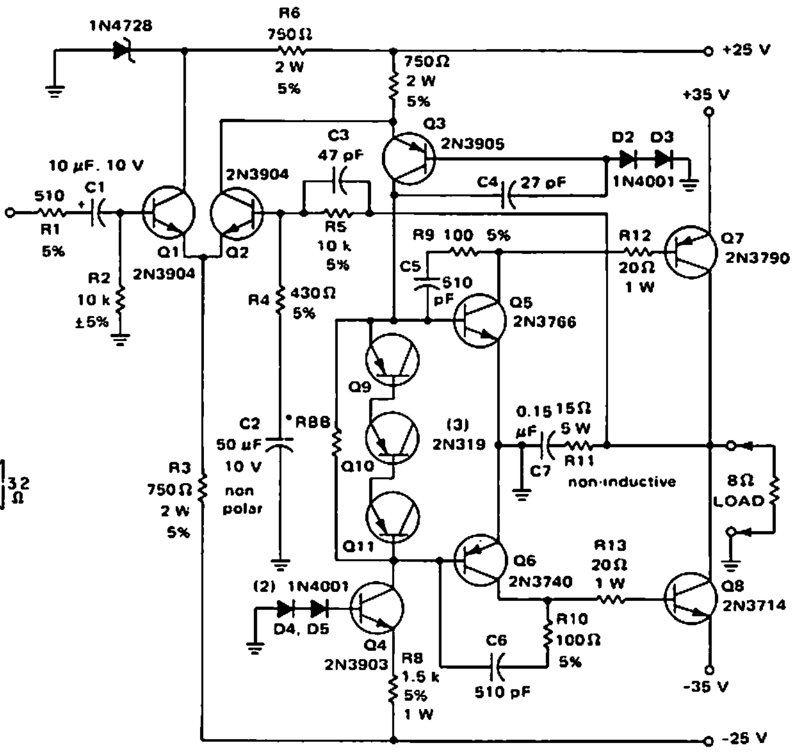
STABILIZING OUTPUT STAGE WITH BARRETERS—Arrangement shown is used in each channel of transistor stereo amplifier, with barreters serving to stabilize operation and protect transistors. Barreter lamps I1 and I2 are Tung-Sol CE101, whose resistance increases exponentially with current from 0.2 ohm until burnout at about 1.5 A. Barreters thus serve as fuses.—Using Barreters for Stabilizing an Output Stage, *Electronic Design*, June 8, 1964, p 68.


+6V
+12V
510KΩ
9
8
47Ω
TYPE 2N2869/2N301
Vin
1µF
10
RCA CA 3020
4
7
1
3
N2
N1
N2
120Ω
47Ω
1000µF
TYPE 2N2869/2N301
5KΩ
2
5
6
12
1µF
11Ω
$N_1/N_2 = \frac{2.3}{1}$
2.3Ω
0.1µF
0.01 µF
120Ω

7-W CLASS-B AMPLIFIER WITH IC—Low-cost integrated circuit drives two-transistor single-ended output stage through coupling transformer.—D. E. Lancaster, Audio Integrated Circuits—What's Available?, *Electronics World*, Oct. 1967, p 34–36.


+9V
RATIO DETECTOR OUTPUT
1µF
510 kΩ
9
8
10
1
CA3020
4
7
5K
3
2
5
6
12
3.2 Ω
ARGONNE TYPE 174 OR EQUIV.
1µF
0.6 Ω
1 µF
0.01 µF

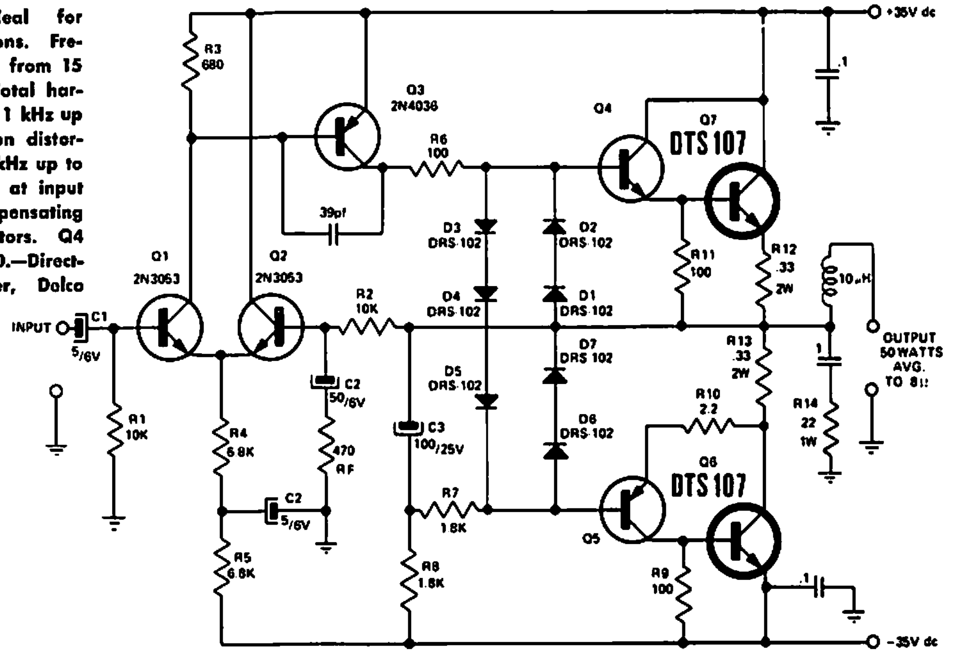
545-MW IC OUTPUT—With change in output transformer, wideband IC amplifier may be used to drive 8-ohm or 16-ohm speaker. Input of 45 mV gives full power output. Developed for use with portable f-m radio.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 273.


1N4728
R6 750Ω 2 W 5%
+25 V
750Ω 2 W 5%
Q3 2N3905
+35 V
C3 47 pF
D2 D3
10 µF, 10 V
C1
2N3904
C4 27 pF
1N4001
510 R1 5%
Q1
Q2
R5 10 k 5%
R9 100 5%
R12 20Ω 1 W
Q7 2N3790
R2 10 k ±5%
2N3904
R4 430Ω 5%
C5 510 pF
Q5 2N3766
Q9
C2 50 µF 10 V non polar
*RBB
(3) 2N319
0.15 µF
15Ω 5 W R11 non-inductive
C7
8Ω LOAD
R3 750Ω 2 W 5%
Q10
Q11
R13 20Ω 1 W
Q6 2N3740
(2) 1N4001
D4, D5
Q4 2N3903
R10 100Ω 5%
Q8 2N3714
C6 510 pF
R8 1.5 k 5% 1 W
-35 V
-25 V

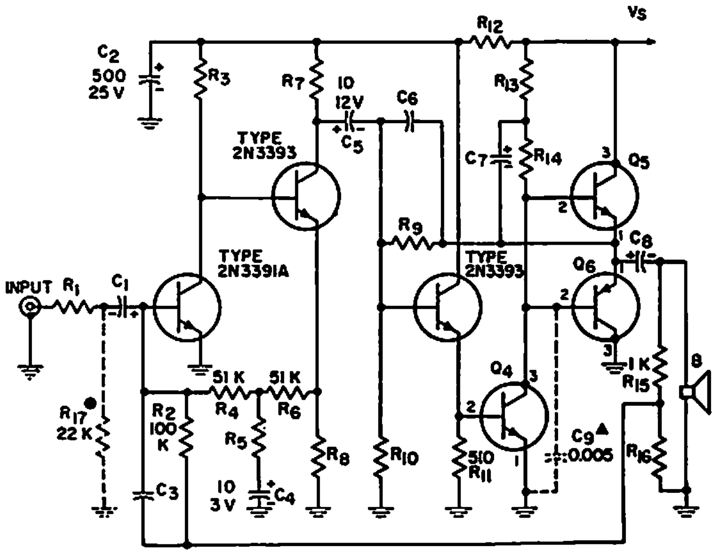
*RBB – AS REQUIRED TO GIVE 20-40 mA QUIESCENT CURRENT IN Q7 AND Q8.

50 W FOR 8 OHMS—Low-cost 1N4728 zener at collector of Q1 limits applied voltage, allowing use of low-cost plastic-encapsulated transistor. Frequency response and distortion meet requirements for hi-fi applications.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–49.

50-W QUASI-COMPLEMENTARY—Ideal for either monaural or stereo applications. Frequency response is flat within 1 dB from 15 Hz to 100 kHz at rated output. Total harmonic distortion is less than 0.1% at 1 kHz up to rated output, and intermodulation distortion less than 0.2% at 60 Hz and 6 kHz up to rated output. Differential amplifier at input keeps output at d-c ground by compensating bias of output silicon power transistors. Q4 is RCA 40409 and Q5 is RCA 40410.—Direct-Coupled 50-Watt Audio Amplifier, Delco Radio, Kokomo, Ind., No. 43, 1968.



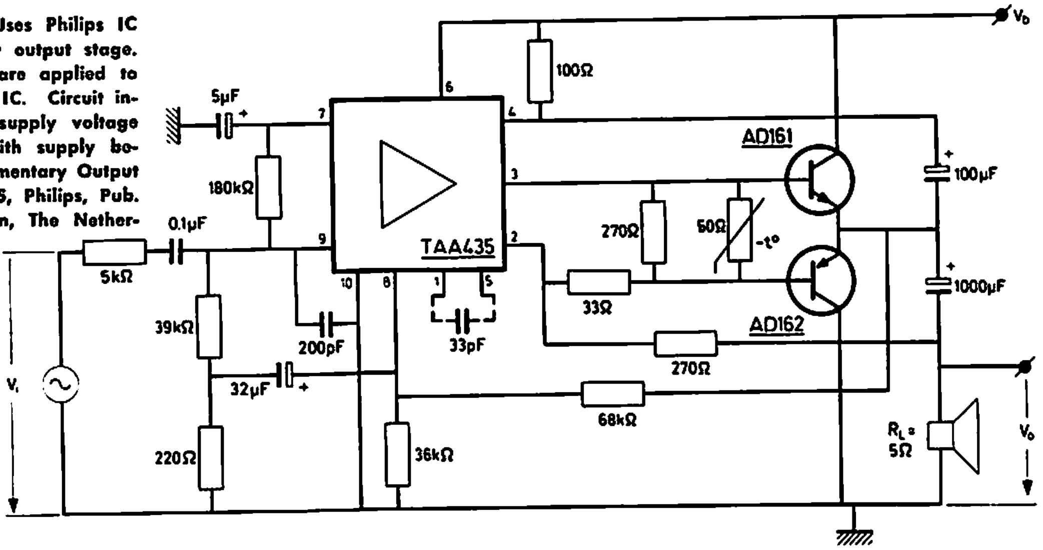
+35V dc
R3 680
Q3 2N4036
Q4
Q7 DTS 107
R6 100
39pf
D3 DRS 102
D2 DRS 102
R11 100
R12 .33 2W
10μH
Q1 2N3063
Q2 2N3063
R2 10K
D4 DRS 102
D1 DRS 102
INPUT
C1 5/6V
D7 DRS 102
R13 .33 2W
OUTPUT 50 WATTS AVG. TO 8Ω
.1
D5 DRS 102
C2 50/6V
R1 10K
R4 6.8K
470 RF
C3 100/25V
R10 2.2
D6 DRS 102
R14 22 1W
Q6 DTS 107
C2 5/6V
R7 1.8K
Q5
R5 6.8K
R8 1.8K
R9 100
.1
-35V dc



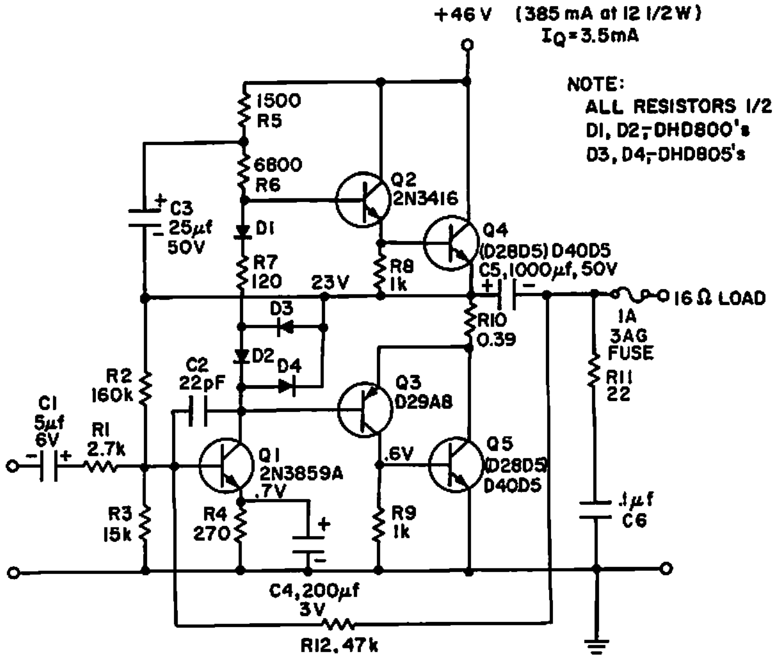
VS
R12
C2 500 25 V
R3
R7
10 12V
C6
C5
R13
TYPE 2N3393
C7
R14
Q5
R9
TYPE 2N3393
C8
Q6
INPUT R1
C1
TYPE 2N3391A
51 K
51 K
Q4
R4
R6
R17 22 K
R2 100 K
R5
R8
R10
510 R11
C9 0.005
1 K R15
R16
8
C3
10 3V
C4

TRUE-COMPLEMENTARY-SYMMETRY AMPLIFIER—Basic circuit can be used for nine different audio amplifiers in power output range of 3 to 20 W. Frequency response is flat well beyond 20 kHz for each, with total harmonic distortion of 1%. Operation approximates that of true class B amplifier. Book gives parts values and supply voltages for each combination of power output and transistor complement.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 411.

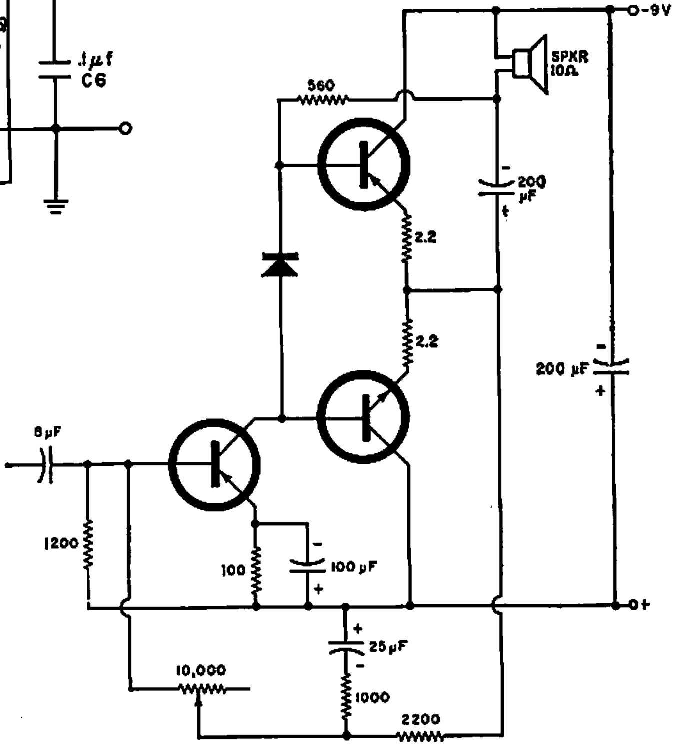
4-W IC POWER AMPLIFIER—Uses Philips IC driver to feed complementary output stage. Both d-c and a-c feedback are applied to input differential amplifier in IC. Circuit includes stabilization against supply voltage fluctuations. Will operate with supply between 10 and 18 V.—Complementary Output Stages Driven By the TAA435, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 18, 1968.



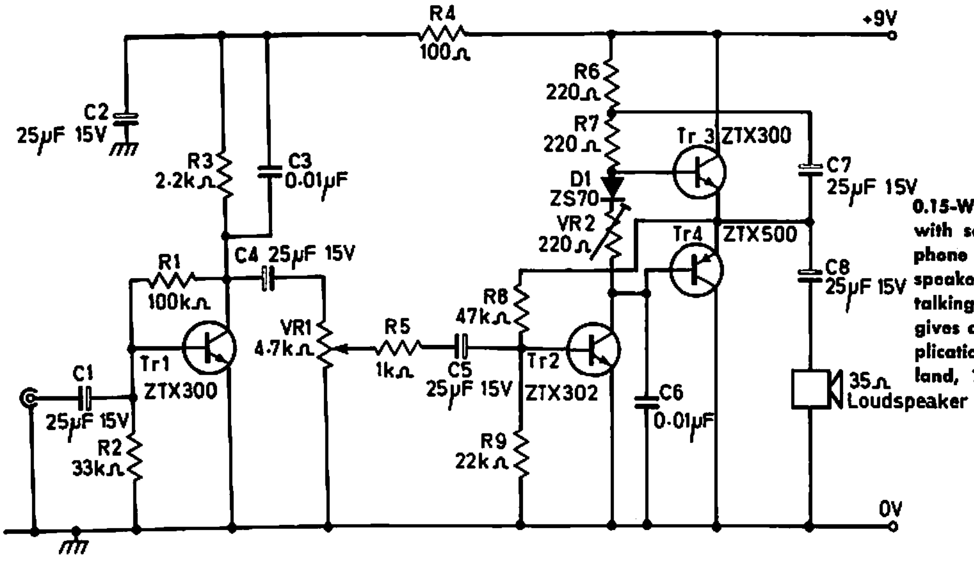
Vb
100Ω
6
5μF
7
4
AD161
100μF
180kΩ
3
270Ω
50Ω
-t°
0.1μF
9
TAA435
2
1000μF
5kΩ
10
8
1
5
33Ω
AD162
39kΩ
200pF
33pF
270Ω
Vi
32μF
68kΩ
220Ω
36kΩ
RL = 5Ω
Vo


+46 V (385 mA at 12 1/2 W)
I_Q = 3.5mA
NOTE:
ALL RESISTORS 1/2 W
D1, D2 - DHD800's
D3, D4 - DHD805's
1500 R5
6800 R6
C3 25μf 50V
D1
R7 120
23V
Q2 2N3416
R8 1k
Q4 (D28D5) D40D5
C5, 1000μf, 50V
16 Ω LOAD
1A 3AG FUSE
R10 0.39
R11 22
D3
D2
D4
C2 22pF
R2 160k
C1 5μf 6V
R1 2.7k
Q1 2N3859A
.7V
Q3 D29A8
.6V
Q5 (D28D5) D40D5
R3 15k
R4 270
R9 1k
C4, 200μf 3V
.1μf C6
R12, 47k

12.5-W QUASI-COMPLEMENTARY PUSH-PULL—Delivers full power to 16-ohm load for 1.1-V input signal. Total harmonic distortion at 10 W is less than 0.5% from 25 to 20,000 Hz.—Dwight V. Jones, Silicon Power Transistor Amplifier Circuits with High Performance at Low Cost, General Electric, Syracuse, N.Y., No. 90.79, 1969.


-9V
SPKR 10Ω
560
200 μF
2.2
2.2
200 μF
8 μF
1200
100
100 μF
+
25 μF
10,000
1000
2200

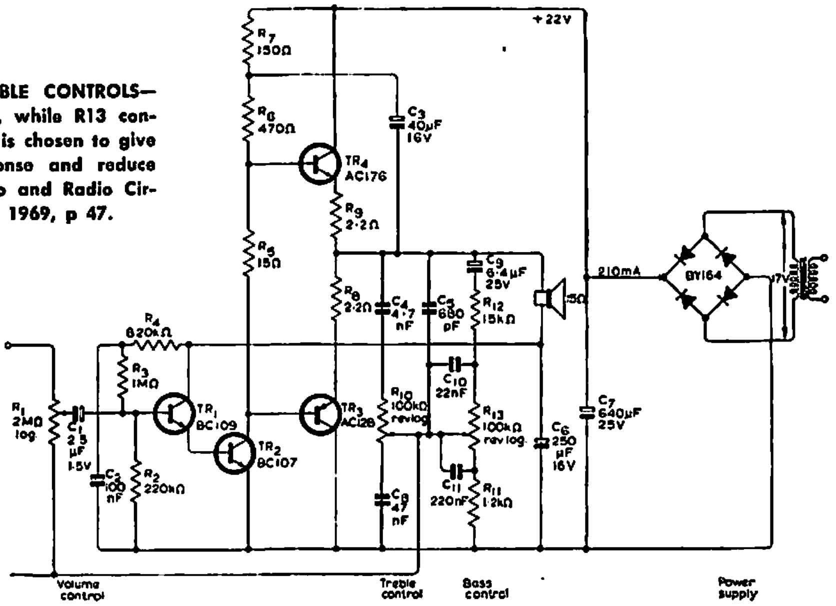
OUTPUT STAGE BIAS COMPENSATION—Use of compensating diode in typical push-pull class-B transistor audio stage minimizes crossover distortion caused by transistor mismatch or by discontinuities at changeover point between half-cycles of amplified waveform. Transistor types depend on power output desired.—P. Halliday, Bias Compensation for Transistor Output Stages, *Electronics World*, Aug. 1967, p 76–78.

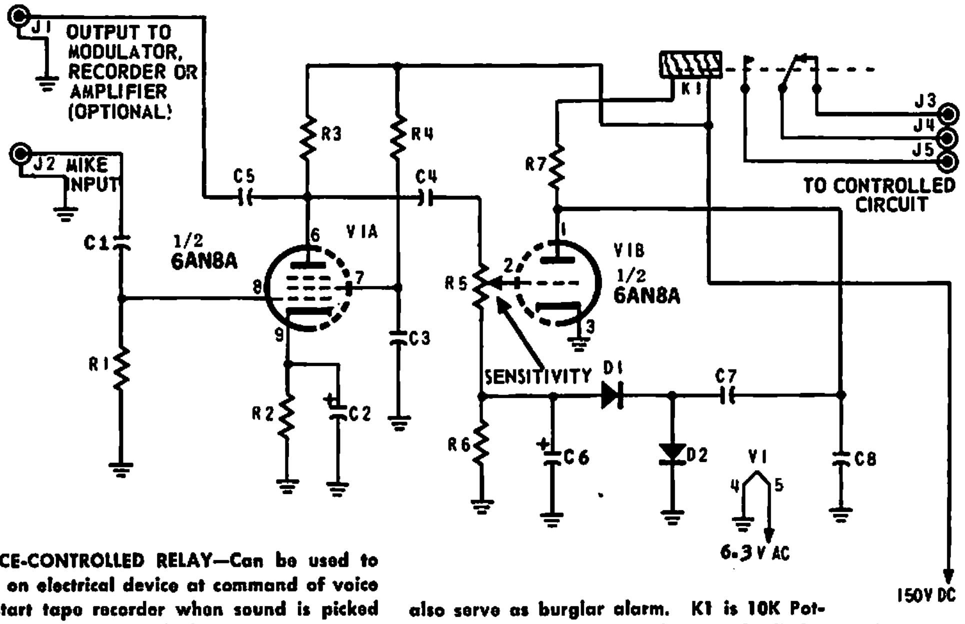

R4 100Ω
+9V
C2 25μF 15V
R3 2.2kΩ
C3 0.01μF
R1 100kΩ
C4 25μF 15V
Tr1 ZTX300
VR1 4.7kΩ
R5 1kΩ
C5 25μF 15V
C1 25μF 15V
R2 33kΩ
R6 220Ω
R7 220Ω
D1 ZS70
VR2 220Ω
Tr 3 ZTX300
Tr4 ZTX500
C7 25μF 15V
C8 25μF 15V
R8 47kΩ
Tr2 ZTX302
R9 22kΩ
C6 0.01μF
35Ω Loudspeaker
0V

0.15-W INTERCOM—May be used as intercom, with second 35-ohm speaker used as microphone at input. With suitable switching, speakers can be interchanged as required for talking or listening at each location. Report gives design procedure.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 50.

CHAPTER 4
Audio Control Circuits

3-W WITH BASS AND TREBLE CONTROLS—R10 cuts and boosts treble, while R13 controls bass. Input transistor is chosen to give improvement in bass response and reduce distortion.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 47.

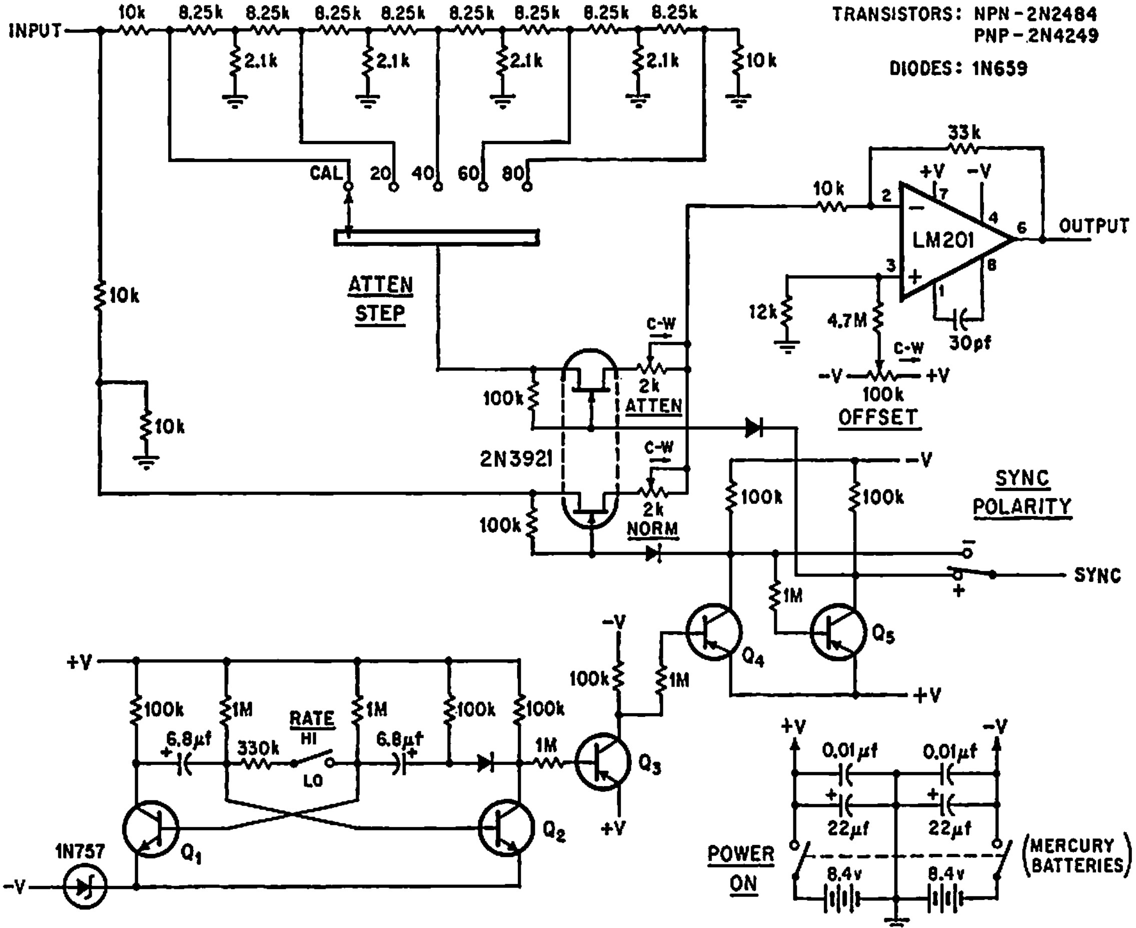

+22V
R7 150Ω
R6 470Ω
C3 40μF 16V
TR4 AC176
R9 2·2Ω
R5 15Ω
R8 2·2Ω
C4 4·7 nF
C5 680 pF
C9 6·4μF 25V
R12 15kΩ
15Ω
210mA
BY164
17V
R4 820kΩ
R3 1MΩ
R1 2MΩ log
C1 2·5 μF 1·5V
TR1 BC109
TR2 BC107
TR3 AC128
R10 100kΩ rev log
C10 22nF
R13 100kΩ rev log
C6 250 μF 16V
C7 640μF 25V
C2 100 nF
R2 220kΩ
C8 47 nF
C11 220nF
R11 1·2kΩ
Volume control
Treble control
Bass control
Power supply


J1 OUTPUT TO MODULATOR, RECORDER OR AMPLIFIER (OPTIONAL)
J2 MIKE INPUT
C1
R1
C5
R3
R4
C4
6
V1A
1/2 6AN8A
8
7
9
R2
C2
C3
R5
SENSITIVITY
R6
C6
K1
R7
1
2
V1B
1/2 6AN8A
3
D1
C7
D2
V1
4
5
6.3 V AC
C8
J3
J4
J5
TO CONTROLLED CIRCUIT
150V DC

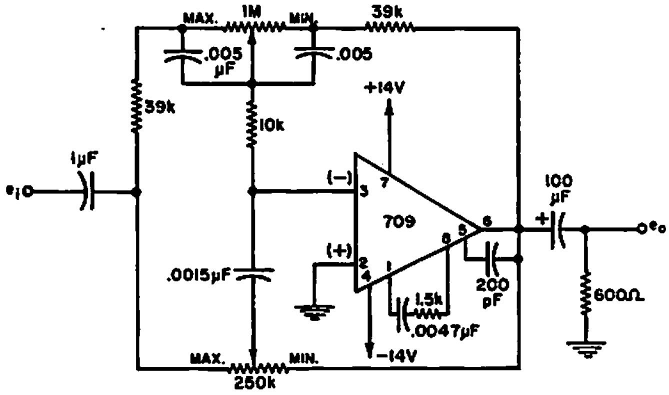
C1, 4, 5, 8 -.002 mfd
C2 -5 mfd
C3 -.15 mfd
C6 -.25 mfd lytic
C7 -.02 mfd

R1 -500K
R2 -1.3K
R3 -110K
R4 -620K
R5 -750K pot
R6 -3.4 meg
R7 -15K

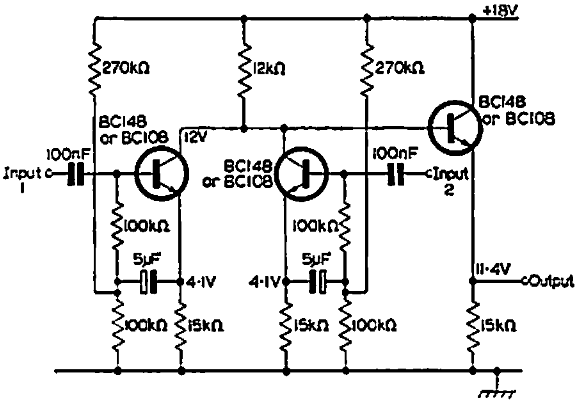
VOICE-CONTROLLED RELAY—Can be used to turn on electrical device at command of voice or start tape recorder when sound is picked up by microphone. If alarm is connected to relay, and R5 adjusted for faint noise, can also serve as burglar alarm. K1 is 10K Potter & Brumfield PW5LS relay. Both diodes are 1N2071.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 71.


INPUT
10k
8.25k
2.1k
10k
CAL
20
40
60
80
ATTEN STEP
TRANSISTORS: NPN-2N2484
PNP-2N4249
DIODES: 1N659
33k
+V
-V
LM201
OUTPUT
12k
4.7M
C-W
30pf
100k OFFSET
2k ATTEN
2k NORM
2N3921
100k
SYNC POLARITY
SYNC
1M
Q4
Q5
Q3
+V
-V
RATE
HI
LO
330k
6.8μf
1N757
Q1
Q2
0.01μf
22μf
8.4v
POWER ON
MERCURY BATTERIES

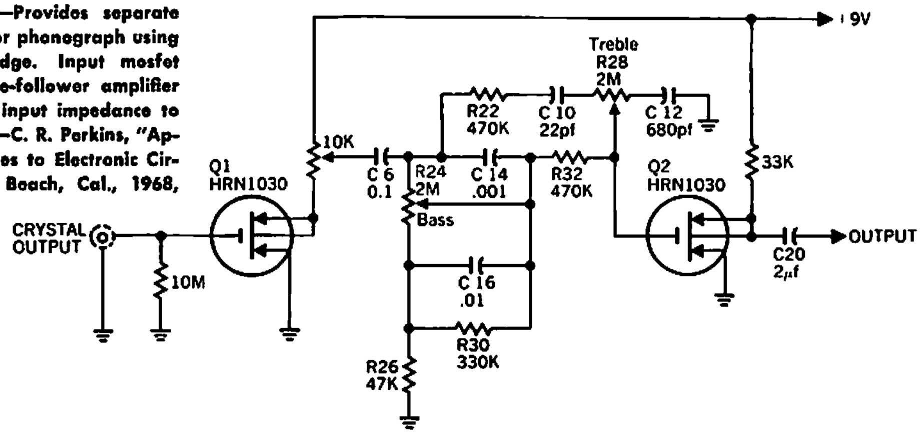
FAST-ACTING ATTENUATOR—Will shift level of audio signal in less than 10 μs, to give up to 80 dB of attenuation in audio amplifier. Incoming signal is split between ladder attenuator and straight-through 6-dB loss network. Dual fet acts as spst switch for selecting either channel to drive astable mvbr followed by inverters Q4 and Q5. Rate of astable can be either 1.2 or 5 s per sample. Signal from fet goes to opamp providing voltage gain of 6 dB to 50-ohm load. Sync output gives 16-V pulses with 10-μs rise time. Use of battery supply isolates circuit from line noise. Can be used to measure response of agc networks.—T. E. O'Brien, Automatic Attenuator Rapidly Changes Signal Level, *Electronics*, Sept. 15, 1969, p 120.


MAX.
1M
MIN.
39k
.005 μF
.005
39k
10k
+14V
1μF
e_i
(−)
(+)
709
.0015μF
1.5k
.0047μF
200 pF
-14V
100 μF
e_o
600Ω
MAX.
MIN.
250k

IC TONE CONTROL—Uses Fairchild μA709 or National LM709 IC opamp as unity-gain inverter when both pots are at mid-positions. At maximum positions, provides about 20 dB of attenuation or boost at low and high frequencies.—S. L. Silver, IC Op Amps Boost Audio Circuit Performance, *Electronics World*, Sept. 1968, p 30–32.

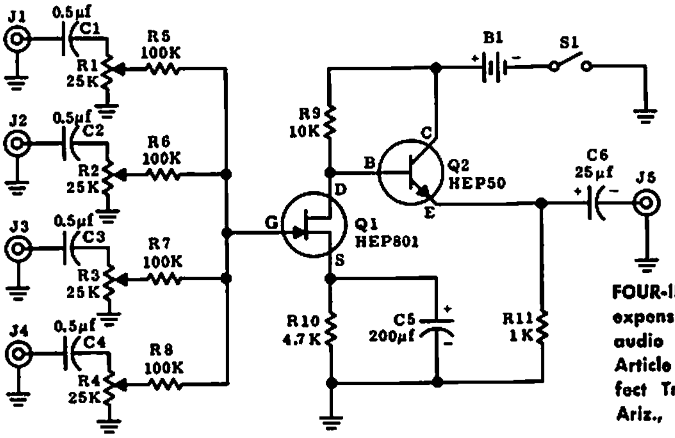

+18V
270kΩ
12kΩ
270kΩ
BC148 or BC108
12V
100nF
Input 1
Input 2
100kΩ
5μF
4·1V
15kΩ
11·4V
Output

TWO-INPUT MIXER—Input transistors use common 12K collector load resistor. Input impedance is 2.5 meg, output is 70 ohms, voltage gain is unity, and distortion is 0.5% for 2 V output.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 126.



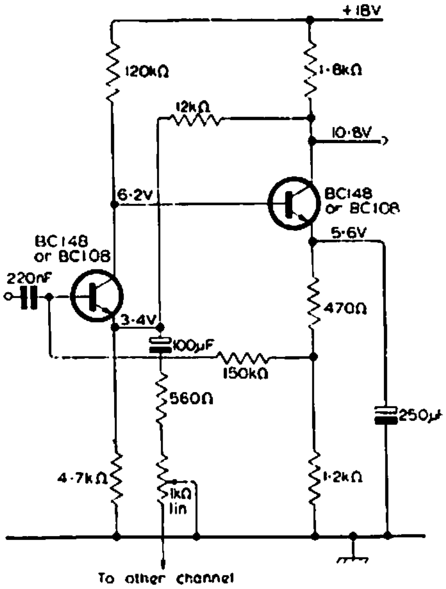
9V
Treble
R28
2M
R22
470K
C 10
22pf
C 12
680pf
10K
C 6
0.1
R24
2M
C 14
.001
R32
470K
Q1
HRN1030
Q2
HRN1030
33K
Bass
CRYSTAL
OUTPUT
10M
OUTPUT
C20
2μf
C 16
.01
R30
330K
R26
47K

PHONO TONE CONTROL—Provides separate bass and treble controls for phonograph using crystal or ceramic cartridge. Input mosfet Q1 is connected as source-follower amplifier providing extremely high input impedance to avoid loading transducer.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 5.



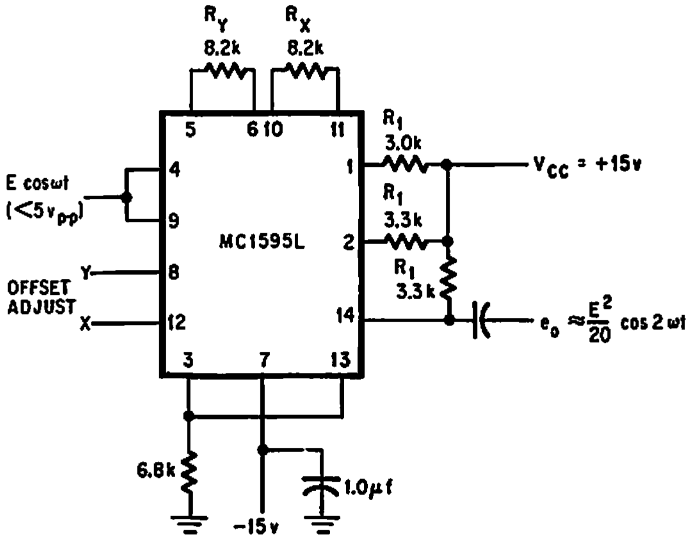
J1
0.5μf
C1
R5
100K
R1
25K
J2
0.5μf
C2
R6
100K
R2
25K
J3
0.5μf
C3
R7
100K
R3
25K
J4
0.5μf
C4
R8
100K
R4
25K
B1
S1
R9
10K
B
C
Q2
HEP50
E
C6
25μf
J5
G
D
Q1
HEP801
S
R10
4.7K
C5
200μf
R11
1K

FOUR-INPUT AUDIO FET—High-quality yet inexpensive fet connects four high-impedance audio sources to single amplifier input. Article gives construction details.—"Field Effect Transistor Projects," Motorola, Phoenix, Ariz., 1966, p 26–34.



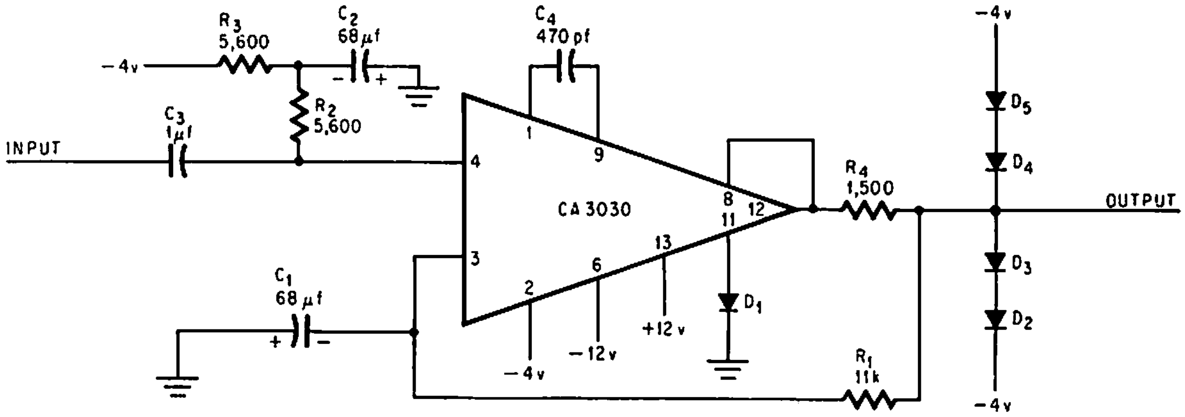
+18V
120kΩ
1·8kΩ
12kΩ
10·8V
6·2V
BC148
or BC108
5·6V
BC148
or BC108
220nF
3·4V
100μF
150kΩ
470Ω
560Ω
250μF
4·7kΩ
1kΩ
lin
1·2kΩ
To other channel

BALANCE CONTROL—When used in each stereo channel, permits varying voltage gain in both channels by 6 dB in opposite directions. Control potentiometer is in feedback circuit.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 129.

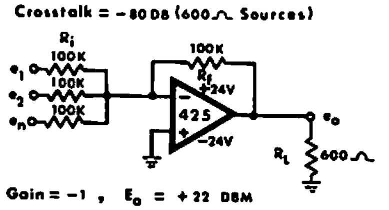


R_Y
8.2k
R_X
8.2k
5
6
10
11
R_1
3.0k
V_CC = +15v
E cosωt
(<5v_pp)
4
9
1
R_1
3.3k
MC1595L
2
R_1
3.3k
Y
8
OFFSET
ADJUST
X
12
14
e_o ≈ E²/20 cos 2ωt
3
7
13
6.8k
1.0μf
−15v

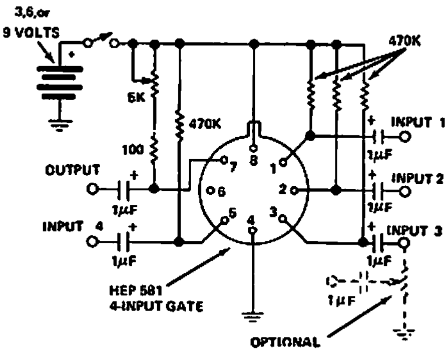
DOUBLING 10 KHZ—Motorola monolithic multiplier gives second harmonic directly when two equal cosine waves are applied to inputs X and Y. A-c coupling removes d-c term. Dynamic range of input is 5 V p-p. Doubled output frequency has less than 1% distortion even without filtering. Will operate well above 200 kHz.—E. Renschler and D. Weiss, Try the Monolithic Multiplier as a Versatile A-C Design Tool, *Electronics*, June 8, 1970, p 100–105.


R3
5,600
C2
68µf
C4
470 pf
−4v
−4 v
C3
1µf
R2
5,600
INPUT
1
9
4
CA 3030
8
11
12
R4
1,500
D5
D4
OUTPUT
13
3
6
2
C1
68 µf
D3
D2
D1
+12 v
−4 v
−12 v
R1
11k
−4v

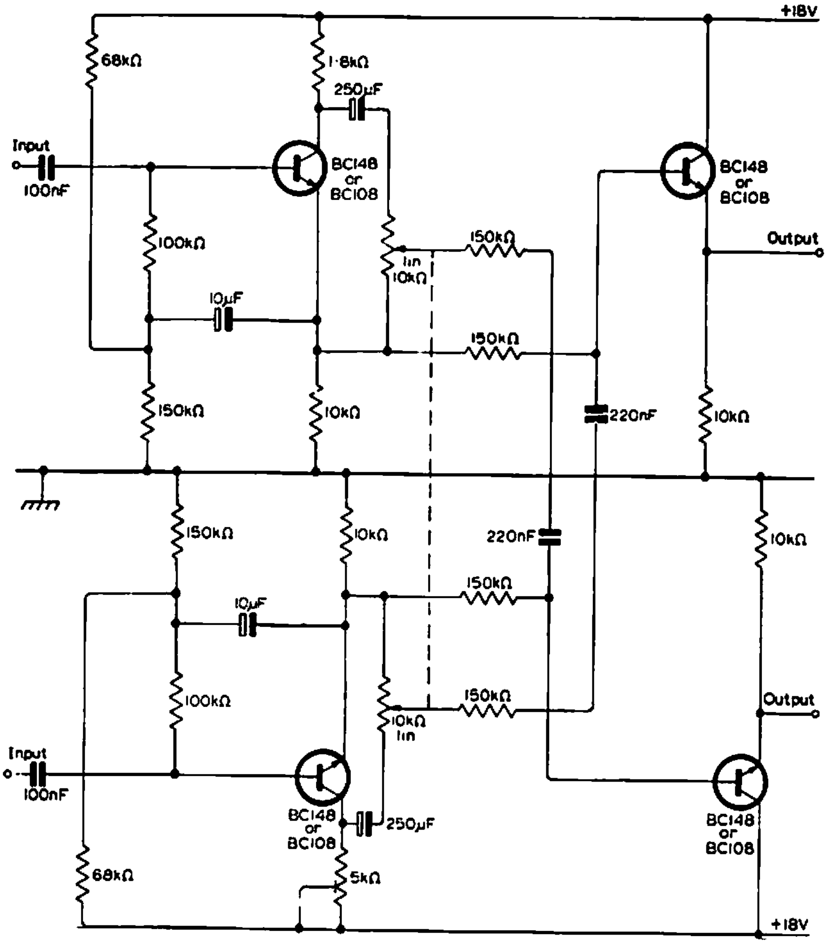
78-DB RANGE—Wideband audio limiter, built around RCA IC opamp, delivers clean sine waves below limiting threshold and symmetrical square waves for higher input voltages. Limiting begins at 0.4 mV input. Can handle up to 6 V p-p. Second harmonic distortion is 0.3% over dynamic range of 54 dB, and 2% for 78 dB.—R. Glasgal, Low-Distortion Limiter Uses IC Operational Amplifier, *Electronics*, October 14, 1968, p 120–121.


Crosstalk = −80 DB (600Ω Sources)
Ri
100K
100K
100K
100K
e1
e2
en
Rf
+24V
425
−24V
eo
RL
600Ω
Gain = −1 , Eo = +22 DBM

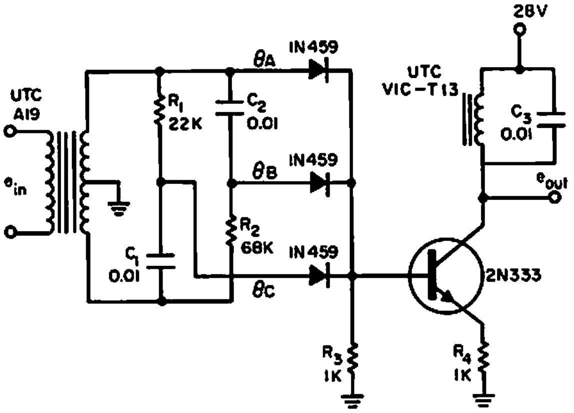
20-CHANNEL MIXER—Active mixer using Model 425 IC opamp connected for unity gain has no insertion loss, because negative input summing point is driven to virtual zero. Up to 20 input channels may be used. Output voltage across 600-ohm load is 22 dBm.—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.


3,6,or
9 VOLTS
+
5K
470K
470K
100
OUTPUT
+
1µF
INPUT 4
+
1µF
8
7
1
6
2
5
4
3
INPUT 1
1µF
INPUT 2
1µF
INPUT 3
1µF
1µF
HEP 581
4-INPUT GATE
OPTIONAL

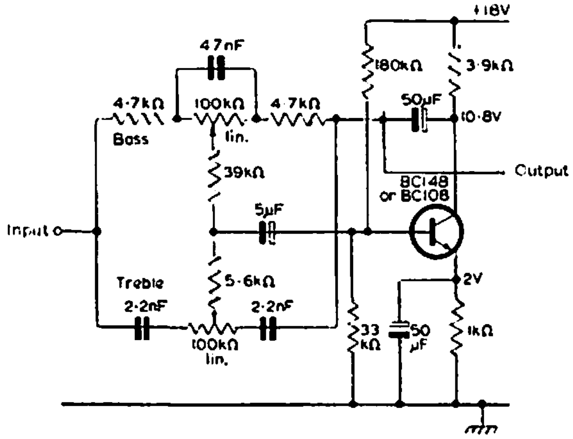
FOUR-INPUT AUDIO IC—Output is about 3 V p-p on input of 0.3 V p-p from low-level microphone or phono. Optional 10K pot and capacitor can be added to each input, as shown by dashed lines for input 3. Adjust 5K pot for maximum undistorted output.—"Tips on Using IC's," Motorola, Phoenix, Ariz., HMA-32, 1968.


+18V
68kΩ
1·8kΩ
250µF
Input
100nF
BC148
or
BC108
BC148
or
BC108
Output
100kΩ
150kΩ
lin
10kΩ
10µF
150kΩ
150kΩ
10kΩ
220nF
10kΩ
150kΩ
10kΩ
220nF
10kΩ
150kΩ
10µF
100kΩ
150kΩ
10kΩ
lin
Output
Input
100nF
BC148
or
BC108
250µF
BC148
or
BC108
68kΩ
5kΩ
+18V

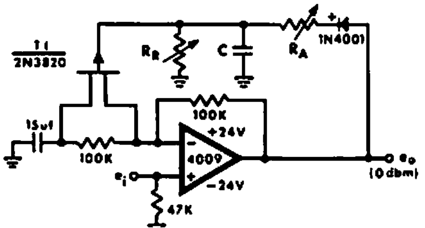
SOUND SOURCE WIDTH CONTROL—Ganged controls give effect of moving stereo sound pickup microphones continuously between in-phase crosstalk of 100% (corresponding to monophonic recording), and anti-phase crosstalk of 24%. Greater anti-phase crosstalk is unnecessary because sound impression falls apart and effect becomes that of two independent sources rather than stereo. Channels are balanced with 5K preset pot.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 134.


28V
UTC A19
e_{in}
R_1 22K
C_2 0.01
C_1 0.01
R_2 68K
θA
θB
θC
IN459
IN459
IN459
UTC VIC-T13
C_3 0.01
e_{out}
2N333
R_3 1K
R_4 1K

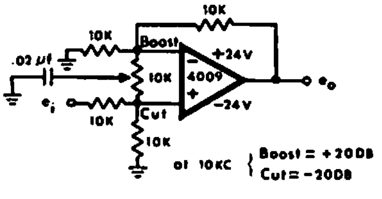
TRIPLER FOR 400-HZ SOURCE—Simple pulser feeding tank network delivers equal-energy pulses at triple-frequency rate to provide good 1,200-Hz sine-wave output with no fundamental-frequency modulation. Values of R1, R2, C1, C2, and C3 may be chosen for any other standard audio frequency. Article gives detailed description of circuit operation, along with design equations.—J. B. Messmer, Precise Frequency-Tripler Uses 400 CPS Standard Source, *Electronic Design*, Nov. 22, 1965, p 61–62.


+18V
4.7nF
4.7kΩ
100kΩ
4.7kΩ
Bass
lin.
39kΩ
5μF
180kΩ
3.9kΩ
50μF
10.8V
Output
BC148 or BC108
Input
Treble
5.6kΩ
2.2nF
2.2nF
100kΩ lin.
33 kΩ
50 μF
2V
1kΩ

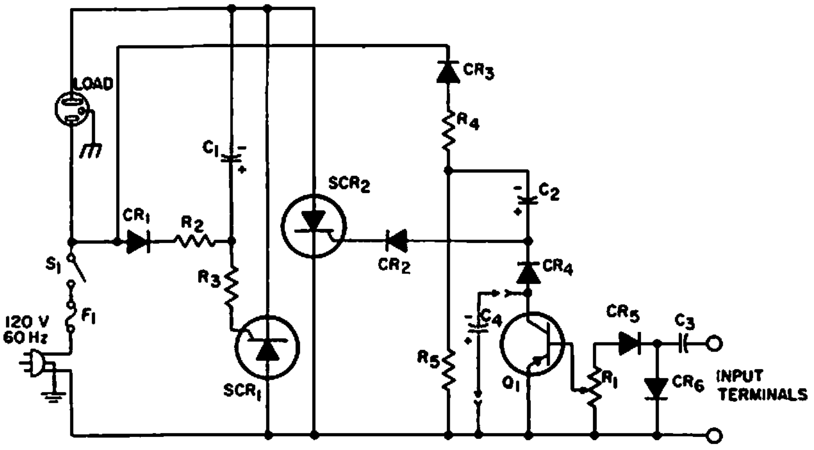
ACTIVE TONE CONTROL—Operates with frequency-dependent feedback network between collector and base of tone-control transistor. At 30 Hz, control range is −22 dB to 19.5 dB, and at 20 Hz is −19 dB to 19.5 dB. Frequency response is flat when both pots are centered.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 131.


Ti 2N3820
R_R
C
R_A
IN4001
15μf
100K
100K
+24V
4009
−24V
e_i
47K
e_o (10dbm)

20-DB AUDIO COMPRESSOR—Uses Model 4009 IC opamp in circuit having adjustable attack-time and release-time pots. For most applications, RA is set for attack time between 10 μs and perhaps 20 ms, while RR is set for release times somewhere between 20 and 200 ms. FET is inside electronic feedback path and automatically adjusts gain of amplifier as function of output voltage. At low signal levels, gain is about 10.—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.

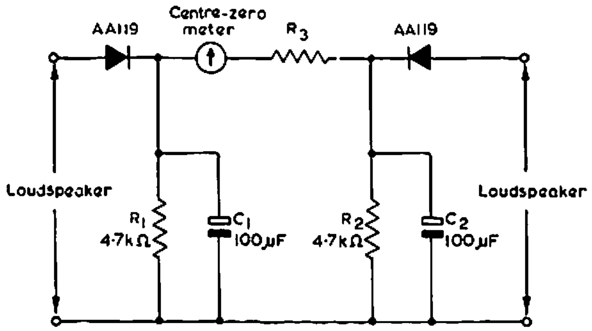

10K
10K
.02μf
Boost
10K
+24V
4009
−24V
e_o
e_i
10K
Cut
10K
at 10KC
Boost = +20DB
Cut = −20DB

TREBLE CONTROL—Uses Model 4009 IC opamp to provide wide range of treble boost and cut, with turn-over frequency of about 800 Hz for values shown.—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.

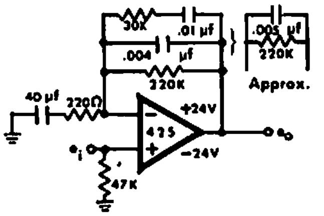

LOAD
C_1
CR_3
R_4
SCR2
C_2
CR_1
R_2
CR_2
S_1
CR_4
R_3
C_4
120 V 60 Hz
F_1
CR_5
C_3
SCR₁
R_5
Q_1
R_1
CR_6
INPUT TERMINALS

$C_1 C_2$ = 10 microfarads, 15 volts, electrolytic
C_3 = 0.1 microfarad, 25 volts or greater
C_4 = 10 to 100 microfarads, 12 volts, electrolytic, to increase release time
$CR_1 CR_2 CR_3 CR_4$ = silicon rectifier, RCA SK3030
$CR_5 CR_6$ = silicon rectifier, type 1N34A
F_1 = fuse, 125 volts, ampere rating depends on load
Q_1 = transistor, RCA SK3005
R_1 = potentiometer, 5000 ohms, 2 watts, linear taper
$R_2 R_4$ = 4700 ohms, 2 watts, 10%
R_3 = 270 ohms, 1/2 watt, 10%
R_5 = 470 ohms, 1/2 watt, 10%
S_1 = switch, 125 volts, 15 amperes, single-pole, single-throw toggle
$SCR_1 SCR_2$ = silicon controlled rectifier, RCA KD2100

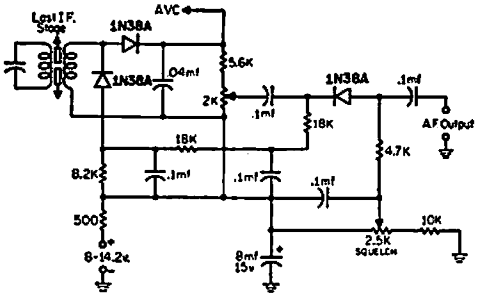
SOUND-OPERATED SWITCH—Will turn on load up to 1 kW for as long as sound or noise signal fed to input by microphone and preamp remains above predetermined level set by R1. Release time can be increased by adding capacitor (up to 100 μF) between emitter and collector of Q1 so switch does not open for momentary interruptions in sound such as between syllables of speech.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 164.


AA119
Centre-zero meter
R_3
AA119
Loudspeaker
Loudspeaker
R_1 4·7kΩ
C_1 100μF
R_2 4·7kΩ
C_2 100μF

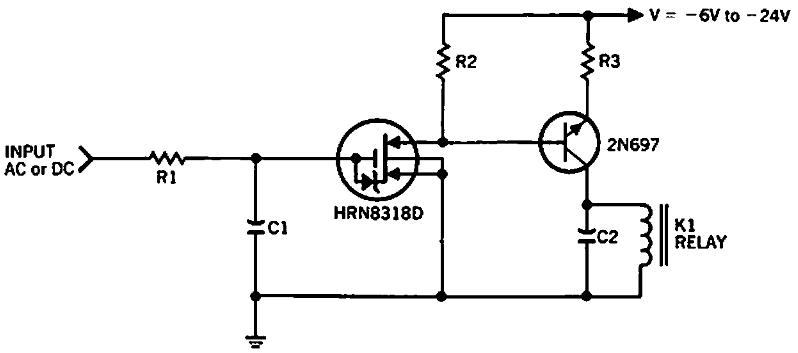
SPEAKER BALANCE METER—Value of R3 is selected to suit current rating of zero-center meter and output of amplifier; typical value is 10K for 1-mA meter. Used to balance the two outputs in a stereo system. Capacitors serve to damp meter movement.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 183.


30K
.01 μf
.004 μf
220K
.005 μf
220K
Approx.
40 μf
220Ω
+24V
425
−24V
e_i
e_o
47K

RIAA EQUALIZATION—Uses Model 425 IC opamp in network giving standard equalization for LP records. Simpler network at right will serve for less critical applications. Large capacitor may be electrolytic because voltage across it is few millivolts as summing point of opamp is driven to virtual zero.—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.

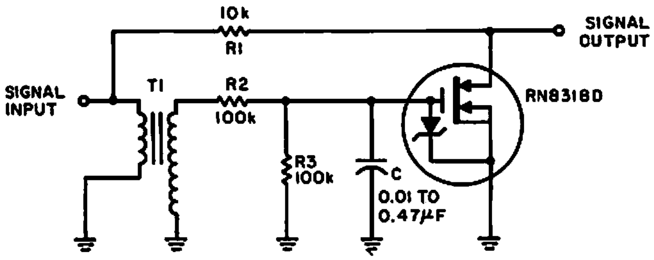

Last I.F. Stage
1N38A
AVC
1N38A
.04mf
5.6K
2K
.1mf
1N38A
.1mf
AF Output
18K
18K
4.7K
8.2K
.1mf
.1mf
.1mf
500
10K
2.5K SQUELCH
8-14.2v
8mf 15v

DETECTOR WITH SQUELCH—Circuit is designed to replace conventional detector of a-m receiver. Diode types are not critical, but all three should be the same. Noise limiting is achieved primarily with diode connected through capacitor to center of 2K pot. Squelch threshold is set by 2.5K pot.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 38.

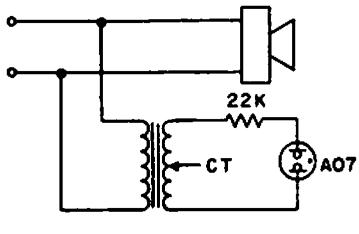

V = −6V to −24V
R2
R3
INPUT AC or DC
R1
2N697
HRN8318D
C1
C2
K1 RELAY

Attack time constant, A = R1C1
Decay time constant, D = $R_{K1}C_2$

AUDIO-ACTIVATED RELAY—Used to detect audio signals and energize relay to feed signals to telephone line or tape recorder. Input mosfet provides very high input impedance, permitting use of high values for time constant circuit R1-C1; typical values are 1 meg and 0.01 μF, giving 1-ms delay in energizing relay, to avoid triggering on noise spikes and other high-frequency signals. Time for relay to drop out after audio signals cease is determined by C2 and inductance of relay. With 100 μF for C2, delay is 2 s.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 36.


10k
R1
SIGNAL OUTPUT
SIGNAL INPUT
T1
R2
100k
RN8318D
R3
100k
C
0.01 TO 0.47μF

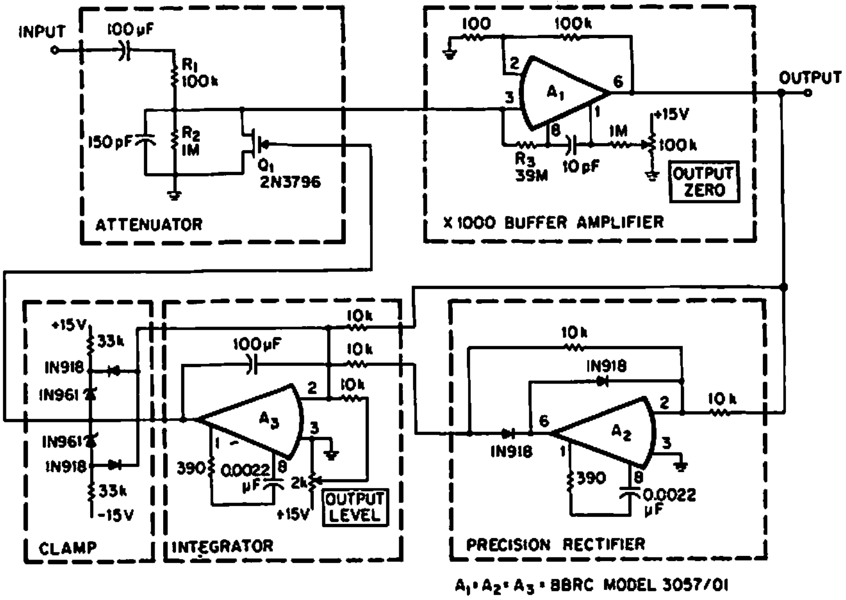
VOLUME COMPRESSOR—Mosfet acts as variable resistance, changing from several hundred ohms to several million ohms depending on value of negative voltage at its gate terminal. With −3 V, resistance is above 10K, and with −10 V it is 300 ohms. Signal source provides required bias. Transformer turns ratio should be at least 20:1.—C. R. Perkins, Volume Compressor Needs No Power Supply, *Electronic Design*, Dec. 20, 1967, p 110.



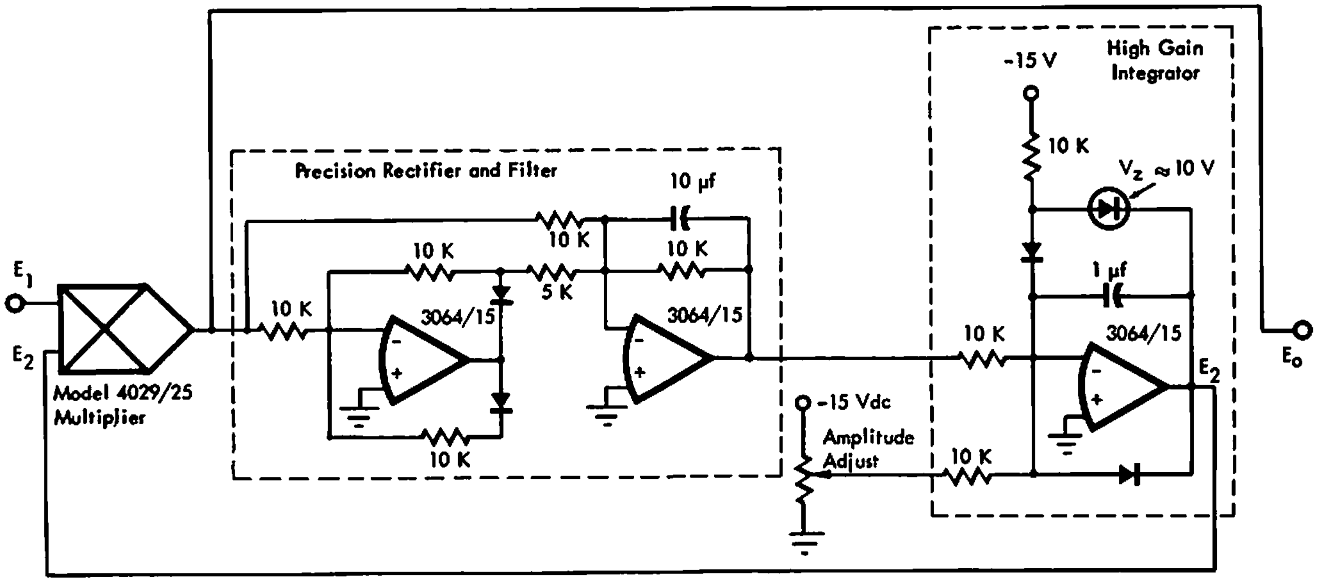
ANNUNCIATOR INDICATOR—Neon indicates which of several remote speakers in communications system is active. Transformer is a-f output transformer wired backwards.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N. J., p. 152.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

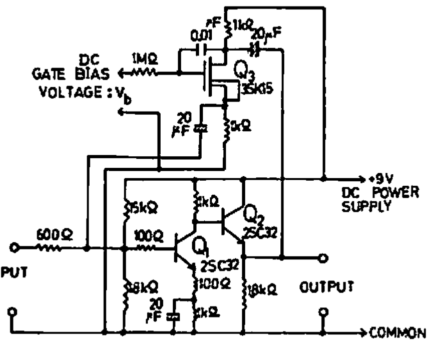
CHAPTER 5
Automatic Gain Control Circuits


INPUT
100 μF
R1
100k
150 pF
R2
1M
Q1
2N3796
ATTENUATOR
100
100k
2
3
A1
6
8
1
R3
39M
10 pF
1M
+15V
100k
OUTPUT ZERO
X 1000 BUFFER AMPLIFIER
OUTPUT
+15V
33k
IN918
IN961
IN961
IN918
33k
-15V
CLAMP
100μF
10k
10k
10k
2
A3
3
1
390
0.0022 μF
8
2k
+15V
OUTPUT LEVEL
INTEGRATOR
10k
IN918
6
A2
2
10 k
IN918
1
3
390
8
0.0022 μF
PRECISION RECTIFIER
A1 • A2 • A3 • BBRC MODEL 3057/01

1,000:1 GAIN RANGE—Insulated-gate fet increases controlled gain range to about 60 dB. Opamp A1 is connected noninverting to prevent loading of variable attenuator R1-R2-Q1. Output is full-wave rectified by A2 and fed to A3 along with reference from 2K output-level pot. A3 integrates sum and applies it to Q1 to complete feedback loop. Clamp circuit around A3 prevents saturation by zero or overload input signals.—E. Guenther, MOS-FET Provides 60-dB Dynamic Range Low-Frequency AGC Circuit, *EEE*, Nov. 1969, p 107.

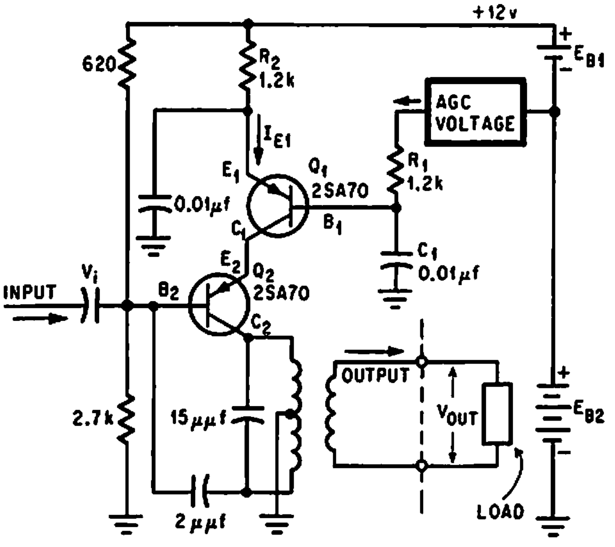

E1
E2
Model 4029/25 Multiplier
Precision Rectifier and Filter
10 K
10 K
10 K
10 K
5 K
10 K
10 pf
3064/15
3064/15
10 K
-15 Vdc
Amplitude Adjust
High Gain Integrator
-15 V
10 K
Vz ≈ 10 V
1 pf
10 K
3064/15
E2
10 K
Eo

MULTIPLIER MODULE FOR AGC—Burr-Brown 4029/25 quarter-square multiplier-divider is combined with amplifier module to give stable, reliable, and accurate agc loop for such military applications as stabilizing oscillator signal amplitude or holding amplitude constant while phase angle is varied by filtering. Designed for frequency range of 10–500 Hz. Amplitude of output signal is converted to d-c and compared with reference voltage to generate error signal for integrator whose output is multiplied by input signal to vary gain. Rate of restabilization of loop after sudden change in input level depends on time constant of integrator and rectifier-filter. —Quarter-Square Multiplier/Dividers, Burr-Brown Research, Tucson, Ariz., PDS-201C, 1969.



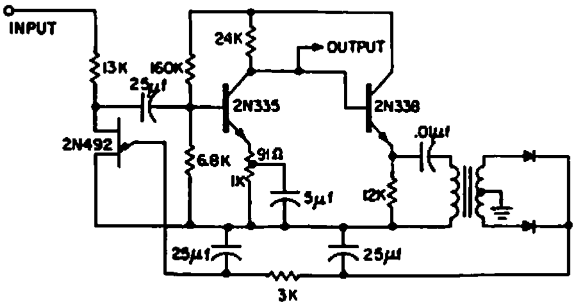
DC GATE BIAS VOLTAGE : V_b
1MΩ
0.01 μF
1kΩ
20μF
Q_3
3SK15
20 μF
5kΩ
+9V DC POWER SUPPLY
35kΩ
1kΩ
Q_2
2SC32
600Ω
100Ω
Q_1
2SC32
INPUT
18kΩ
100Ω
18kΩ
OUTPUT
20 μF
1kΩ
COMMON

MOS TRANSISTOR AS VARIABLE RESISTOR—Provides resistance range of 0.8 to 50,000 ohms depending on strength of applied signal. When used in feedback path of agc amplifier (Q3), gives agc range of 3:1. Input signal applied to base of Q1 appears at emitter of Q2 and is fed back through mos transistor Q3 to base of Q1.—H. Ikeda, MOST Variable Resistor and Its Application to an AGC Amplifier, *IEEE Journal of Solid-State Circuits*, Feb. 1970, p 43–45.



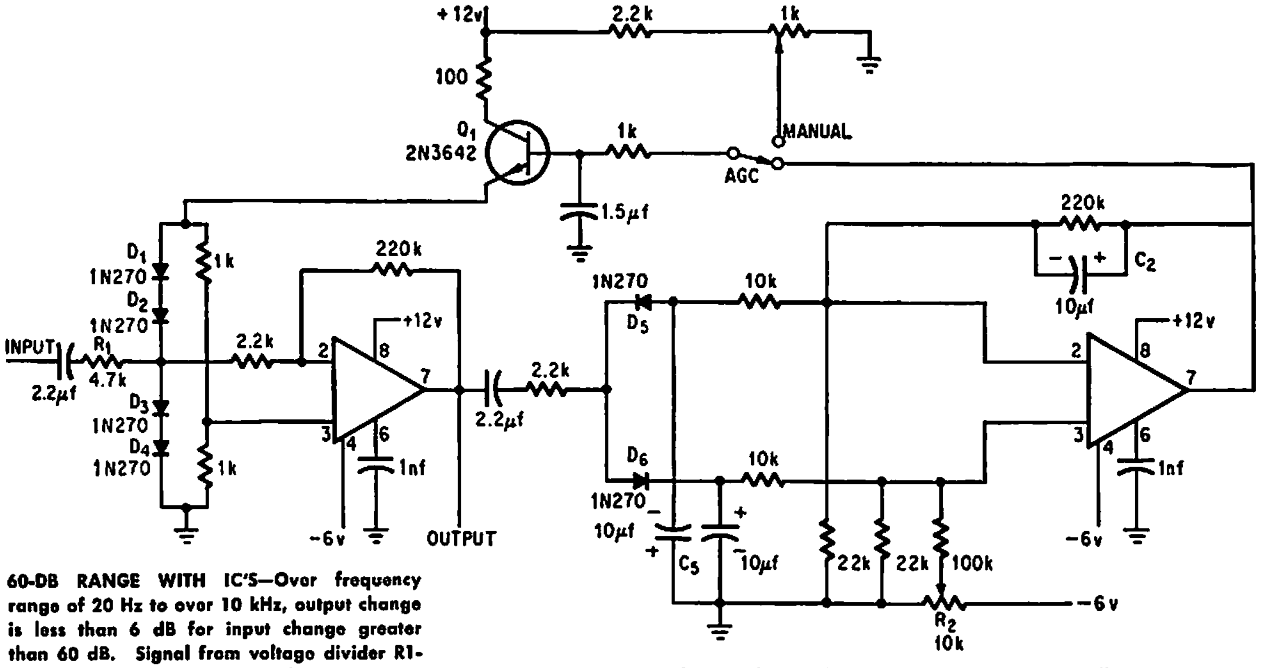
+12v
620
R_2 1.2k
I_{E1}
E_{B1}
AGC VOLTAGE
R_1 1.2k
0.01μf
E_1
Q_1 2SA70
B_1
C_1
C_1 0.01μf
V_i
INPUT
B_2
E_2
Q_2 2SA70
C_2
OUTPUT
V_{OUT}
2.7k
15μμf
E_{B2}
2μμf
LOAD

50-DB AGC—Used in Sony portable tv sets to handle large input signals without distortion or overload. Two transistors give far greater control range than conventional single-stage agc. Q2 amplifies, while Q1 serves are variable impedance in emitter circuit of Q2 and controls bias of Q2.—Two-Stage Gain Control for Portable TV Set, *Electronics*, Nov. 14, 1966, p 171–172.



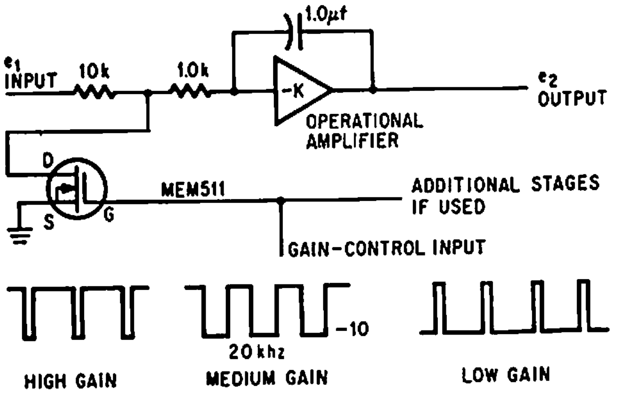
INPUT
24K
OUTPUT
13K
160K
25μf
2N335
2N338
.01μf
2N492
6.8K
91Ω
1K
5μf
12K
25μf
25μf
3K

LIMITED AGC FOR OSCILLATOR—Ujt compensates oscillator whose output varies inversely with frequency, to keep output essentially constant at 7-V p-p over frequency range of 2.8 to 3.1 kHz. Operation is based on negative resistance characteristic of ujt.—R. S. Hughes, Automatic Gain Control Circuit Uses Unijunction Transistor, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 111.

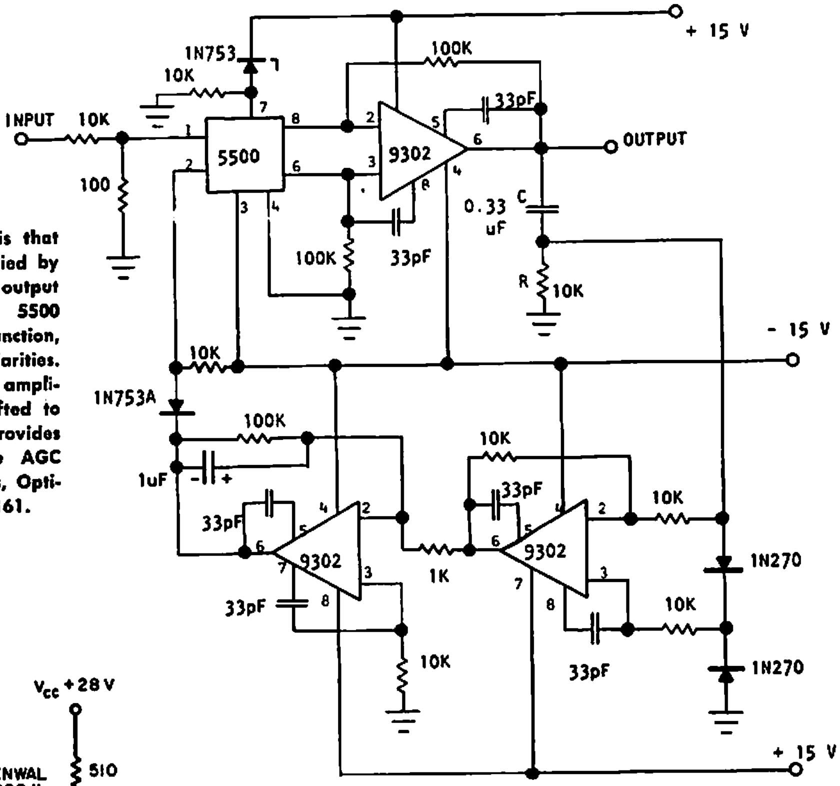


+12v
2.2k
1k
100
Q_1 2N3642
1k
MANUAL
AGC
1.5μf
220k
D_1 1N270
1k
220k
C_2
D_2 1N270
10μf
INPUT
R_1 4.7k
2.2k
+12v
1N270 D_5
10k
+12v
2.2μf
D_3 1N270
2
8
7
2.2k
2
8
7
D_4 1N270
1k
3
4
6
1nf
2.2μf
D_6 1N270
10k
3
4
6
1nf
-6v
OUTPUT
10μf
C_5
10μf
22k
22k
100k
-6v
-6v
R_2 10k

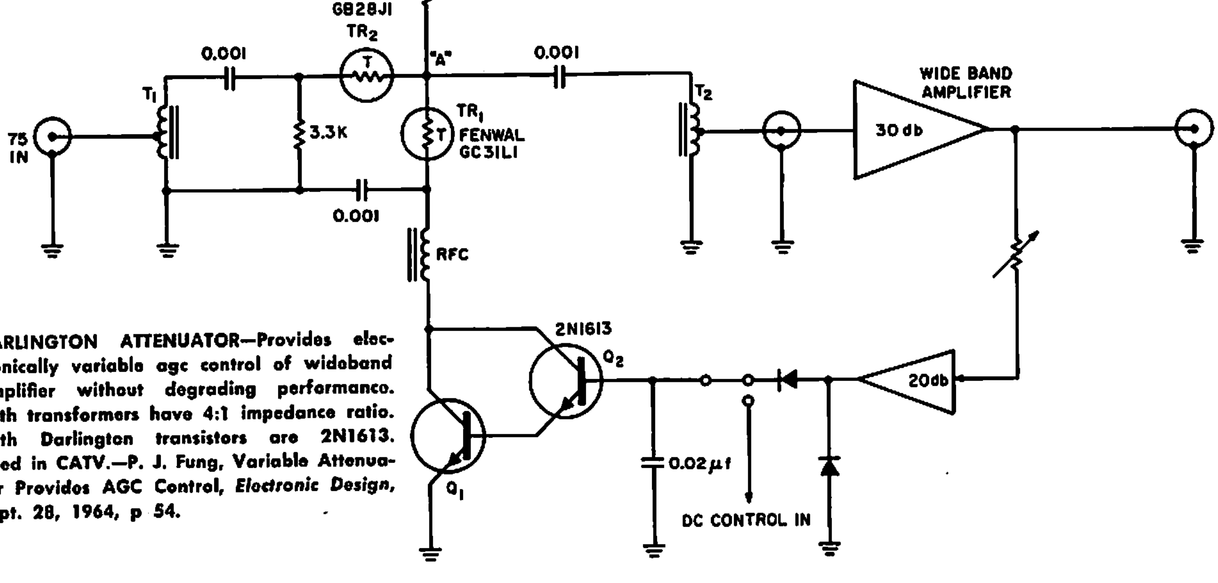
60-DB RANGE WITH IC'S—Over frequency range of 20 Hz to over 10 kHz, output change is less than 6 dB for input change greater than 60 dB. Signal from voltage divider R1-D1-D2-D3-D4 is amplified by first IC opamp having gain of 100, rectified by D5-D6, then fed back to input through second opamp and buffer Q1. For manual control, switch inserts potentiometer in feedback loop. Input signal should be several volts, for maximum agc range.—W. H. Ellis, Jr., AGC Circuit Possesses 60-Decibel Gain, *Electronics*, Dec. 12, 1966, p 107–108.


1.0μf
e1
INPUT
10k
1.0k
-K
OPERATIONAL AMPLIFIER
e2
OUTPUT
D
S
G
MEM511
ADDITIONAL STAGES IF USED
GAIN-CONTROL INPUT
20 khz
-10
HIGH GAIN
MEDIUM GAIN
LOW GAIN

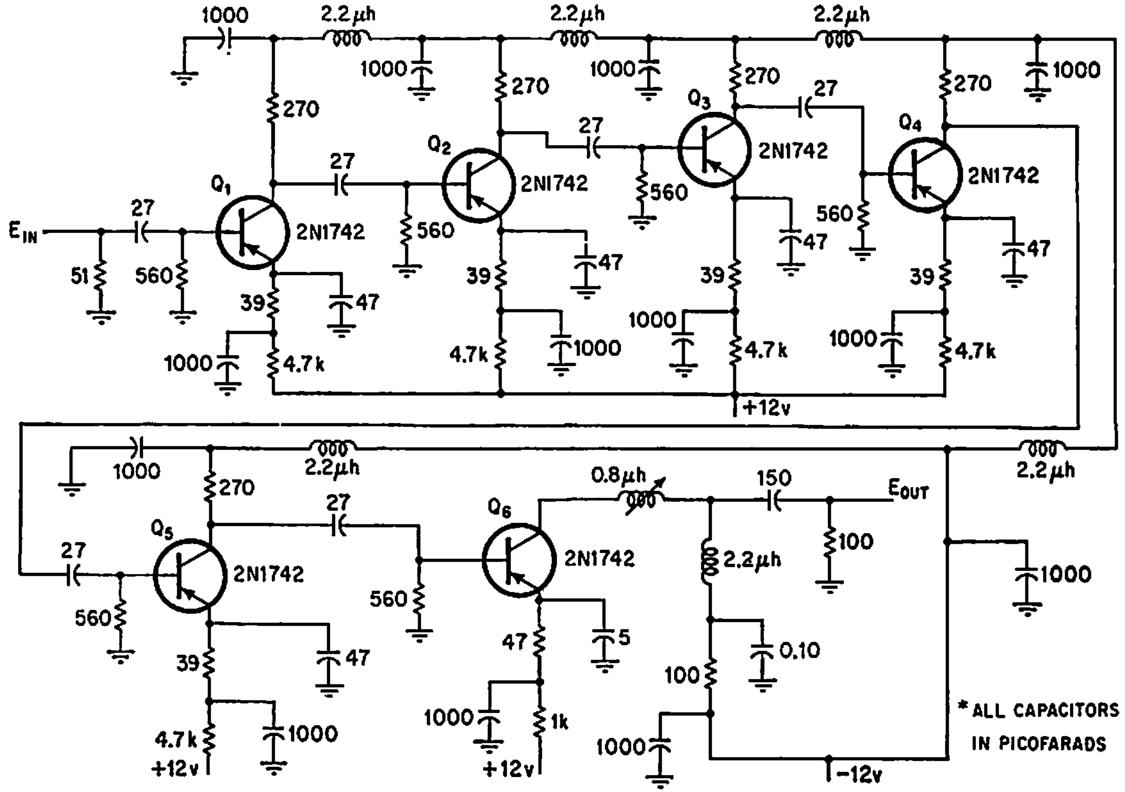
CHOPPER-CONTROLLED GAIN—Gain of any opamp may be varied over 32-dB range by varying ratio of OFF and ON times of 20-kHz pulse-width-modulated source applied to single fet. Resulting chopping of input to opamp, at significantly higher rate than upper cutoff frequency of amplifier, attenuates input signal during pulse ON time while giving normal gain during OFF time.—D. E. Lancaster, Operational Amplifier Gain Varied by FET Chopper, *Electronics*, Oct. 2, 1967, p 98.


+ 15 V
1N753
10K
100K
INPUT
10K
100
5500
7
8
1
2
6
3
4
33pF
9302
2
3
5
6
4
8
OUTPUT
0.33 uF
C
100K
33pF
R
10K
- 15 V
10K
1N753A
100K
1uF
33pF
33pF
9302
10K
1K
10K
33pF
9302
10K
1N270
10K
33pF
1N270
+ 15 V

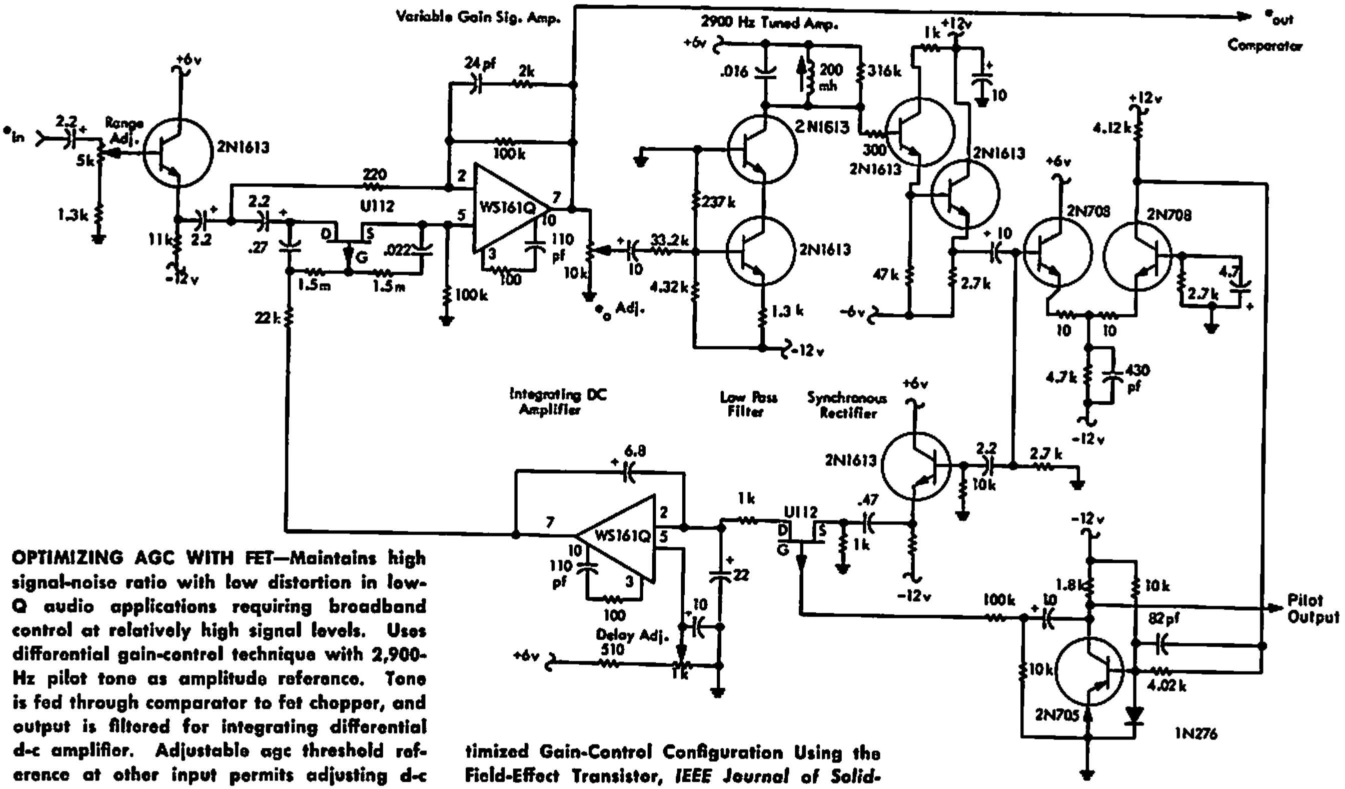
HIGH-ACCURACY AGC—Arrangement is that of multiplier, with input signal multiplied by corrective d-c voltage required to keep output level constant. Uses two-quadrant 5500 multiplier with 9302 opamp for this function, giving 10 V output level of both polarities. Output a-c signal is full-wave rectified, amplified, integrated, and its d-c level shifted to control multiplier. 1N753A diode provides d-c level compatibility.—An Accurate AGC Amplifier Using OEI Monolithic Circuits, Optical Electronics, Tucson, Ariz., No. 10161.


Vcc +28 V
510
FENWAL GB28J1
TR2
T
"A"
0.001
0.001
T1
T2
75 IN
3.3K
TR1
FENWAL GC31L1
0.001
RFC
WIDE BAND AMPLIFIER
30 db
2N1613
Q2
Q1
20db
0.02μf
DC CONTROL IN

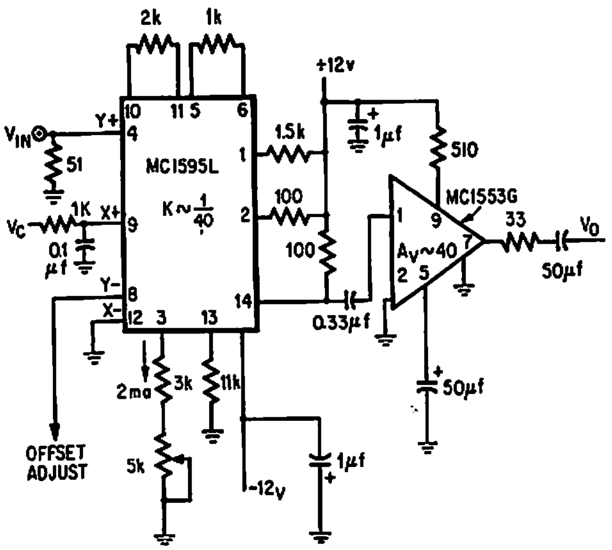
DARLINGTON ATTENUATOR—Provides electronically variable agc control of wideband amplifier without degrading performance. Both transformers have 4:1 impedance ratio. Both Darlington transistors are 2N1613. Used in CATV.—P. J. Fung, Variable Attenuator Provides AGC Control, *Electronic Design*, Sept. 28, 1964, p 54.


1000
2.2μh
2.2μh
2.2μh
1000
1000
1000
270
270
270
270
27
27
27
27
Q1
Q2
Q3
Q4
2N1742
2N1742
2N1742
2N1742
E_IN
51
560
560
560
560
39
39
39
39
47
47
47
47
1000
1000
1000
1000
4.7k
4.7k
4.7k
4.7k
+12v
1000
2.2μh
2.2μh
Q5
Q6
2N1742
2N1742
0.8μh
150
E_OUT
100
2.2μh
0.10
100
47
5
1k
1000
1000
1000
+12v
+12v
−12v
*ALL CAPACITORS IN PICOFARADS

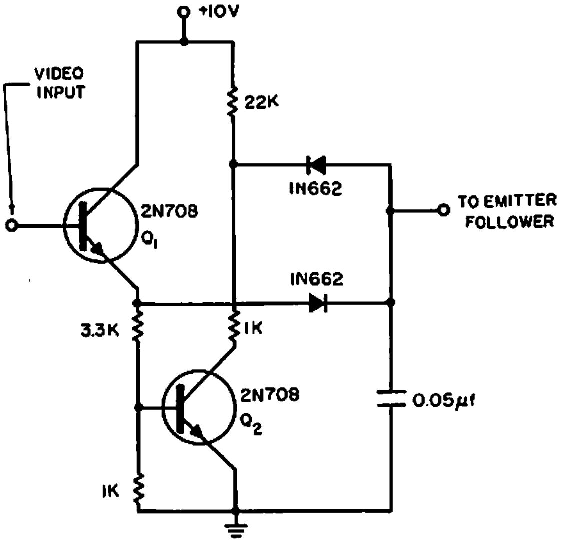
CONSTANT-OUTPUT LIMITER—Provides constant output essentially independent of changes in input amplitude, without introducing phase shift. Limiting begins at input level of 9 mV, and circuit holds output level constant within 0.06 dB even though input level increases 50 dB. Output stage Q6 has resonant circuit tuned to 80 MHz and drives 50-ohm or 100-ohm cable. Upper cutoff frequency of 100 MHz is limited only by transistors used.—R. J. Turner, Transistors Improve High-Frequency Limiter, *Electronics*, Oct. 13, 1969, p 94.


Variable Gain Sig. Amp.
2900 Hz Tuned Amp.
e_out
Comparator
e_in
2.2
Range Adj.
5k
1.3k
2N1613
+6v
11k
2.2
−12v
2.2
.27
24pf
2k
100k
220
U112
D
S
G
.022
1.5m
1.5m
WS161Q
110 pf
100
100k
22k
10
33.2k
10k
e_o Adj.
.016
200 mh
316k
2N1613
300
2N1613
237k
4.32k
2N1613
1.3k
−12v
1k
+12v
10
2N1613
47k
2.7k
−6v
10
2N708
2N708
4.12k
+12v
4.7
2.7k
10
10
4.7k
430 pf
−12v
Integrating DC Amplifier
Low Pass Filter
Synchronous Rectifier
+6v
2N1613
2.2
2.7k
10k
6.8
WS161Q
110 pf
100
Delay Adj.
510
1k
+6v
1k
U112
D
S
G
.47
1k
22
10
−12v
−12v
1.8k
10k
100k
10
82pf
Pilot Output
10k
2N705
4.02k
1N276

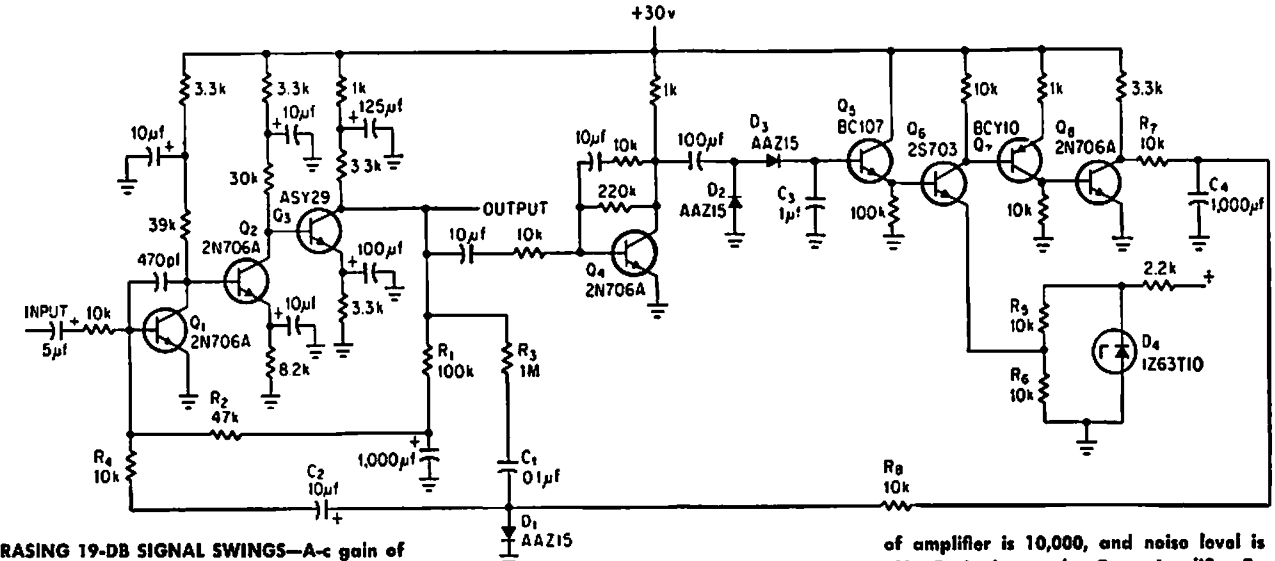
OPTIMIZING AGC WITH FET—Maintains high signal-noise ratio with low distortion in low-Q audio applications requiring broadband control at relatively high signal levels. Uses differential gain-control technique with 2,900-Hz pilot tone as amplitude reference. Tone is fed through comparator to fet chopper, and output is filtered for integrating differential d-c amplifier. Adjustable agc threshold reference at other input permits adjusting d-c output of amplifier.—H. N. Leighton, An Optimized Gain-Control Configuration Using the Field-Effect Transistor, *IEEE Journal of Solid-State Circuits*, Dec. 1968, p 441–447.


2k
1k
+12v
10
11
5
6
VIN
Y+
4
51
MC1595L
1
1.5k
1μf
510
1K
X+
9
K≈1/40
2
100
MC1553G
VC
0.1 μf
100
1
9
33
VO
AV≈40
7
2
5
50μf
Y-
8
14
X-
12
3
13
0.33μf
50μf
2ma
3k
11k
OFFSET ADJUST
5k
1μf
-12v

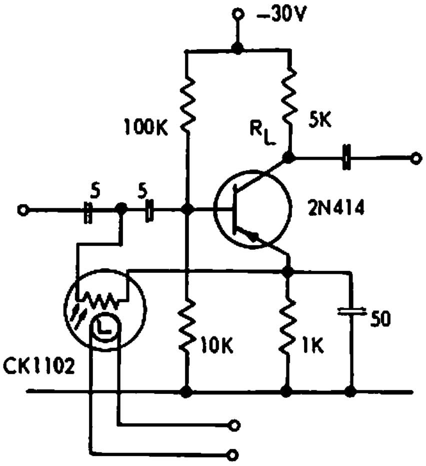
AGC WITH IC MULTIPLIER—Circuit requires 0-1 V d-c control voltage to provide linear gain control of 1-V p-p signal at 200 kHz. Peak-to-peak value of output is thus exactly the same as value of control voltage. Gain is recovered with IC video amplifier having gain of 40.—E. Renschler and D. Weiss, Try the Monolithic Multiplier as a Versatile A-C Design Tool, *Electronics*, June 8, 1970, p 100–105.


+10V
VIDEO INPUT
22K
IN662
TO EMITTER FOLLOWER
2N708
Q1
IN662
3.3K
1K
2N708
Q2
0.05μf
1K

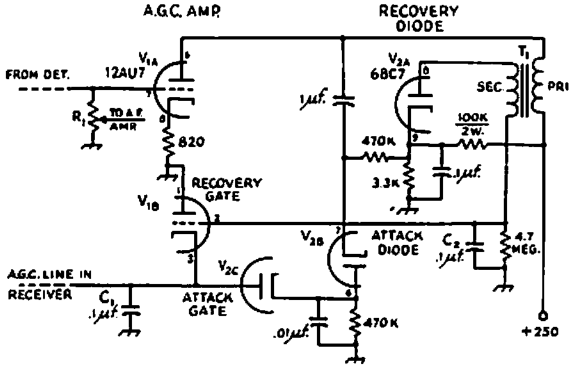
BOXCAR FOR PULSE AGC—Provides control over gain of video amplifier when both pulse width and frequency are variable. Used to keep amplitude of r-f burst constant despite variations in signal amplitude, frequency, or pulse width. Boxcar circuit is sample-and-hold integrator. Output of standard emitter-follower is desired agc voltage to be applied to controlled amplifier. With values shown, circuit will handle inputs of 2 to 8 V at 1 to 50 kHz and pulse widths of 5 to 500 μs.—G. P. Klein, Boxcar Circuit Provides Pulse Amplifier AGC, *Electronic Design*, Sept. 13, 1965, p 83–84.


+30v
3.3k
3.3k
1k
125μf
10μf
10μf
3.3k
30k
ASY29
Q3
39k
Q2
2N706A
470pf
100μf
INPUT
10k
5μf
Q1
2N706A
10μf
3.3k
8.2k
R2
47k
OUTPUT
10μf
10k
R1
100k
R3
1M
1,000μf
R4
10k
C2
10μf
C1
0.1μf
D1
AAZ15
1k
10μf
10k
100μf
D3
AAZ15
220k
D2
AAZ15
C3
1μf
Q4
2N706A
Q5
BC107
100k
Q6
2S703
10k
BCY10
Q7
1k
Q8
2N706A
10k
3.3k
R7
10k
C4
1,000μf
2.2k
+
R5
10k
D4
1Z63T10
R6
10k
R8
10k

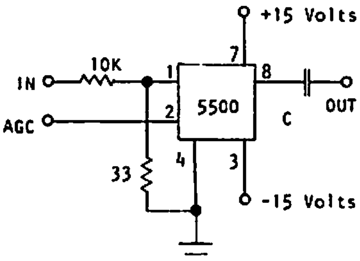
ERASING 19-DB SIGNAL SWINGS—A-c gain of 10–50,000 Hz amplifier is automatically controlled by error signal that changes dynamic resistance of diode D1 in feedback loop. Used in system for determining density of plasma in microwave cavity. Maximum gain of amplifier is 10,000, and noise level is 20 μV.—C. A. J. van der Geer, Amplifier Erases Swing of 19-DB in Input Signals, *Electronics*, May 29, 1967, p 85–86.


-30V
100K
RL
5K
5
5
2N414
CK1102
10K
1K
50

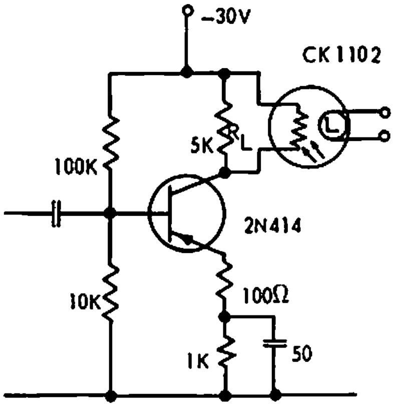
10-DB OPTOELECTRONIC—Uses photocell of Raysistor to shunt input of transistor, with one end of Raysistor tied to emitter to protect low-frequency response. Requires d-c control voltage of 0 to 1 V.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 12.


A.G.C. AMP.
RECOVERY DIODE
FROM DET.
V1A
12AU7
R1
TO A.F. AMP.
820
RECOVERY GATE
V1B
A.G.C. LINE IN RECEIVER
C1
.1µf.
ATTACK GATE
V2C
1µf.
V2A
6BC7
SEC.
PRI
T1
100K 2W.
470K
3.3K
.1µf.
V2B
ATTACK DIODE
C2
.1µf.
4.7 MEG.
.01µf.
470K
+250

AGC FOR SSB—Provides fast attack and slow decay, for improved reception with ssb receiver. R1 is normal volume control in receiver and T1 is 1:3 step-up audio transformer such as Stancor A-53. Uses audio drive from output of detector in receiver. Requires receiver having good skirt selectivity, with no d-c return from agc line to ground.—G. W. Luick, Improved A. G. C. For S. S. B. Reception, "Single Sideband for the Radio Amateur," ARRL, Newington, Conn., 1965, p 180.


+15 Volts
IN
10K
AGC
1
2
7
8
5500
C
OUT
33
4
3
-15 Volts

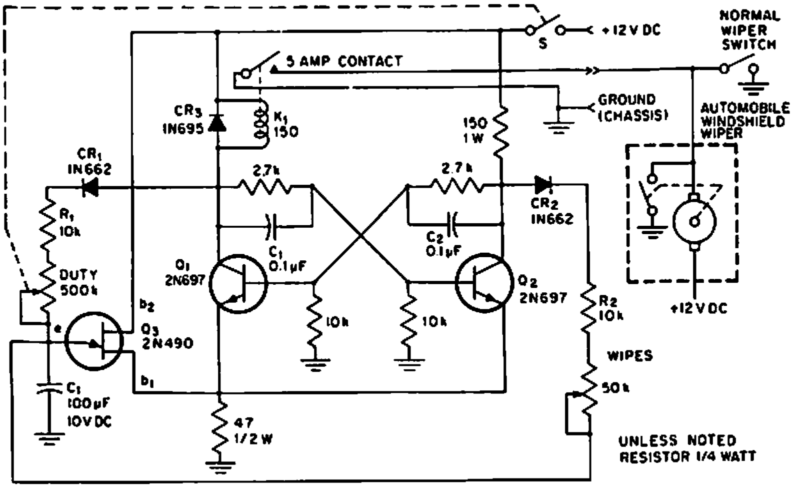
VOLTAGE-CONTROLLED GAIN—Analog multiplier makes agc voltage act on input signal up to 100 kHz, to give over 40 dB of agc range with low distortion. If signal level is under 10 mV at input, resistive divider is not needed and 5500 will then provide useful voltage gain.—Applying the Model 5500 Monolithic Analog Multiplier, Optical Electronics, Tucson, Ariz., No. 10138.


-30V
CK1102
100K
5K
RL
2N414
10K
100Ω
1K
50

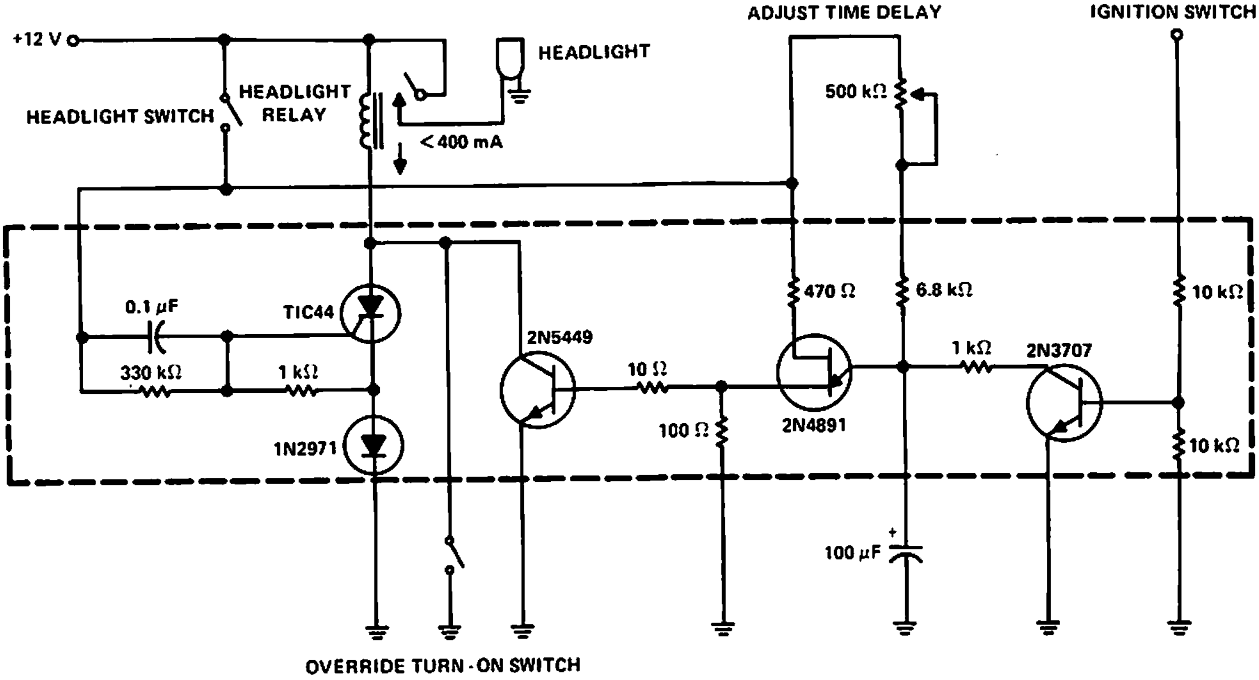
15-DB OPTOELECTRONIC—Uses Raysistor in collector circuit, so collector load decreases and reduces gain when input increases. Changing load resistance RL to 15K increases control range to over 30 dB for d-c control voltage of 0 to 1 V.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 12.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

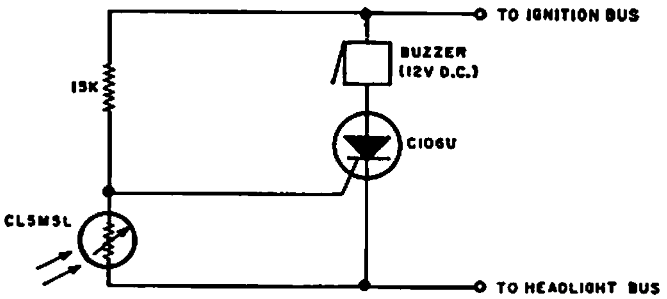
CHAPTER 6
Automotive Control Circuits


NORMAL WIPER SWITCH
S
+12 V DC
5 AMP CONTACT
GROUND (CHASSIS)
AUTOMOBILE WINDSHIELD WIPER
CR3 1N695
K1 150
150 1 W
CR1 1N662
2.7k
2.7k
CR2 1N662
R1 10k
C1 0.1μF
C2 0.1μF
Q1 2N697
Q2 2N697
DUTY 500k
b2
e
Q3 2N490
b1
10k
10k
R2 10k
+12 V DC
WIPES
50k
C1 100μF 10V DC
47 1/2 W
UNLESS NOTED RESISTOR 1/4 WATT

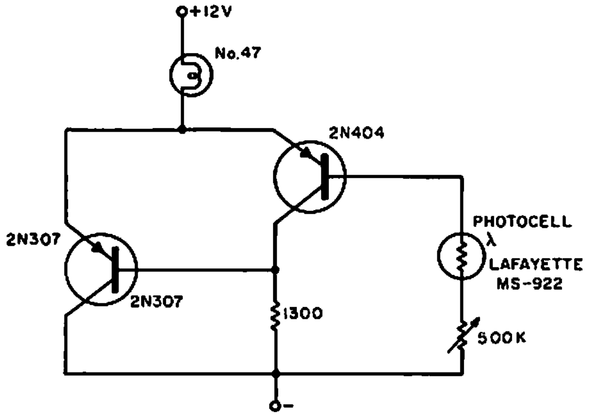
VARIABLE WIPER—Flip-flop drives ujt timer and wiper motor relay. Setting of duty pot determines interval, in range of 1 to 80 s, at which ujt timer Q3 will be activated and power applied to wiper motor through flip-flop. Setting of WIPES pot determines interval before flip-flop is switched back, in range of 1 to 8 s. Typical setting is 1 s for single wiping action. Chief advantage is ability to set wiper for operation at long time intervals, such as once every 30 s, for very light rain.—J. L. Shagena and T. H. Miller, Variable Control for Automobile Windshield Wiper, *EEE*, June 1969, p 140–141.


ADJUST TIME DELAY
IGNITION SWITCH
+12 V
HEADLIGHT
HEADLIGHT SWITCH
HEADLIGHT RELAY
<400 mA
500 kΩ
0.1 μF
TIC44
470 Ω
6.8 kΩ
10 kΩ
2N5449
1 kΩ
2N3707
330 kΩ
1 kΩ
10 Ω
100 Ω
2N4891
1N2971
10 kΩ
100 μF
+
OVERRIDE TURN-ON SWITCH

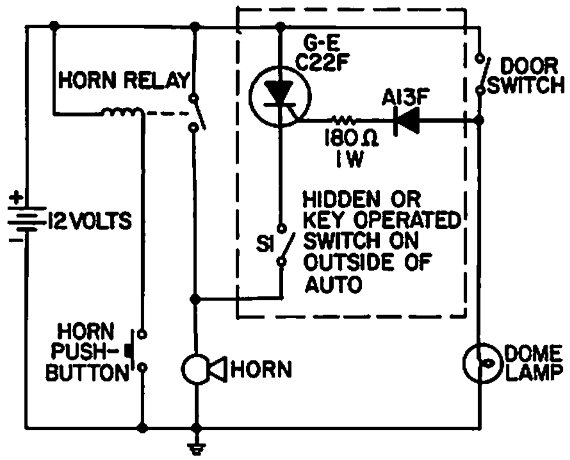
AUTOMATIC HEADLIGHT SWITCH—Headlights in car are turned off automatically in from 1 s to 15 minutes after ignition is turned off, with amount of delay being adjustable with 500K pot. Ujt is used as timer. —"Preferred Semiconductors and Components," Texas Instruments, Dallas, Texas, CC101, 1968, p 24114A.


TO IGNITION BUS
BUZZER (12V D.C.)
15K
C106U
CL5M5L
TO HEADLIGHT BUS

SCR HEADLIGHT-OFF ALARM—Sounds buzzer until headlights are turned on after dark. Mount photocell on inside of windshield facing out. If buzzer sounds too early, before it is dark enough for headlights, increase resistor value. Circuit is for negative ground; for positive ground, interchange connections to headlight and ignition bus.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.

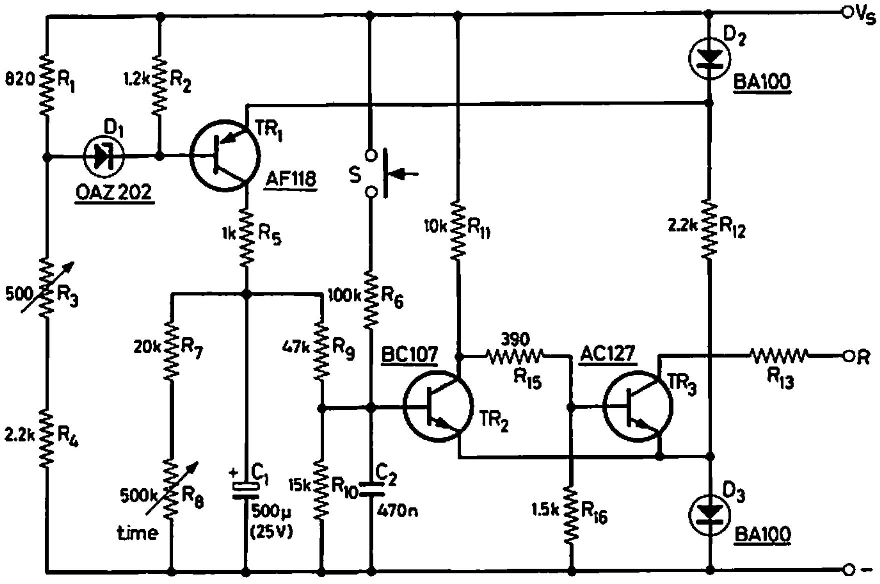

+12V
No.47
2N404
2N307
2N307
1300
PHOTOCELL
λ
LAFAYETTE
MS-922
500K
-

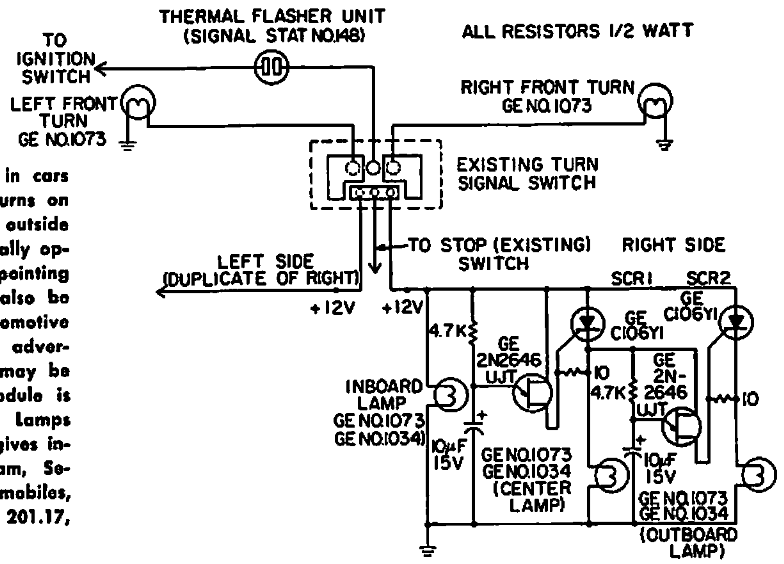
HEADLIGHT BURNOUT INDICATOR—Turns on pilot lamp on dashboard if photocell mounted near edge of headlight does not pick up light when headlight switch is turned on. Circuit is Schmitt trigger. Designed for 12-V battery with negative ground. Can also be used to monitor tail-light or stoplight.—M. Dickey, Inexpensive Circuit Makes Remote Light Indicator, *Electronic Design*, Sept. 14, 1964, p 75–76.


HORN RELAY
G-E C22F
A13F
DOOR SWITCH
180Ω 1W
+
12VOLTS
-
HIDDEN OR KEY OPERATED SWITCH ON OUTSIDE OF AUTO
S1
HORN PUSH-BUTTON
HORN
DOME LAMP

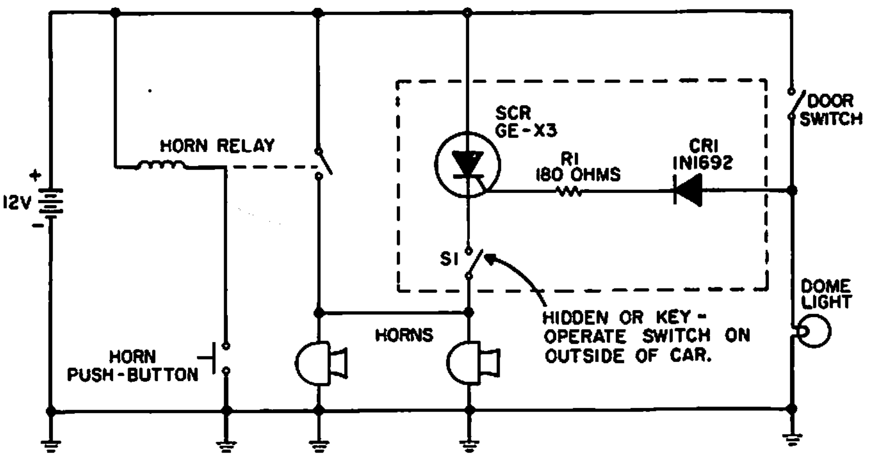
AUTO THEFT ALARM—Simple scr control, energized by closing S1, latches in when door of car is opened by thief and keeps horn blowing continuously until S1 is opened. Used in many London taxis; police have master key for key switch S1 mounted on left front fender, to turn off horn after catching thief. —F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 4.

ELECTRIC CAR FUEL GAGE—Monitors discharge rate of 24-V battery in electrically powered vehicle. Turns on lamp to warn that battery has discharged enough to require immediate attention, and disconnects motor before battery is damaged. Includes override button that can be held down to get vehicle out of hazardous traffic situation. Action of voltage sensor can be adjusted to allow for age, history, and nominal output voltage of individual batteries. Report describes auxiliary measuring circuit that displays battery output voltage against expanded scale covering important range from nominal maximum charge to critical discharge (corresponding to fuel gage indication).—Battery Discharge Sensor for Electrically Powered Vehicles, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 434, 1966.

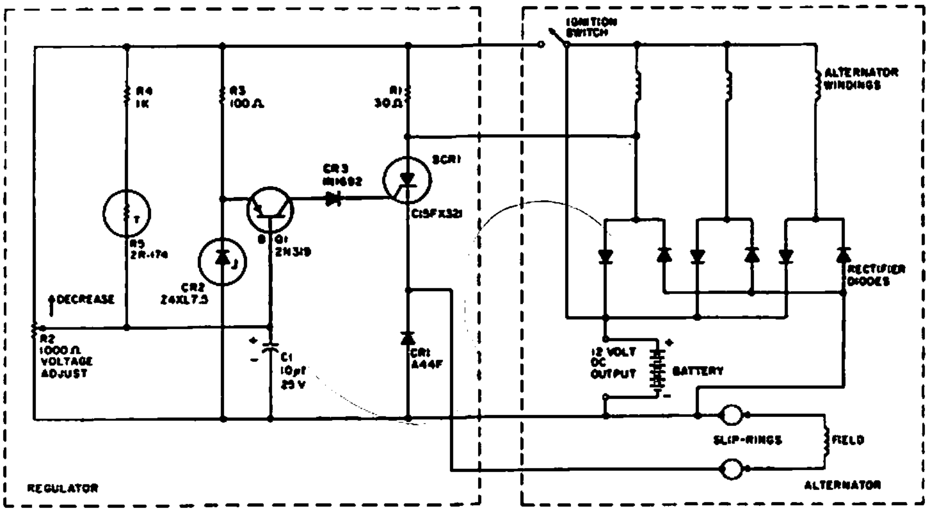

V_S
820 R_1
1.2k R_2
D_1
OAZ202
TR_1
AF118
S
D_2
BA100
1k R_5
10k R_{11}
2.2k R_{12}
500 R_3
100k R_6
20k R_7
47k R_9
BC107
390
R_{15}
AC127
TR_3
R
R_{13}
TR_2
2.2k R_4
500k R_8
time
C_1
500μ (25V)
15k R_{10}
C_2
470n
1.5k R_{16}
D_3
BA100
-


THERMAL FLASHER UNIT (SIGNAL STAT NO.148)
ALL RESISTORS 1/2 WATT
TO IGNITION SWITCH
LEFT FRONT TURN GE NO.1073
RIGHT FRONT TURN GE NO.1073
EXISTING TURN SIGNAL SWITCH
LEFT SIDE (DUPLICATE OF RIGHT)
TO STOP (EXISTING) SWITCH
RIGHT SIDE
+12V
+12V
SCR1
SCR2
GE C106Y1
GE C106Y1
4.7K
GE 2N2646 UJT
10
4.7K
GE 2N-2646 UJT
10
INBOARD LAMP GE NO.1073 GE NO.1034
10μF 15V
GE NO.1073 GE NO.1034 (CENTER LAMP)
10μF 15V
GE NO.1073 GE NO.1034 (OUTBOARD LAMP)

SEQUENTIAL TURN SIGNAL—For use in cars having three rear lights per side. Turns on rear lights in sequence from center to outside when turn-signal switch is conventionally operated, to simulate flashing arrow pointing in direction of intended turn. Can also be used with any other three 12-V automotive lamps for beacons, barricade lights, advertising signs, etc. Additional stages may be added, provided thermal flasher module is changed to have required capacity. Lamps are energized 0.25 s apart. Article gives installation instructions.—D. R. Grafham, Sequential Turn Signal System for Automobiles, General Electric, Syracuse, N.Y., No. 201.17, 1966.

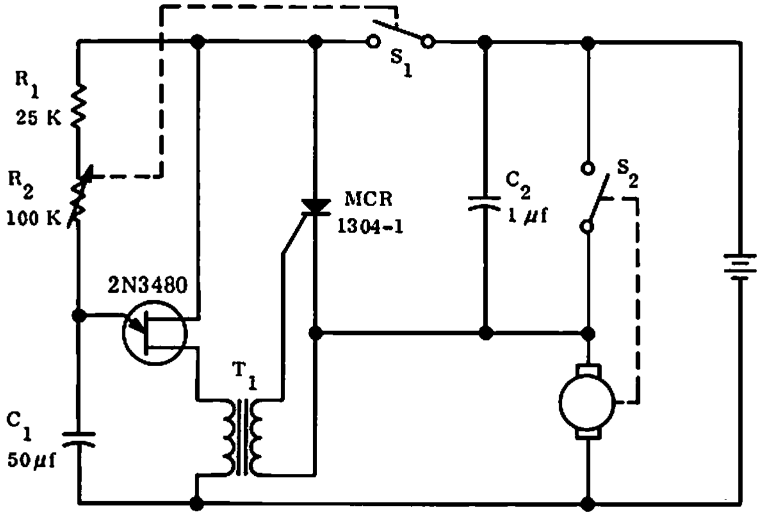

+
12V
-
HORN RELAY
HORN PUSH-BUTTON
SCR GE-X3
R1 180 OHMS
CR1 1N1692
S1
HORNS
HIDDEN OR KEY-OPERATE SWITCH ON OUTSIDE OF CAR.
DOOR SWITCH
DOME LIGHT

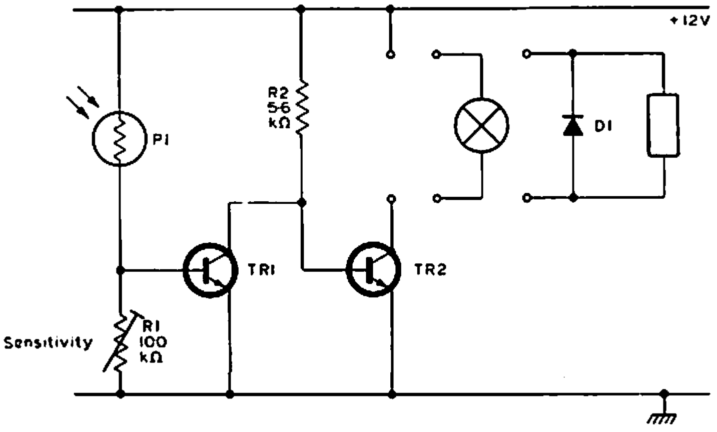
BURGLAR ALARM—Circuit is activated by closing S1 after leaving car. When any door is then opened that has switch for turning on dome light, scr is triggered and applies power to horns. Once activated, horns can be turned off only by opening concealed or key-operated switch S1. To prevent horns from going off when returning to car, open S1 before opening door. Arrangement shown applies only to negative-grounded cars.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 50.


R4 1K
R3 100Ω
R1 30Ω
SCR1
CR3 1N1692
C15FX321
T
R5 2R-174
CR2 Z4XL7.5
Q1 2N319
DECREASE
R2 1000Ω VOLTAGE ADJUST
+
-
C1 10μf 25V
CR1 A44F
REGULATOR
IGNITION SWITCH
ALTERNATOR WINDINGS
RECTIFIER DIODES
12 VOLT DC OUTPUT
+
BATTERY
-
SLIP-RINGS
FIELD
ALTERNATOR

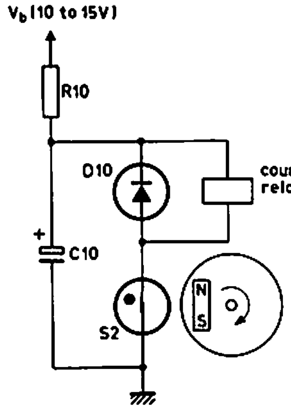
ALTERNATOR REGULATOR—Scr control circuit applies rectified output of alternator to 12-V auto battery whenever it is in need of charge, and automatically opens when battery is fully charged. To adjust, connect voltmeter across battery, with engine running at moderate speed, and turn R2 in direction of higher voltage until battery voltage levels off at 14.5 V for normal room temperature (use 15 V if adjusting outdoors at 0 F).—Automotive Alternator Regulator, General Electric, Auburn, N.Y., No. 630.15.

SCR WINDSHIELD WIPER CONTROL—R2 controls repetition rate at which windshield wiper motor is energized to drive blade across windshield and back at full wiping speed. Connections shown are for negative ground. Used to operate wiper less frequently when rain is light, without slowing blade so much that it interferes with vision or perhaps stalls part-way across.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 6–3–2.

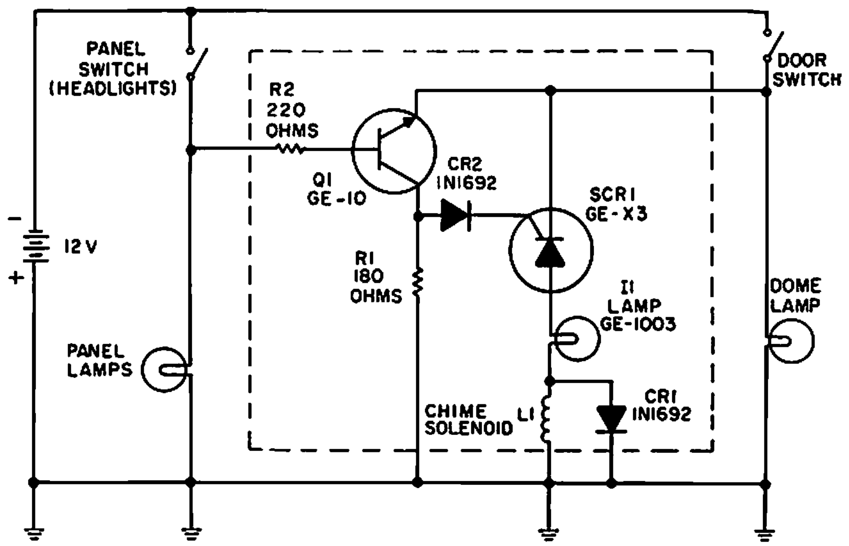

R_1
25 K
R_2
100 K
2N3480
C_1
50µf
T_1
MCR
1304-1
S_1
C_2
1 µf
S_2


+12V
R2
5·6
kΩ
P1
D1
TR1
TR2
Sensitivity
R1
100
kΩ

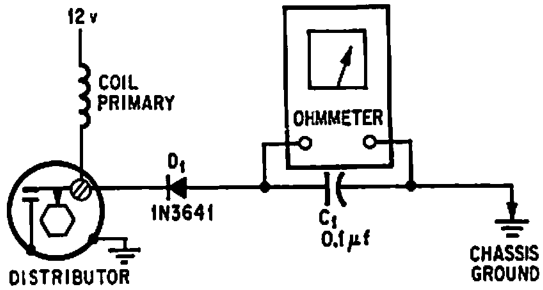
PARKING-LIGHT TURN-ON—Simple two-transistor d-c amplifier requires only two resistors and photocell to energize lamp or relay load. Can be used to turn on 12-V 2.2-W automobile parking light automatically when darkness falls. Power limitation is due to fact that current in TR2 increases gradually as light is reduced, making dissipation in transistor high during transitional period. With maximum setting of sensitivity control, lamp is energized at 1 lux and deenergized at 3.3 lux. At minimum sensitivity, lamp comes on at 0.1 lux and goes off at 0.5 lux. Transistors are BFY52 and P1 is ORP60 or ORP61.—Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


V_b (10 to 15V)
R10
D10
count
relay
+
C10
S2
N
S

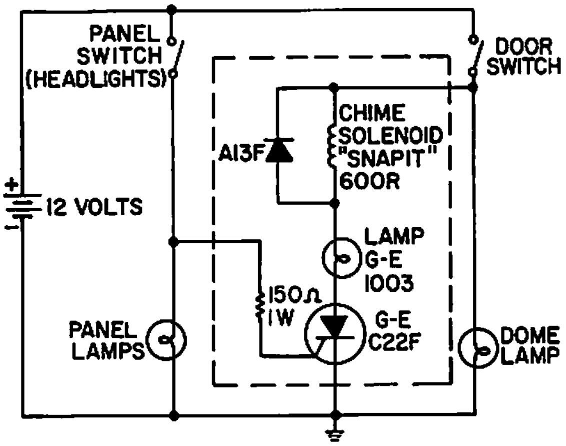
ODOMETER—Magnet on transmission shaft or driveshaft trips reed relay once per 100 revolutions to actuate electromechanical count relay that, in European version, advances count once per 100 meters of distance moved by car. Uses 100:1 reduction gear between shaft and rotating magnet. Diode is BAX13, S2 is reed contact, R10 is 1K, and C10 is 470 µF.—A. G. Kerteling, Electronic Speedometer/Odometer Using Reed Contact Type Signal Transmitter, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 89, 1970.


PANEL
SWITCH
(HEADLIGHTS)
R2
220
OHMS
Q1
GE-10
CR2
1N1692
SCR1
GE-X3
DOOR
SWITCH
−
12V
+
R1
180
OHMS
I1
LAMP
GE-1003
DOME
LAMP
PANEL
LAMPS
CHIME
SOLENOID
L1
CR1
1N1692

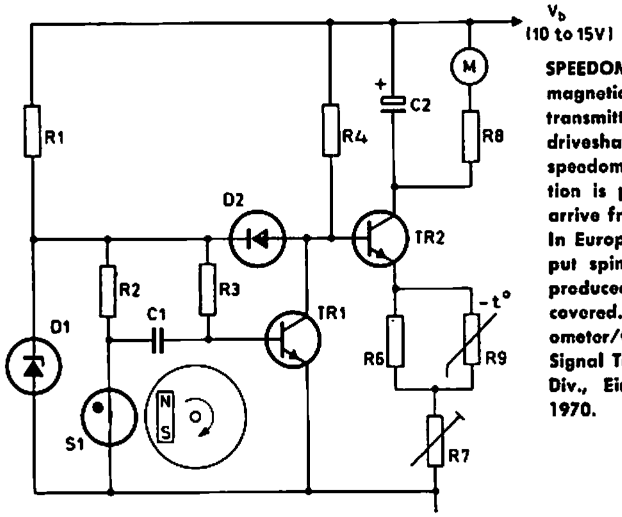
POSITIVE-GROUND LIGHTS-ON CHIME—Scr circuit actuates chime once when car door is open with lights on, as reminder to turn lights off. Single-stroke feature gives gentle reminder without becoming nuisance when door is kept open for loading or unloading passengers. Lamp in series with chime provides supplemental continuous visual indication without overheating chime solenoid, because lamp has much higher resistance when hot than when cold.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 46.


12 v
COIL PRIMARY
OHMMETER
D1
1N3641
C1
0.1μf
CHASSIS GROUND
DISTRIBUTOR

DWELL ANGLE—Simple diode-capacitor arrangement permits use of ohmmeter to measure breaker-point dwell angle (portion of rotation during which points are closed). With engine running, ohmmeter reads average of infinite resistance when points are open and zero resistance when closed. Article tells how to calculate dwell angle for engines with four, six, and eight cylinders.—E. W. Herrigan, Ohmmeter and Diode Measure Dwell Angle, *Electronics*, Aug. 5, 1968, p 105–106.


PANEL SWITCH (HEADLIGHTS)
DOOR SWITCH
CHIME SOLENOID "SNAPIT" 600R
A13F
12 VOLTS
LAMP G-E 1003
150Ω 1W
G-E C22F
PANEL LAMPS
DOME LAMP

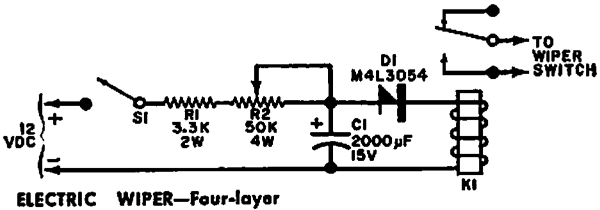
BATTERY-SAVER—Simple scr circuit makes chime ring if car door is opened while headlights are on, as reminder to turn them off. —F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 4.


V_b (10 to 15V)
M
C2
R1
R4
R8
D2
TR2
-t°
R2
R3
C1
TR1
D1
R6
R9
S1
N
S
R7

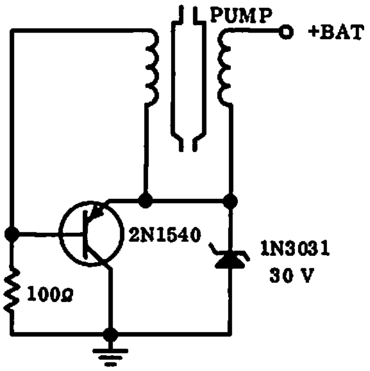
SPEEDOMETER—Monostable mvbr is driven by magnetically actuated reed contact in signal transmitter coupled either to transmission or driveshaft of auto, eliminating need for speedometer-odometer cable. Meter indication is proportional to rate at which pulses arrive from transmitter when car is in motion. In European version, speed of transmitter input spindle was such that reed contacts S1 produced one pulse per meter of distance covered.—A. G. Korteling, Electronic Speedometer/Odometer Using Reed Contact Type Signal Transmitter, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 89, 1970.

R1 = 680 Ω
R2 = 10 kΩ
R3 = 10 kΩ
R4 = 1.5 kΩ
R6 = 68 Ω
R7 = 100 Ω, potentiometer
R8 = 1 kΩ
R9 = 130 Ω, NTC thermistor

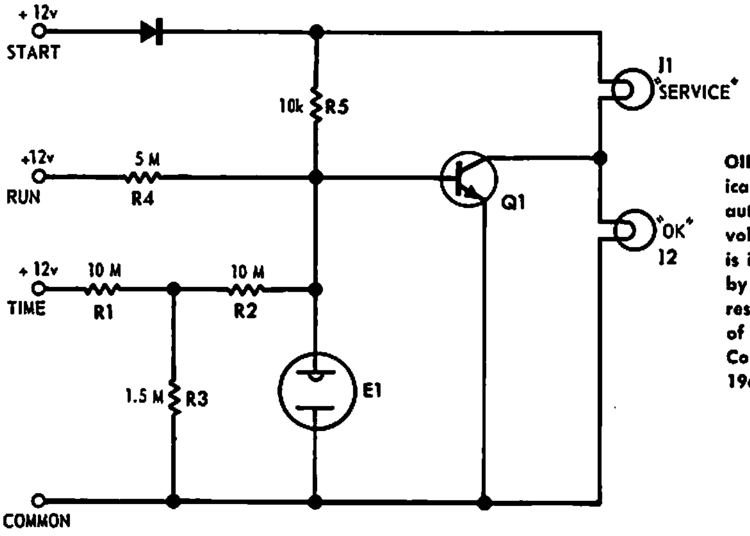
C1 = 270 nF
C2 = 330 μF
D1 = BZY88-C5V6
D2 = BAX13
TR1, TR2 = BC147
S1 = Reed contact RI-12
M = Moving coil meter 5 mA, 0.6 V


TO WIPER SWITCH
D1
M4L3054
12 VDC
+
−
S1
R1
3.3K
2W
R2
50K
4W
+
C1
2000μF
15V
K1

SLOWING UP ELECTRIC WIPER—Four-layer diode D1 in simple relaxation oscillator drives relay K1 which in turn controls switch of electric windshield wiper motor. R2 determines rate at which C1 is charged to point where it breaks down D1 and operates wiper. When C1 discharges below 1 mA, D1 turns off and relay drops out for start of new cycle. Will work with either ground polarity. —C. A. Huber, Slow-Kick Windshield Wiper, *Popular Electronics*, April 1970, p 86.

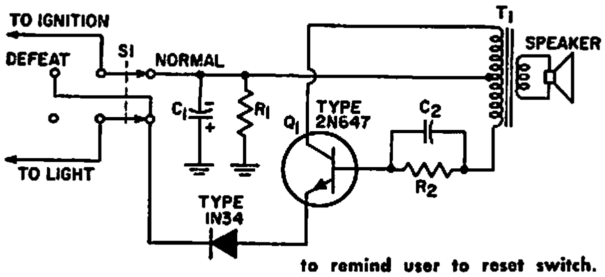

PUMP
+BAT
2N1540
1N3031
30 V
100Ω

FUEL PUMP OSCILLATOR WITH ZENER—30-V zener across transistor speeds decay of solenoid current after plunger has been pulled in, thereby increasing frequency of operation and pumping rate. Designed to give 16 strokes of plunger per second with battery voltage of 13.5 V.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 7–3–3.

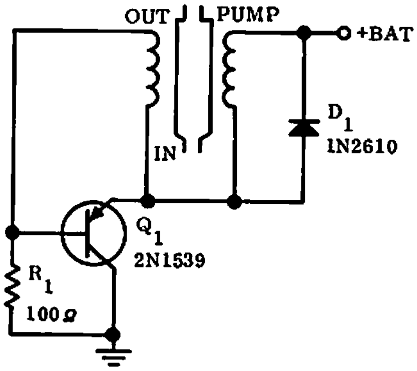

+12v
START
J1
SERVICE
10k R5
+12v
RUN
5 M
R4
Q1
OK
I2
+12v
TIME
10 M
R1
10 M
R2
1.5 M R3
E1
COMMON

Q1 = Philco PET 6002 or Equivalent
I1 = No. 161
I2 = No. 170SD

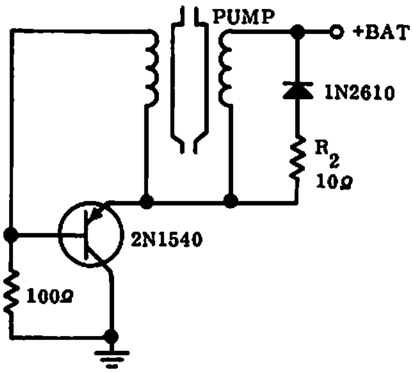
OIL-CHANGE COMPUTER—Simple electrochemical-cell circuit turns on lamp I1 when oil in auto engine should be changed. Factors involved are running time of engine, time oil is in engine, and number of cold starts made by engine. All three factors are weighted by resistors and used to control rate of transfer of platable material in cell E1.—J. Rose, E-Cell Computer Solves Oily Problem, *EDN*, Sept. 6, 1967, p 42–43.


TO IGNITION
DEFEAT
S1
NORMAL
TO LIGHT
C1
+
R1
Q1
TYPE 2N647
C2
T1
SPEAKER
R2
TYPE 1N34

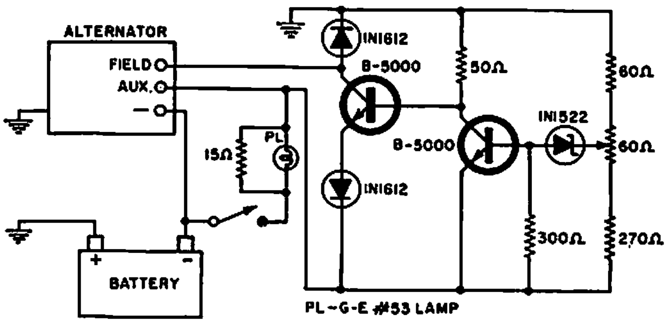
POSITIVE-GROUND HEADLIGHT ALARM—Speaker howls if ignition is turned off but lights left on. Can be defeated with S1, but alarm then sounds when ignition is turned on, to remind user to reset switch. C1 is 0.22 μF, C2 30 μF, R1 15K, and R2 680. Secondary of audio output transformer T1 should match speaker.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 517.


OUT
PUMP
+BAT
IN
D1
1N2610
Q1
2N1539
R1
100Ω

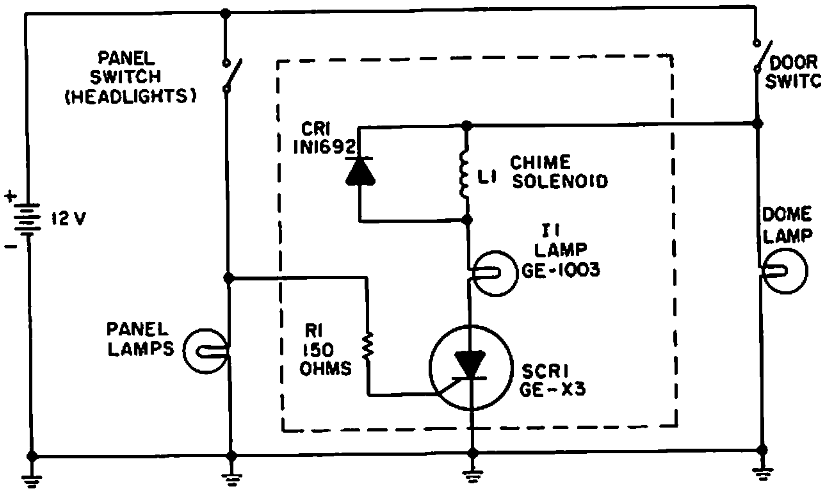
ELECTRIC FUEL PUMP—Basic blocking oscillator drives solenoid of Bendix plunger-type electric fuel pump, with feedback winding added to complete oscillator circuit. Transistor conducts for 25 ms to make plunger move full distance back into solenoid.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 7–3–1.


PUMP
+BAT
1N2610
R2
10Ω
2N1540
100Ω

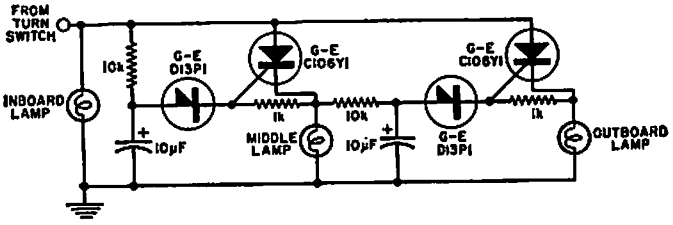
HIGH-SPEED ELECTRIC FUEL PUMP—Use of 10-ohm resistor R2 in series with diode across feedback winding of oscillator decreases off time of solenoid, thereby increasing frequency of operation and pumping rate.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 7–3–2.


ALTERNATOR
FIELD
AUX.
−
1N1612
B-5000
50Ω
60Ω
1N1522
B-5000
60Ω
15Ω
PL
1N1612
300Ω
270Ω
+
−
BATTERY
PL-G-E #53 LAMP

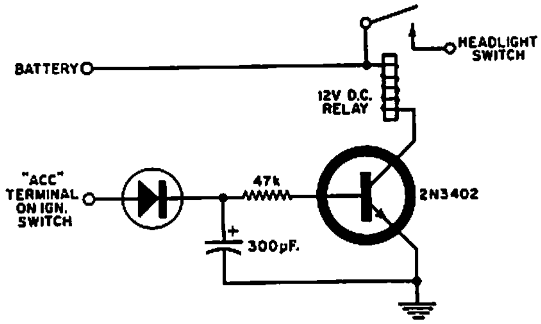
ALTERNATOR VOLTAGE REGULATOR—Uses two inexpensive Bendix plastic-encased power transistors rated at 25 W each and 35 V.—D. E. Lancaster, Plastic Power Transistors—Advantages and Applications, *Electronics World*, Feb. 1968, p 50–52.


PANEL SWITCH (HEADLIGHTS)
DOOR SWITCH
CR1 1N1692
L1
CHIME SOLENOID
+
12 V
-
DOME LAMP
I1 LAMP GE-1003
PANEL LAMPS
R1 150 OHMS
SCR1 GE-X3

NEGATIVE-GROUND LIGHTS-ON CHIME—Scr circuit actuates chime once when car door is open with lights on, as reminder to turn lights off. Single-stroke feature gives gentle reminder without becoming nuisance when door is kept open for loading or unloading passengers. Lamp in series with chime provides supplemental continuous visual indication without overheating chime solenoid, because lamp has much higher resistance when hot than when cold.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 46.

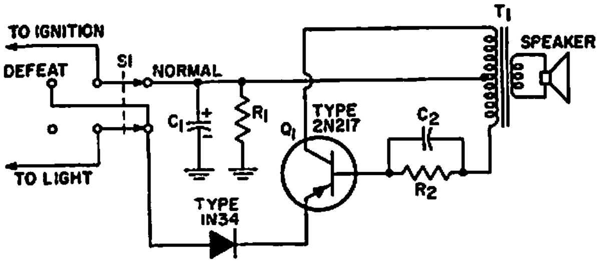

FROM TURN SWITCH
10k
G-E D13P1
G-E C106Y1
G-E C106Y1
INBOARD LAMP
1k
10k
1k
+
10μF
MIDDLE LAMP
10μF
+
G-E D13P1
OUTBOARD LAMP

SEQUENTIAL TAIL-LIGHTS—Uses scr's to create sequential tail-light flashing, in combination with D13P1 four-layer breakdown diodes to open the circuit and reset the scr's. Breakover occurs at 6 to 10 V.—R. M. Brown, Automotive Electronics, *Electronics World*, May 1967, p 23–29.


HEADLIGHT SWITCH
BATTERY
12V D.C. RELAY
"ACC" TERMINAL ON IGN. SWITCH
47k
2N3402
+
300μF.

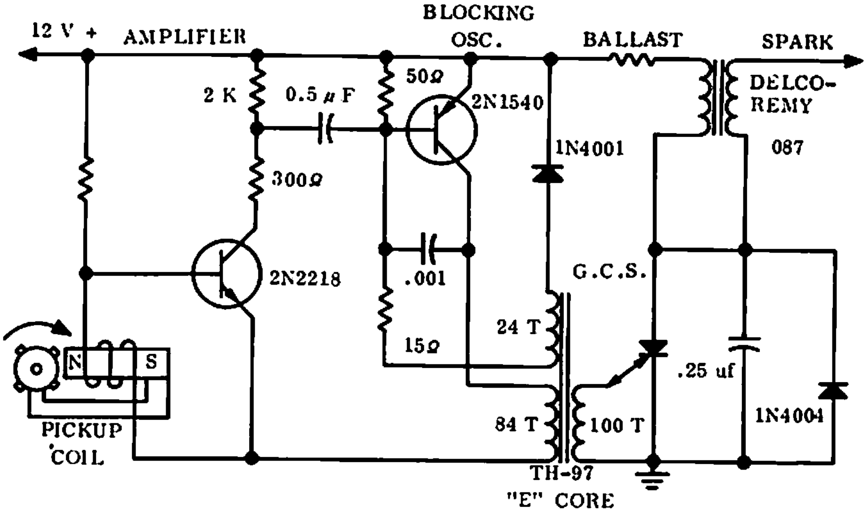
HEADLIGHT-OFF TIME DELAY—Gives 60 to 90 s after ignition switch is turned off, before turning off headlights automatically if driver forgets them or wants driveway lighted while he unlocks door to house.—R. M. Brown, Automotive Electronics, *Electronics World*, May 1967, p 23–29.

NEGATIVE-GROUND HEADLIGHT ALARM—Speaker howls if auto lights are on when ignition is turned off. Can be defeated with S1 if lights are left on intentionally, but alarm then sounds when ignition is turned back on to remind user that switch should be returned to normal position. C1 is 0.22 μF, C2 30 μF, R1 15K, and R2 680. Secondary of audio output transformer T1 should match speaker. —"Transistor Manual," RCA, Harrison, N.J., SC-13, p 517.

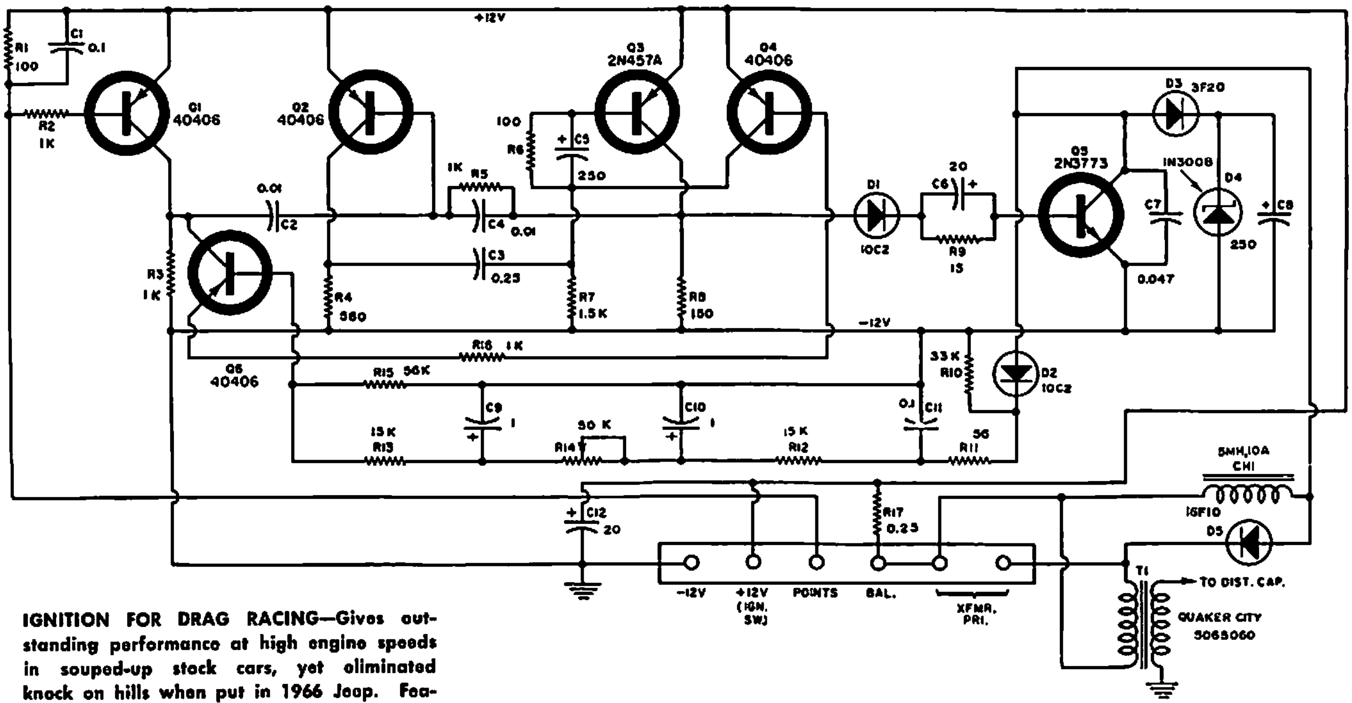

TO IGNITION
DEFEAT
S1
NORMAL
TO LIGHT
C1
+
R1
Q1
TYPE 2N217
C2
R2
T1
SPEAKER
TYPE 1N34

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

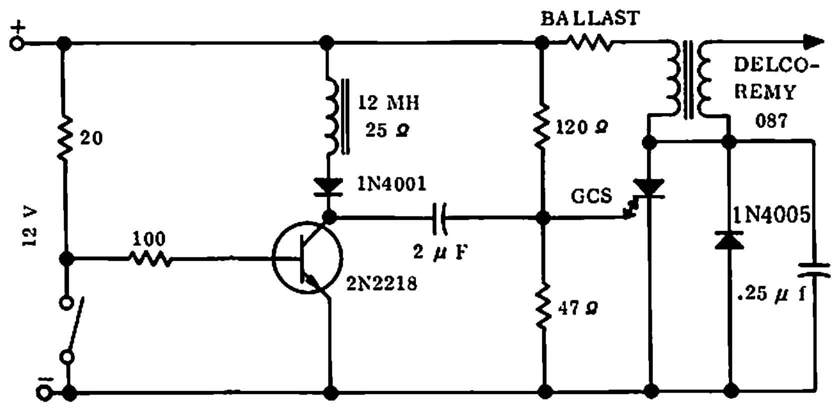
CHAPTER 7
Automotive Ignition Circuits


12 V +
AMPLIFIER
BLOCKING OSC.
BALLAST
SPARK
2 K
0.5 μF
50Ω
2N1540
DELCO-REMY 087
1N4001
300Ω
2N2218
.001
G.C.S.
24 T
15Ω
.25 uf
1N4004
N
S
PICKUP COIL
84 T
100 T
TH-97 "E" CORE

TRIGGERED ONE-SHOT IGNITION—Uses silicon gate control switch that turns on like scr but is turned off by small reverse voltage pulse applied to gate. Trigger can be obtained from magnetic pickup as shown, or from photoelectric pickup actuated by distributor shaft.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 11–18.

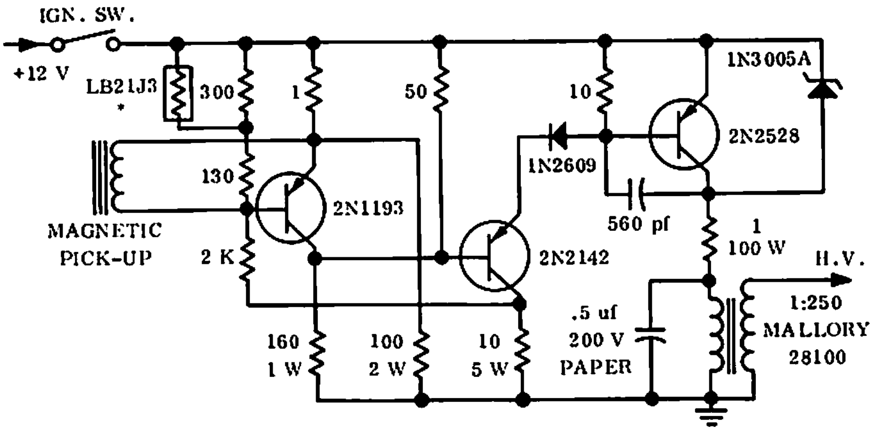

+12V
R1 100
C1 0.1
R2 1K
Q1 40406
Q2 40406
Q3 2N457A
Q4 40406
100 R6
C5 250
1K R5
0.01 C2
C4 0.01
C3 0.25
R3 1K
R4 560
R7 1.5K
R8 150
R16 1K
Q6 40406
R15 56K
C9 1
C10 1
15K R13
50 K R14
15 K R12
D1 10C2
20 C6
R9 15
Q5 2N3773
D3 3F20
1N3008 D4
C7 0.047
C8 250
-12V
33K R10
D2 10C2
0.1 C11
56 R11
C12 20
R17 0.25
5MH,10A CH1
16F10 D5
T1
TO DIST. CAP.
QUAKER CITY 5065060
-12V
+12V (IGN. SW)
POINTS
BAL.
XFMR. PRI.

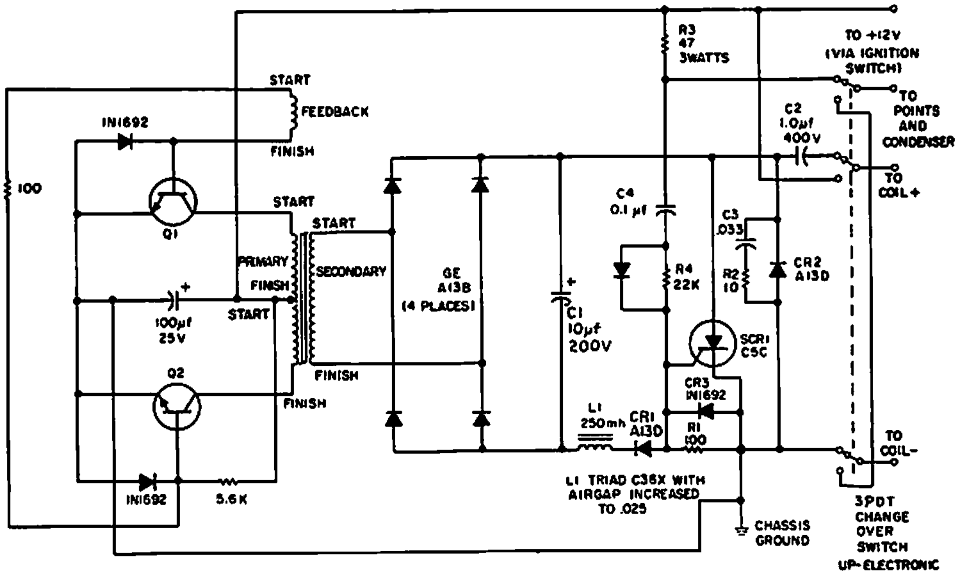
IGNITION FOR DRAG RACING—Gives outstanding performance at high engine speeds in souped-up stock cars, yet eliminated knock on hills when put in 1966 Jeep. Features include special storage choke coil and high-voltage pulse transformer that together provide hot spark long enough to assure complete ignition. Article describes system operation and adjustment procedures.—H. I. Keroes, High-"Q" Inductive Electronic Ignition System, *Electronics World*, July 1969, p 32–34 and 61–62.


+
BALLAST
DELCO-
REMY
087
20
12 V
12 MH
25 Ω
1N4001
120 Ω
GCS
1N4005
100
2 μ F
2N2218
.25 μ f
47 Ω
−

CAPACITOR-TURN-OFF IGNITION—Uses silicon gate control switch that turns on much like scr, but can be turned off by relatively small reverse voltage pulse applied to gate. Can turn off 7-A coil current at voltage levels approaching 500 V. Capacitor charges to voltage level of 25–30 V, dependent on energy stored in inductance while transistor is on.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 11–17.

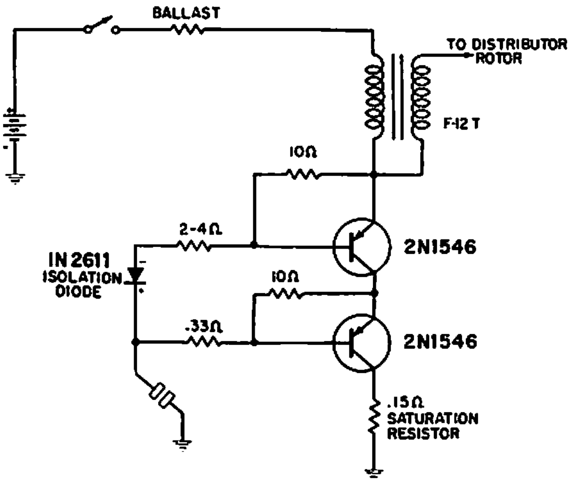
CONTACTLESS IGNITION—Magnetic pickup triggered by rotating teeth on distributor shaft serves in place of distributor contacts. Fenwal thermistor in bias circuit of 2N1193 ensures proper operation of circuit at low temperatures and low ignition speeds where pickup trigger signals are very low.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 11–4.


IGN. SW.
+12 V
LB21J3
*
300
1
50
10
1N3005A
2N2528
1N2609
130
2N1193
MAGNETIC
PICK-UP
2 K
560 pf
1
100 W
2N2142
H.V.
.5 uf
200 V
PAPER
1:250
MALLORY
28100
160
1 W
100
2 W
10
5 W

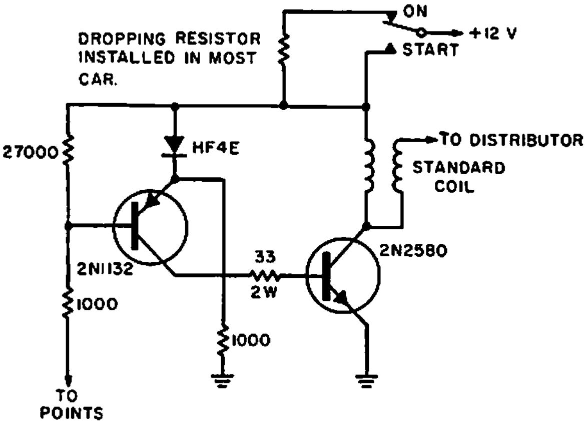

R3
47
3WATTS
TO +12V
(VIA IGNITION
SWITCH)
TO
POINTS
AND
CONDENSER
START
FEEDBACK
FINISH
IN1692
100
C2
1.0μf
400V
TO
COIL+
Q1
START
START
PRIMARY
FINISH
SECONDARY
GE
A13B
(4 PLACES)
C4
0.1 μf
C3
.033
R4
22K
R2
10
CR2
A13D
+
100μf
25V
START
C1
10μf
200V
SCR1
C5C
Q2
FINISH
FINISH
CR3
IN1692
L1
250mh
CR1
A13D
R1
100
TO
COIL−
IN1692
5.6K
L1 TRIAD C36X WITH
AIRGAP INCREASED
TO .025
CHASSIS
GROUND
3PDT
CHANGE
OVER
SWITCH
UP-ELECTRONIC
DOWN-REGULAR
IGNITION

Q1, Q2 - GE2N2192A - MOUNT EACH TRANSISTOR ON THERMALLOY #2210A HEATSINK
T1 - FERROXCUBE 206F440 -3C5 "E" CORES (2 REQUIRED); FERROXCUBE 595F425 BOBBIN
WIND 140 TURNS SEC FIRST (4 LAYER)#30AWG FORMVAR WIRE; INSULATE WITH 1 LAYER MYLAR TAPE
WIND 9 TURNS FEEDBACK NEXT (1 LAYER) #30 AWG FORMVAR WIRE
BIFILAR WIND (2 X 9 TURNS) PRIMARY LAST (2 LAYERS) #20 AWG FORMVAR WIRE.

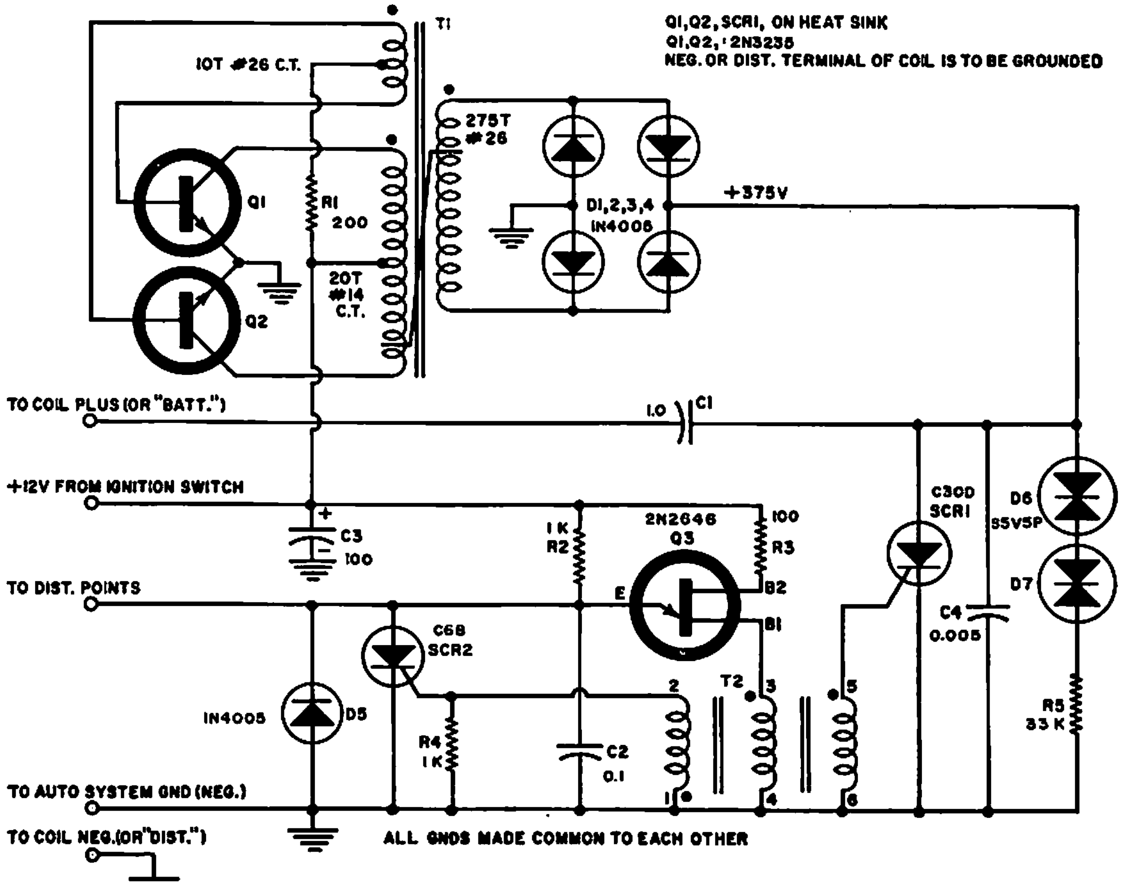
SCR CAPACITOR-DISCHARGE IGNITION—Delivers relatively constant ignition voltage over entire speed range of idling to maximum rpm limit (about 5,500 rpm for 4-stroke V8 engine of most modern automobiles. Eliminates distributor contact wear from arcing because contacts handle only low-current scr trigger signal. Alternatively, scr can be triggered by pulse output of magnetic pickup attached to distributor in place of contacts.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 32.


BALLAST
TO DISTRIBUTOR ROTOR
F-12 T
10Ω
2-4Ω
IN2611 ISOLATION DIODE
2N1546
10Ω
.33Ω
2N1546
.15Ω SATURATION RESISTOR

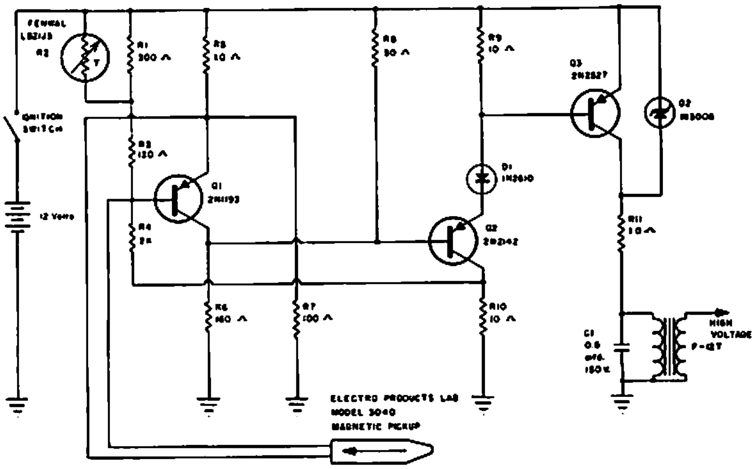
DUAL-TRANSISTOR IGNITION—Use of two low-voltage transistors in place of much more costly high-voltage unit gives comparable reliability. Possible drawback is lack of zener diode protection. Circuit is Slep Electronics Co. TS-14.—B. Ward, "Transistor Ignition Systems Handbook," H. W. Sams & Co., Indianapolis, Ind., 1966, p 93.


ON
+12 V
START
DROPPING RESISTOR INSTALLED IN MOST CAR.
27000
HF4E
TO DISTRIBUTOR
STANDARD COIL
2N1132
33
2W
2N2580
1000
1000
TO POINTS

ELECTRONIC IGNITION WITH STANDARD COIL—Uses existing wiring and standard ignition coil, improves gas mileage at high speeds, is not affected by high temperature, and extends life of points to that of car itself.—A. M. Hildebrant, Transistor Auto Ignition Uses Standard Coil, *Electronic Design,* May 11, 1964, p 83.

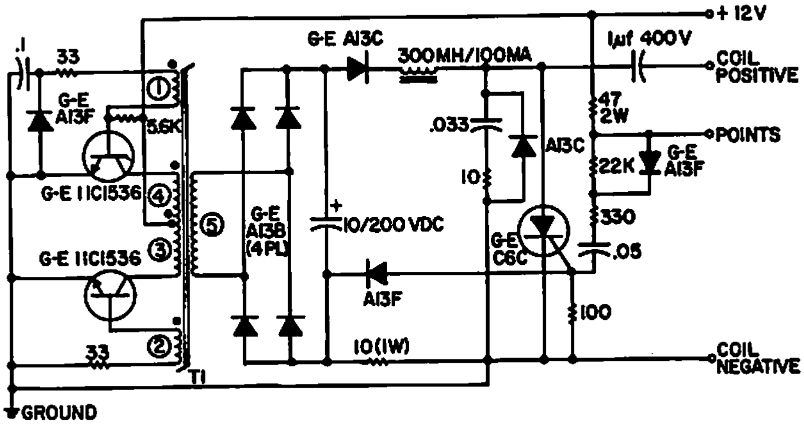

T1
10T #26 C.T.
Q1
R1 200
Q2
20T #14 C.T.
275T #26
D1,2,3,4 IN4005
+375V
Q1,Q2,SCR1, ON HEAT SINK
Q1,Q2, 2N3235
NEG. OR DIST. TERMINAL OF COIL IS TO BE GROUNDED
TO COIL PLUS (OR "BATT.")
1.0
C1
+12V FROM IGNITION SWITCH
C3 100
1 K R2
2N2646 Q3
100 R3
E
B2
B1
C30D SCR1
D6 85V5P
D7
C4 0.005
TO DIST. POINTS
C6B SCR2
IN4005
D5
R4 1K
C2 0.1
2
T2
3
5
1
4
6
R5 33 K
TO AUTO SYSTEM GND (NEG.)
TO COIL NEG.(OR "DIST.")
ALL GNDS MADE COMMON TO EACH OTHER

TWO-SCR IGNITION—Improves engine performance, increases miles per gallon, and prevents multiple firing or misfiring caused by point bounce. Power supply uses inverter and bridge to step up battery voltage from 12 V to 375 V for charging energy storage capacitor C1. Opening of distributor points triggers SCR1 into conduction, thereby discharging C1 through ignition coil. Article gives construction details, including winding of T1 on toroid core. T2 is Pulse Engineering PE2225 or Sprague 11Z13 1:1:1 pulse transformer. Works only on cars with negative ground.—C. C. Morris and R. D. Morton, Unique Capacitor-Discharge Ignition System, *Electronics World,* Jan. 1969, p 45–48 and 56.

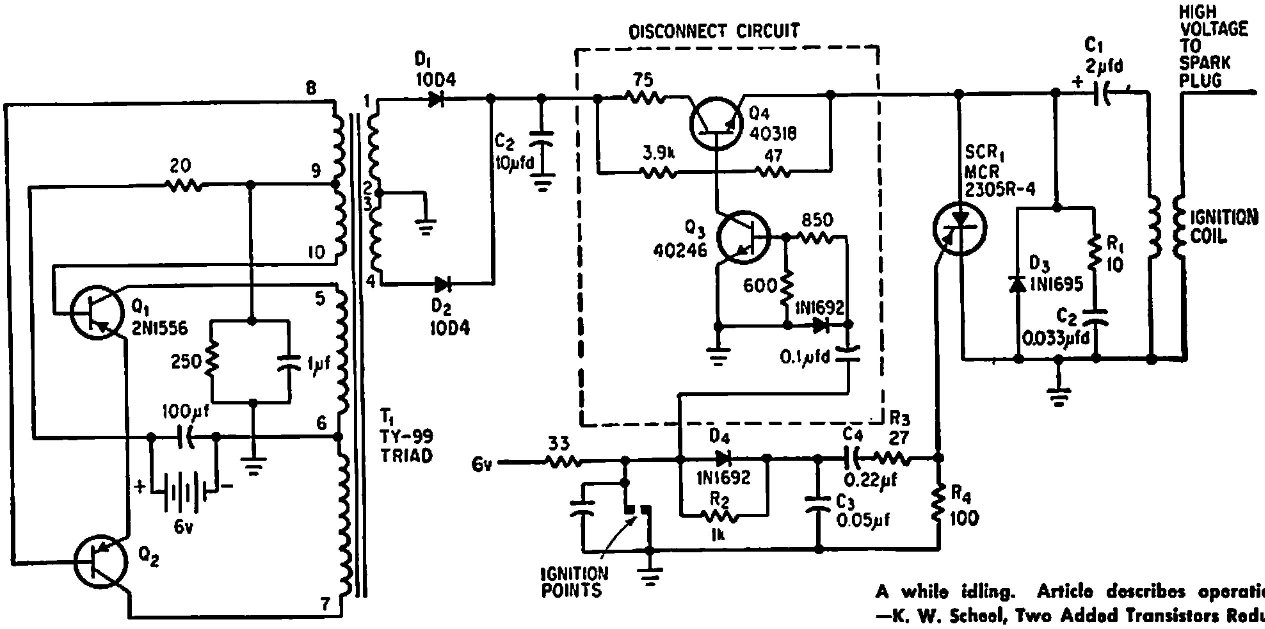

FENWAL LB21J3 R2
R1 300 Ω
R5 10 Ω
R8 30 Ω
R9 10 Ω
Q3 2N2527
D2 1N3008
IGNITION SWITCH
12 Volts
R3 130 Ω
Q1 2N1193
D1 1N2610
R4 2K
Q2 2N2142
R11 10 Ω
R6 160 Ω
R7 100 Ω
R10 10 Ω
C1 0.5 mfd. 150V
HIGH VOLTAGE F-12T
ELECTRO PRODUCTS LAB MODEL 3040 MAGNETIC PICKUP

BREAKERLESS IGNITION—Motorola system, using magnetic pickup in place of distributor points, was used in somewhat similar form on Pontiac Grand Prix. Requires 8-tooth iron or steel star wheel for 8-cylinder engine (6 for 6-cylinder) mounted on rotor of distributor, with each spoke as wide at tip as dwell angle specified for car in which it will be used. Magnetic pickup is mounted on breaker plate, using bracket, with sufficiently wide relief hole in distributor case to permit movement by centrifugal and vacuum advance mechanisms. Pickup coil contains small permanent magnet in tip.—B. Ward, "Transistor Ignition Systems Handbook," H. W. Sams & Co., Indianapolis, Ind., 1966, p 63.

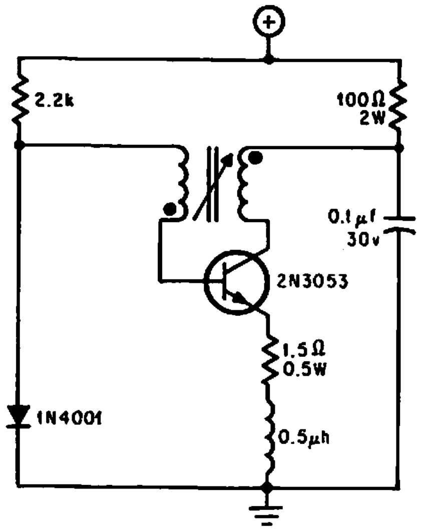
SCR CAPACITOR-DISCHARGE IGNITION—Driven by silicon-transistor inverter, drawing less than 2 A from battery over entire speed range. Will provide full spark voltage for speeds up to 6,000 rpm on 8-cylinder engine. Distributor points carry very little current so there is no arcing and very little wear. Existing points, capacitor, ballast, and coil of car are used. Lockout circuit in scr gate prevents false triggering by contact bounce, eliminating misfiring.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 25.


+12V
G-E A13C
300MH/100MA
1μf 400V
COIL POSITIVE
.1
33
①
G-E A13F
5.6K
47 2W
POINTS
.033
A13C
10
22K
G-E A13F
G-E 11C1536
④
⑤
G-E A13B (4PL)
+
10/200 VDC
330
G-E C6C
.05
G-E 11C1536
③
A13F
100
33
②
10(1W)
COIL NEGATIVE
T1
GROUND

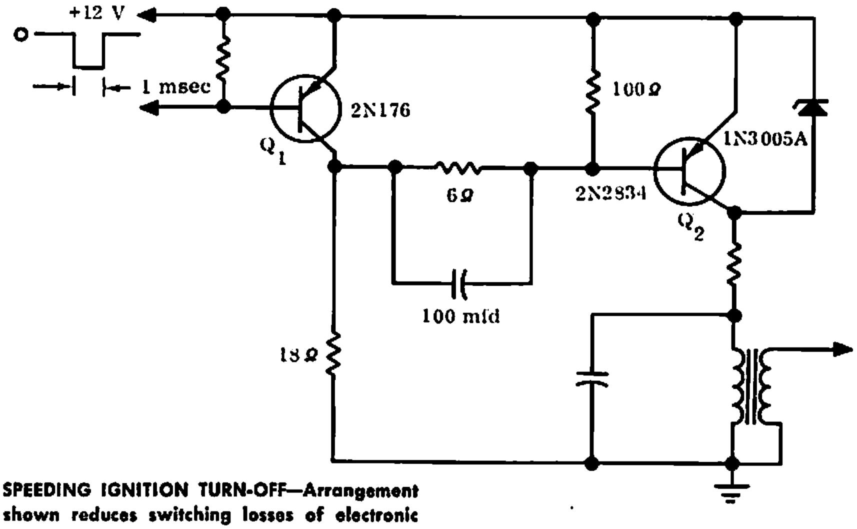
T1 {
TWO #206F440-3C3 "E" CORES } FERROXCUBE, SAUGERTIES, N.Y.
ONE #595F425 BOBBIN
① & ② EACH 5 TURNS #32 HEAVY FORMVAR BIFILAR WOUND
③ & ④ EACH 9 TURNS #20 HEAVY FORMVAR BIFILAR WOUND
⑤ 126 TURNS #32 HEAVY FORMVAR


DISCONNECT CIRCUIT
HIGH VOLTAGE TO SPARK PLUG
8
D1 10D4
1
C1 2μfd
+
75
Q4 40318
20
9
C2 10μfd
3.9k
47
2
3
SCR1 MCR 2305R-4
10
Q3 40246
850
IGNITION COIL
4
D2 10D4
600
D3 1N1695
R1 10
5
Q1 2N1556
1N1692
C2 0.033μfd
250
1μf
0.1μfd
100μf
6
T1 TY-99 TRIAD
R3 27
D4
C4
6v
33
1N1692
0.22μf
+
−
R2 1k
C3 0.05μf
R4 100
6v
Q2
IGNITION POINTS
7

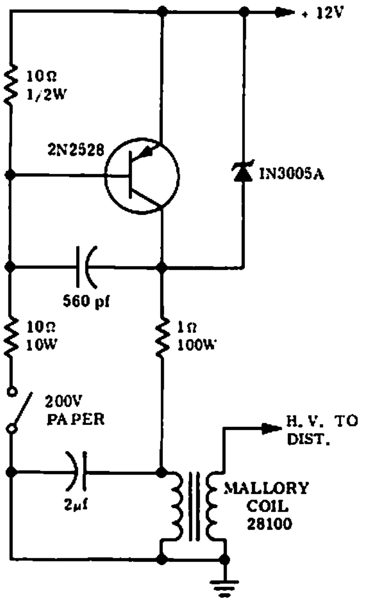
LOW-DRAIN ELECTRONIC IGNITION—Addition of transistors Q3 and Q4 to capacitor-discharge ignition system improves performance at high speeds and cuts current drain to 1 A while idling. Article describes operation. —K. W. Scheel, Two Added Transistors Reduce Ignition-System Current Drain, *Electronics*, May 29, 1967, p 87.


2.2k
100Ω 2W
0.1µf 30v
2N3053
1.5Ω 0.5W
1N4001
0.5µh

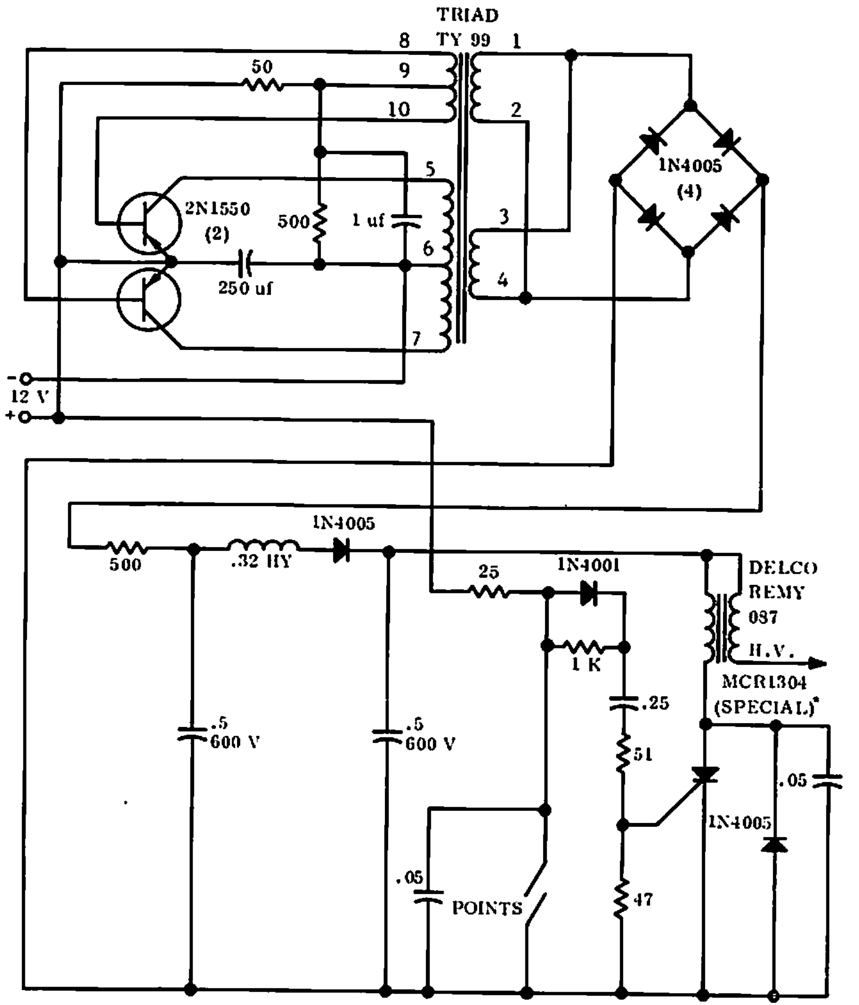
BREAKERLESS TRIGGER FOR IGNITION—Eliminates need for engine retiming and resetting of breaker point gap. Uses simple oscillator circuit in which high average current is obtained with transformer feedback. Fits into distributor housing in place of breaker points. Rotation of cam in air gap of trigger transformer makes circuit go in and out of nonlinear oscillation, producing square wave through 100-ohm resistor. Circuit can also be used as proximity switch.—R. L. Ronci, Good Timing, *Electronics*, Sept. 18, 1967, p 50.


+12 V
1 msec
2N176
Q1
100Ω
1N3005A
6Ω
2N2834
Q2
100 mfd
18Ω

SPEEDING IGNITION TURN-OFF—Arrangement shown reduces switching losses of electronic ignition system and increases ignition coil output, by reverse-biasing transistor to decrease turn-off time of transistor. Charge on 100-µF capacitor, obtained when Q1 is nonconducting, supplies reverse bias for Q2 when Q1 is triggered on. Reduces erosion at gap of spark-plug electrodes.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 11–10.

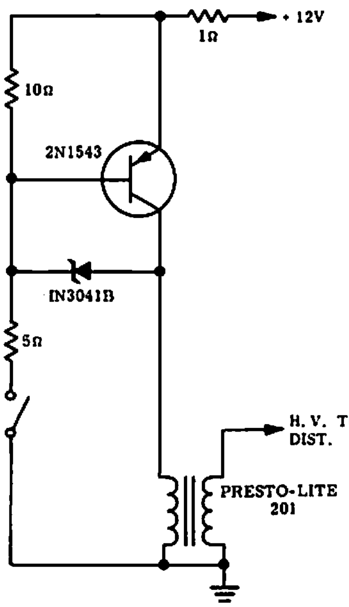

+ 12V
10Ω 1/2W
2N2528
1N3005A
560 pf
10Ω 10W
1Ω 100W
200V PAPER
H.V. TO DIST.
2µf
MALLORY COIL 28100

100-V ZENER PROTECTS IGNITION TRANSISTOR—Zener is connected between emitter and collector of transistor in electronic ignition system, with voltage rating chosen for protection against surges without affecting reliability of circuit operation.—"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 7–9.

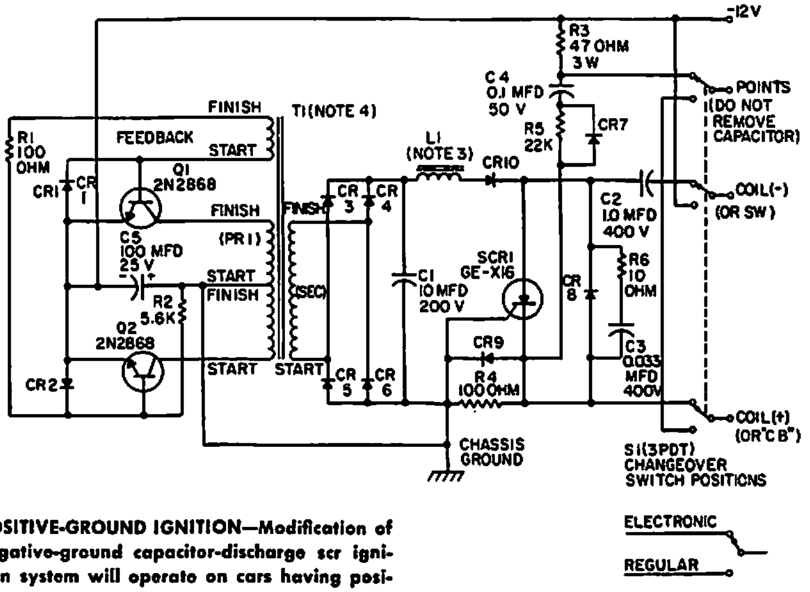

TRIAD TY 99
8
9
10
1
2
50
5
3
6
4
7
1N4005 (4)
2N1550 (2)
500
1 uf
250 uf
-
12 V
+
500
.32 HY
1N4005
25
1N4001
DELCO REMY 087
H.V.
1 K
.25
MCR1304 (SPECIAL)*
.5 600 V
.5 600 V
51
.05
1N4005
.05
POINTS
47

* REQUIRES VBO = 500
PRV = 25 V

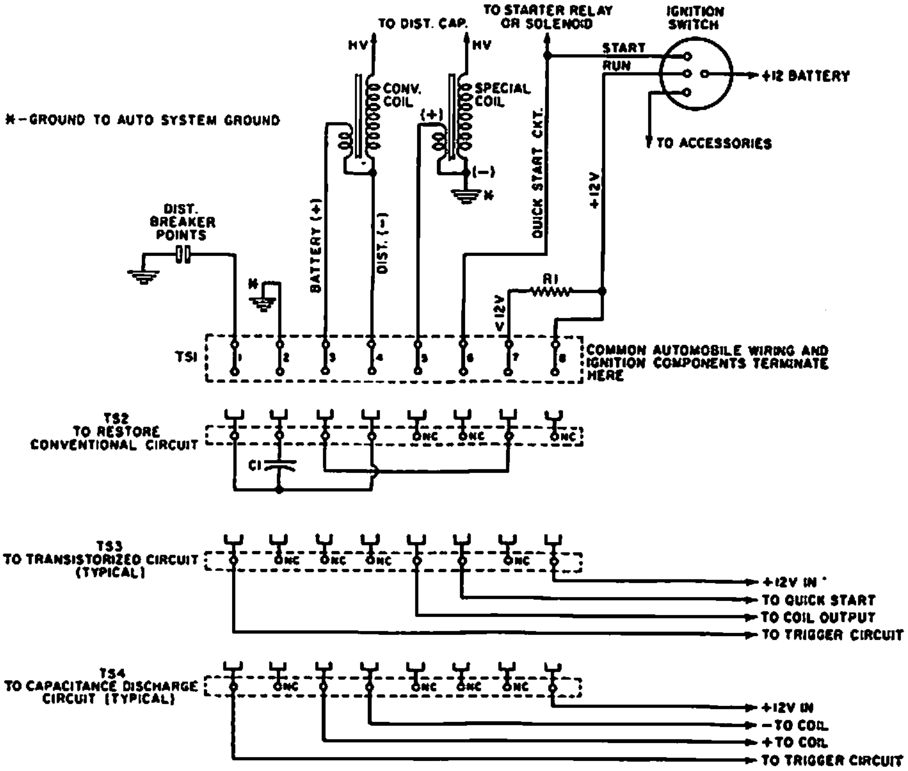
INVERTER FOR IGNITION—Two-transistor inverter drives bridge rectifier to give d-c/d-c converter providing 200 to 400 V d-c for more efficient operation of scr capacitor-discharge ignition system.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 11–13.


+ 12V
1Ω
10Ω
2N1543
IN3041B
5Ω
H. V. TO DIST.
PRESTO-LITE 201

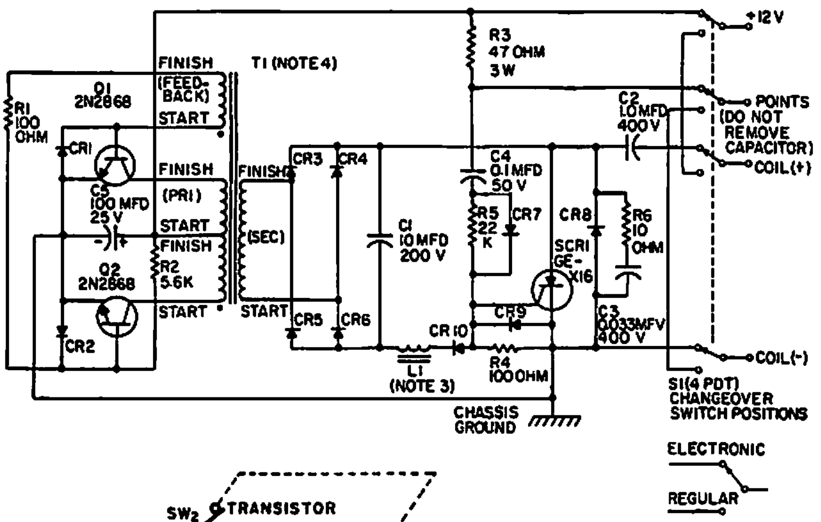
75-V ZENER PROTECTS IGNITION TRANSISTOR—Zener is connected between base and collector of transistor in electronic ignition system, with voltage rating chosen for protection against surges without affecting reliability of circuit operation.—"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 7–9.


-12V
R3
47 OHM
3W
C4
0.1 MFD
50 V
R5
22K
CR7
POINTS
(DO NOT REMOVE CAPACITOR)
FINISH
T1(NOTE 4)
R1
100
OHM
FEEDBACK
START
Q1
2N2868
CR1
CR1
L1
(NOTE 3)
CR10
COIL(-)
(OR SW)
C2
1.0 MFD
400 V
FINISH
(PRI)
FINISH
CR 3
CR 4
C5
100 MFD
25 V
SCR1
GE-X16
R6
10
OHM
START
FINISH
(SEC)
C1
10 MFD
200 V
CR 8
R2
5.6K
Q2
2N2868
CR9
C3
0.033 MFD
400V
CR2
START
START
CR 5
CR 6
R4
100 OHM
COIL(+)
(OR "CB")
CHASSIS GROUND
S1(3PDT) CHANGEOVER SWITCH POSITIONS
ELECTRONIC
REGULAR

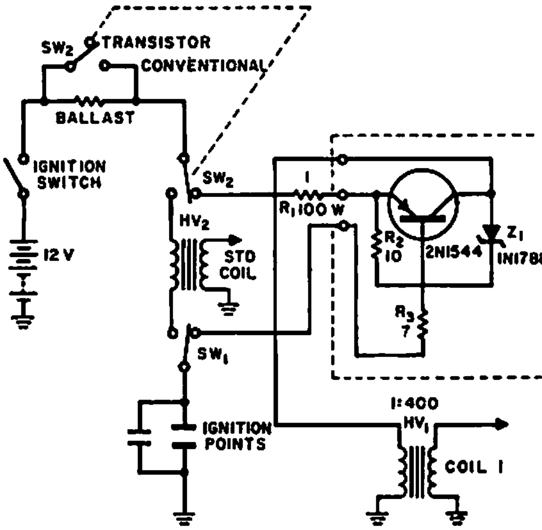
POSITIVE-GROUND IGNITION—Modification of negative-ground capacitor-discharge scr ignition system will operate on cars having positive ground. Diodes CR3-CR6 are 1N1693, CR8 and CR10 are 1N1695, and all others 1N1692. Book gives construction details, including winding data for T1.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 63.

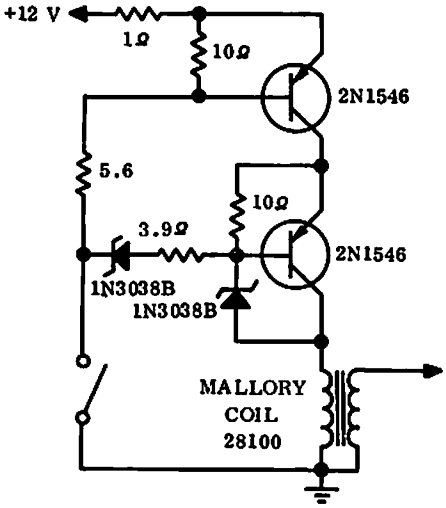

TO DIST. CAP.
TO STARTER RELAY OR SOLENOID
IGNITION SWITCH
START
RUN
+12 BATTERY
HV
HV
CONV. COIL
SPECIAL COIL
(+)
(-)
*-GROUND TO AUTO SYSTEM GROUND
TO ACCESSORIES
QUICK START CKT.
+12V
DIST. BREAKER POINTS
BATTERY (+)
DIST. (-)
R1
+12V
TS1
1 2 3 4 5 6 7 8
COMMON AUTOMOBILE WIRING AND IGNITION COMPONENTS TERMINATE HERE
TS2
TO RESTORE CONVENTIONAL CIRCUIT
C1
NC
TS3
TO TRANSISTORIZED CIRCUIT (TYPICAL)
+12V IN
TO QUICK START
TO COIL OUTPUT
TO TRIGGER CIRCUIT
TS4
TO CAPACITANCE DISCHARGE CIRCUIT (TYPICAL)
+12V IN
-TO COIL
+TO COIL
TO TRIGGER CIRCUIT

ELECTRONIC IGNITION ADAPTER—Permits testing all types of transistor and capacitor-discharge ignition systems on automobile and returning to conventional system without rewiring. All wires needed for installation are terminated in central location, using screw-type terminal strip. R1 is original ballast resistor, and C1 is original capacitor removed from distributor housing.—C. C. Morris, Universal Wiring for Automotive Ignition Systems, *Electronics World*, Aug. 1967, p 48.


+12V
FINISH
T1 (NOTE 4)
Q1
2N2868
(FEED-BACK)
START
R1
100
OHM
CR1
FINISH
(PRI)
C5
100 MFD
25 V
START
FINISH
Q2
2N2868
R2
5.6K
START
CR2
FINISH
(SEC)
START
CR3
CR4
CR5
CR6
C1
10 MFD
200 V
R3
47 OHM
3W
C4
0.1 MFD
50 V
R5
22
K
CR7
CR8
SCR1
GE-X16
R6
10
OHM
C2
1.0 MFD
400 V
C3
.0033MFV
400 V
CR9
CR10
L1
(NOTE 3)
R4
100 OHM
CHASSIS
GROUND
POINTS
(DO NOT REMOVE CAPACITOR)
COIL(+)
COIL(-)
S1(4 PDT)
CHANGEOVER
SWITCH POSITIONS
ELECTRONIC
REGULAR

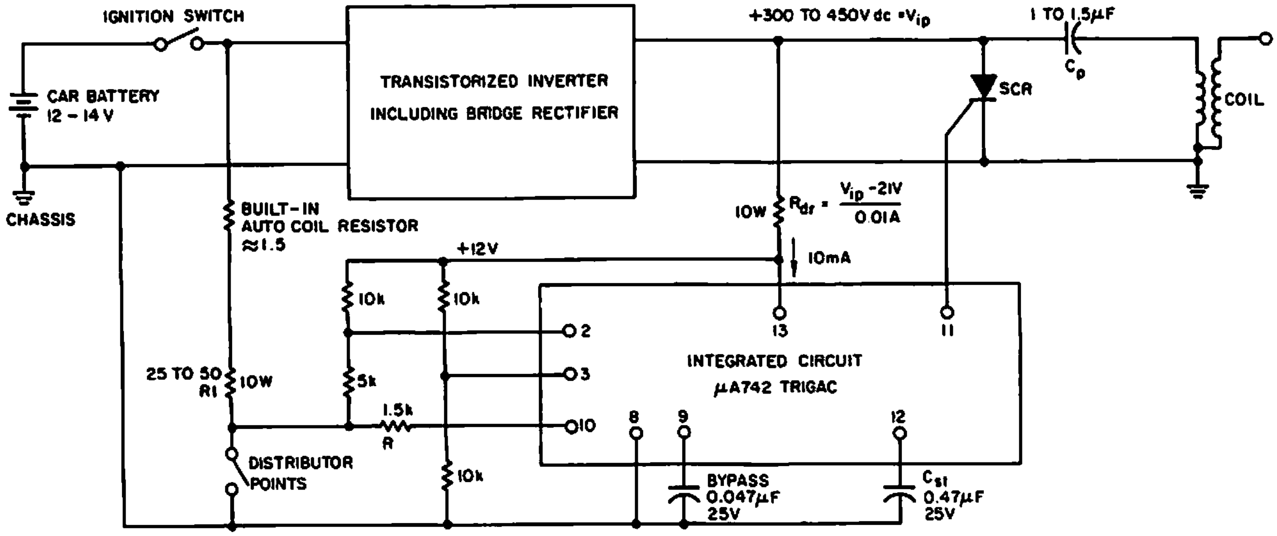
CAPACITOR-DISCHARGE SCR IGNITION—Circuit includes inverter and bridge rectifier for charging capacitor to 175 V d-c and scr triggering circuit for discharging capacitor through primary of ignition coil. Inverter Q1—Q2 converts negative-ground auto battery voltage to high-voltage a-c at about 8,000 Hz. Delivers about 23,000 Hz peak output from standard 12.6-V ignition coil, yet will operate on 6.5-V d-c input for good cold-weather starting. Book gives constructions details, including winding data for T1. Diodes CR3-CR6 are 1N1693, CR8 and CR10 are 1N1695, and all others 1N1692.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 60.


SW2
TRANSISTOR
CONVENTIONAL
BALLAST
IGNITION
SWITCH
12 V
SW2
HV2
STD
COIL
SW1
IGNITION
POINTS
I
R1 100 W
R2
10
2N1544
Z1
1N1788
R3
7
1:400
HV1
COIL I

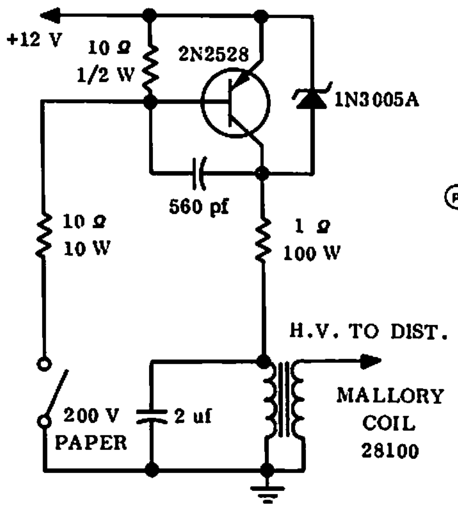

+12 V
1Ω
10Ω
2N1546
5.6
10Ω
3.9Ω
2N1546
1N3038B
1N3038B
MALLORY
COIL
28100

TWO-TRANSISTOR IGNITION—Medium-voltage transistors in series meet 120-V switching requirement for ignition coil having low turns ratio (below 325:1) and requiring between 7 and 12 A of collector current.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 11—3.

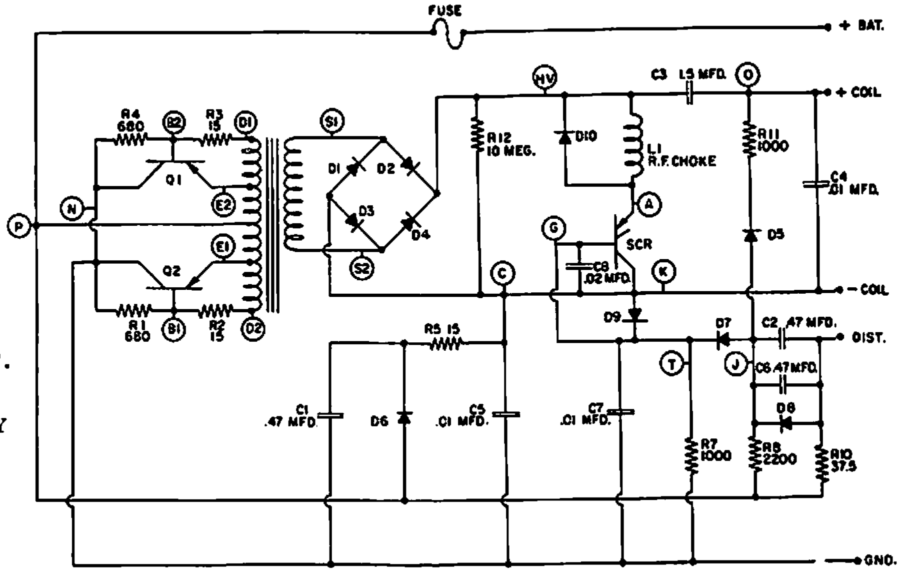
QUICK-CHANGEOVER TRANSISTOR IGNITION—Single-transistor ignition improves performance and increases life of breaker points. Conventional ignition can be restored by operating both switches and moving high-voltage cable back to standard ignition coil.—J. Nawracaj, Transistor Ignition System Improves Engine Performance, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 232.


IGNITION SWITCH
CAR BATTERY
12 - 14 V
CHASSIS
TRANSISTORIZED INVERTER
INCLUDING BRIDGE RECTIFIER
+300 TO 450Vdc =Vip
1 TO 1.5μF
Cp
SCR
COIL
BUILT-IN
AUTO COIL RESISTOR
≈1.5
+12V
10W
Rdr = (Vip -21V)/0.01A
10mA
10k
10k
5k
25 TO 50
R1
10W
1.5k
R
DISTRIBUTOR
POINTS
10k
2
3
10
13
11
8
9
12
INTEGRATED CIRCUIT
μA742 TRIGAC
BYPASS
0.047μF
25V
Cst
0.47μF
25V

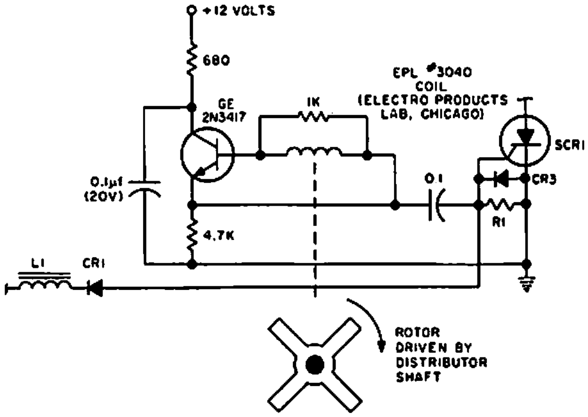
IC-SCR IGNITION—IC provides peak current of 2 A for firing almost any scr of capacitor-discharge electronic ignition system. Circuit prevents multiple firing caused by distributor points bounce at very low cranking speeds and at high speeds.—W. L. Brown, Improved IC Fires SCRs Used in Auto Ignition, *Electronic Design*, July 5, 1970, p 68 and 70.


+12 V
10 Ω
1/2 W
2N2528
1N3005A
560 pf
10 Ω
10 W
1 Ω
100 W
H.V. TO DIST.
200 V
PAPER
2 uf
MALLORY
COIL
28100

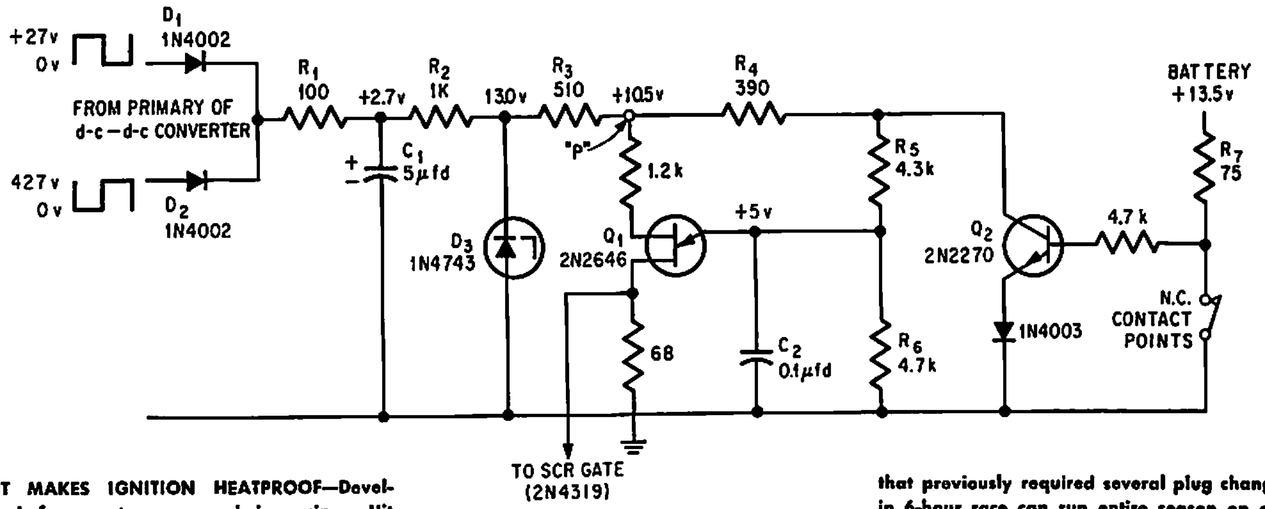
SINGLE-TRANSISTOR IGNITION—Uses graded-base high-voltage transistor for switching load line up to 120 V for ignition coil having low turns ratio (below 325:1) and requiring between 7 and 12 A of collector current.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 11–3.


FUSE
+ BAT.
HV
C3 1.5 MFD.
O
+ COIL
R4
680
B2
R3
15
D1
S1
R12
10 MEG.
D10
L1
R.F. CHOKE
R11
1000
Q1
D1
D2
C4
.01 MFD.
N
E2
D3
A
P
D4
G
D5
SCR
E1
C8
.02 MFD.
K
Q2
S2
C
– COIL
R1
680
B1
R2
15
D2
D9
D7
C2 .47 MFD.
R5 15
DIST.
T
J
C6 .47 MFD.
D8
C1
.47 MFD.
D6
C5
.01 MFD.
C7
.01 MFD.
R7
1000
R8
2200
R10
37.5
GND.

SCR IGNITION—Consists of d-c/d-c converter for stepping up auto battery voltage to about 400 V for charging C3. When first cylinder comes up on compression to position where spark plug should be fired, points open and current through D7 switches on scr to discharge C3 through ignition coil. Brochure describes operation in detail.—MARK TEN—A New Ignition System for All Motor Vehicles, Delta Products, Grand Junction, Colo., 1969.


+12 VOLTS
680
GE
2N3417
1K
EPL #3040
COIL
(ELECTRO PRODUCTS
LAB, CHICAGO)
SCR1
0.1µf
(20V)
0.1
CR3
R1
4.7K
L1
CR1
ROTOR
DRIVEN BY
DISTRIBUTOR
SHAFT

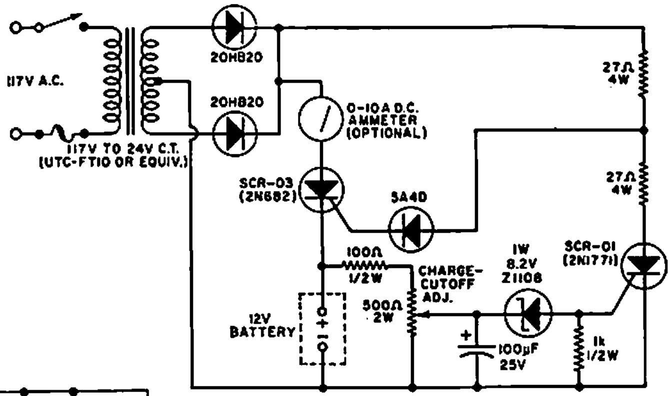
CONTACTLESS IGNITION TRIGGER—Four-pole permanent magnet mounted on distributor rotor generates scr trigger pulses in pickup coil, for driving scr of capacitor-discharge automotive ignition. Distributor contacts are then unnecessary. Circuit shown amplifies and differentiates pulse before it is applied to gate of scr. Magnet-coil combination is commercially available.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 33.


+27v
0v
D1
1N4002
FROM PRIMARY OF
d-c–d-c CONVERTER
427v
0v
D2
1N4002
R1
100
+2.7v
C1
5µfd
R2
1K
13.0v
D3
1N4743
R3
510
+10.5v
"P"
1.2k
Q1
2N2646
68
TO SCR GATE
(2N4319)
R4
390
+5v
C2
0.1µfd
R5
4.3k
R6
4.7k
Q2
2N2270
1N4003
4.7 k
BATTERY
+13.5v
R7
75
N.C.
CONTACT
POINTS

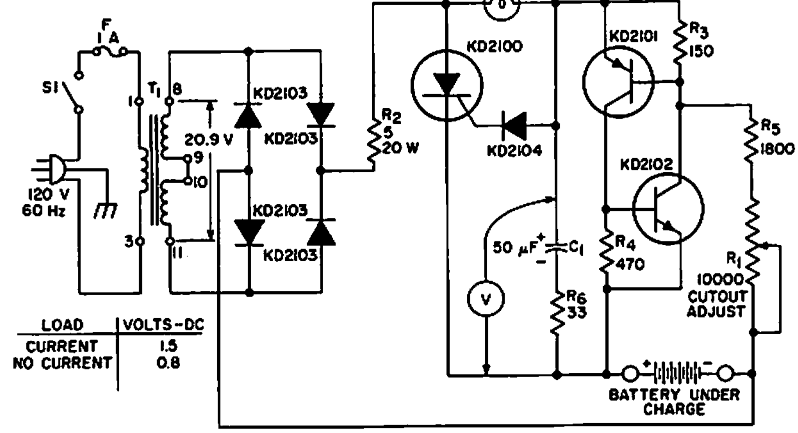
UJT MAKES IGNITION HEATPROOF—Developed for sports cars used in racing. Ujt trigger in capacitor-discharge ignition maintains quality of ignition pulse over temperature range of –30 to 160 F with simultaneous supply voltage variations of more than 30% above and below battery voltage. Entire ignition system costs less than $50. Race cars that previously required several plug changes in 6-hour race can run entire season on one set of plugs.—F. Haney, Unijunction Trigger Boosts Ignition Reliability, *Electronics*, Sept. 18, 1967, p 107–108.

CHAPTER 8

Battery-Charging Circuits

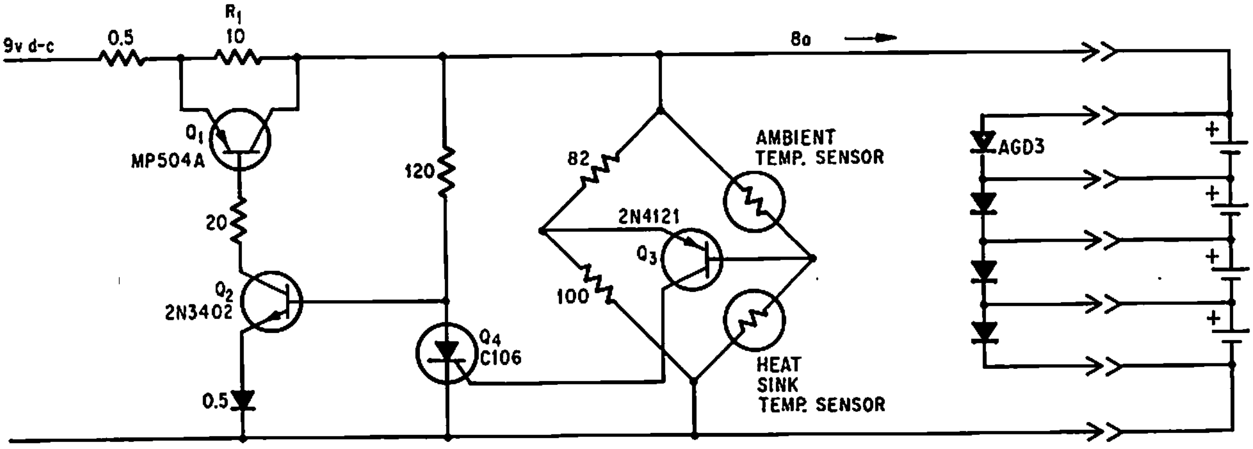

117V A.C.
117V TO 24V C.T. (UTC-FT10 OR EQUIV.)
20HB20
20HB20
0-10A D.C. AMMETER (OPTIONAL)
27Ω 4W
27Ω 4W
SCR-03 (2N682)
5A4D
100Ω 1/2W
CHARGE-CUTOFF ADJ.
500Ω 2W
12V BATTERY
1W 8.2V Z1108
SCR-01 (2N1771)
100µF 25V
1k 1/2W

AUTOMATIC TRICKLE—Controlled battery charger delivers up to 10 A initially, after which charging rate is reduced to trickle at preset level determined by setting of charge-cutoff potentiometer.—D. Cooper, SCR's and Triacs—the Revolution Continues, *Electronics World*, Aug. 1968, p 25–28.


I1 No. 1488
F 1A
S1
T1
1
3
8
9
10
11
20.9 V
120 V 60 Hz
KD2103
KD2103
KD2103
KD2103
R2 5 20 W
KD2100
KD2104
KD2101
KD2102
R3 150
R5 1800
50 µF C1
R4 470
R6 33
V
R1 10000 CUTOUT ADJUST
BATTERY UNDER CHARGE

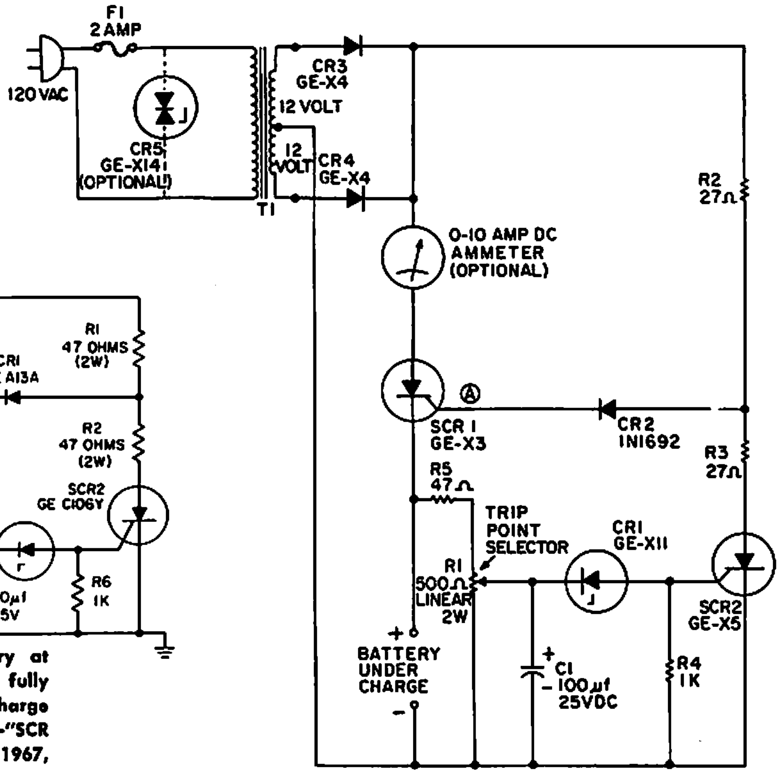
LOAD	VOLTS-DC
CURRENT	1.5
NO CURRENT	0.8

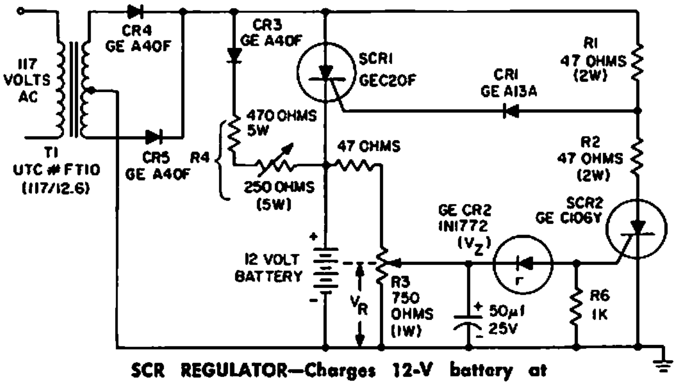
12-V CHARGER WITH 150-MA TRICKLE—Gives essentially full-wave charging at 2 A, with R2 limiting current to safe value when battery is completely dead. When battery is fully charged, two-transistor regenerative switch saturates and prevents scr from triggering, while turning on full-charge indicator lamp. Trickle charge then flows through lamp and transistor switch to battery.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 73.


9v d-c
0.5
R1 10
8a
Q1 MP504A
20
Q2 2N3402
0.5
120
Q4 C106
82
100
2N4121
Q3
AMBIENT TEMP. SENSOR
HEAT SINK TEMP. SENSOR
AGD3

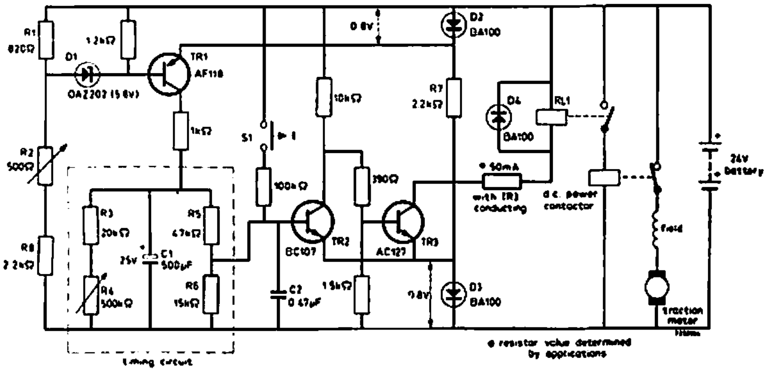
PROTECTING NICKEL-CADMIUM CELLS—Special diodes, called Amp-Gates by Mallory, shunt individual nickel-cadmium cells during fast recharge to prevent cells from overheating and rupturing. Two thermistors in bridge circuit sense when battery is fully charged and terminate charging, to protect diodes from overheating that would result if they carried full charging current. Developed for use with cordless appliances.—J. V. Ball, There's No Overcharge For Fast-Charged Batteries, *Electronics*, Jan. 22, 1968, p 97–100.

12-V ON-OFF BATTERY CHARGER—Automatically switches off when battery is fully charged, and switches itself back on just before battery is fully discharged. To adjust, connect fully charged battery and adjust R1 until charging just stops.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 52.

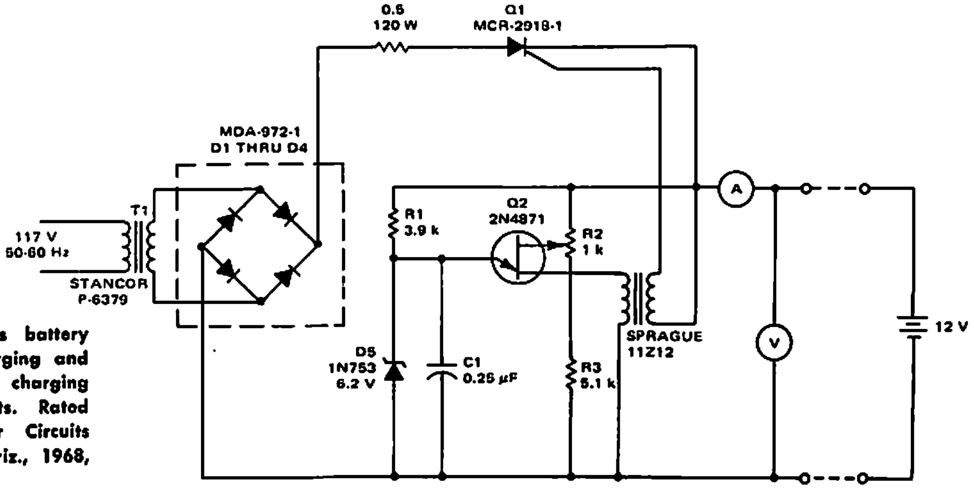

F1
2 AMP
120 VAC
CR5
GE-X14
(OPTIONAL)
T1
CR3
GE-X4
12 VOLT
12 VOLT
CR4
GE-X4
R2
27Ω
0-10 AMP DC
AMMETER
(OPTIONAL)
Ⓐ
SCR 1
GE-X3
CR2
1N1692
R3
27Ω
R5
47Ω
TRIP
POINT
SELECTOR
R1
500Ω
LINEAR
2W
CR1
GE-X11
SCR2
GE-X5
+
BATTERY
UNDER
CHARGE
-
C1
100µf
25VDC
R4
1K


117
VOLTS
AC
T1
UTC # FT10
(117/12.6)
CR4
GE A40F
CR5
GE A40F
R4
CR3
GE A40F
470 OHMS
5W
250 OHMS
(5W)
SCR1
GEC20F
CR1
GE A13A
R1
47 OHMS
(2W)
R2
47 OHMS
(2W)
47 OHMS
12 VOLT
BATTERY
V_R
R3
750
OHMS
(1W)
GE CR2
1N1772
(V_Z)
50µf
25V
SCR2
GE C106Y
R6
1K

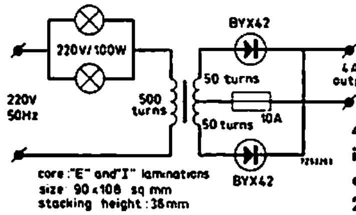
SCR REGULATOR—Charges 12-V battery at rate of up to 6 A. When battery is fully charged, SCR1 shuts off, and trickle charge (determined by R4) continues to flow.—"SCR Manual," 4th Edition, General Electric, 1967, p 152–153.


R1
820Ω
1.2kΩ
D1
OAZ203 (5.6V)
TR1
AF118
1kΩ
R2
500Ω
R8
2.2kΩ
R3
20kΩ
R4
500kΩ
25V
C1
500µF
R5
47kΩ
R6
15kΩ
timing circuit
S1
100kΩ
C2
0.47µF
10kΩ
TR2
BC107
390Ω
1.5kΩ
TR3
AC127
0.8V
R7
2.2kΩ
D2
BA100
D3
BA100
0.8V
D4
BA100
RL1
* 50mA
with (R) conducting
d.c. power contactor
field
traction motor
24V
battery
* resistor value determined by applications

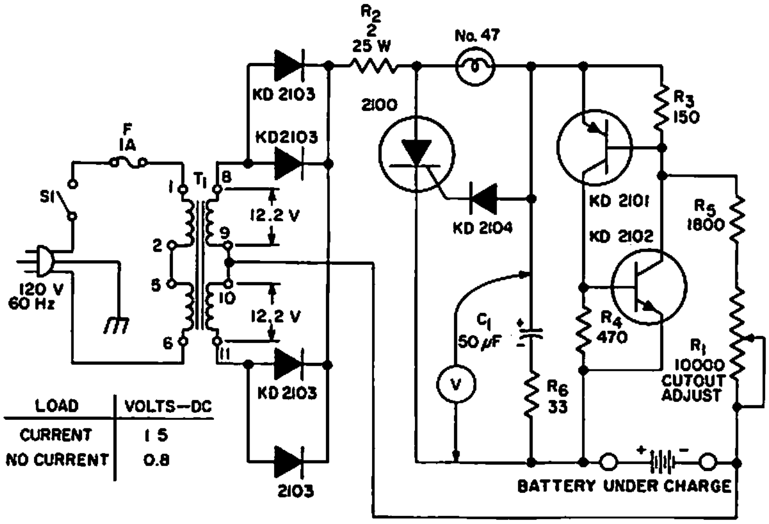
BATTERY VOLTAGE SENSOR—Used on electric golf carts and other electric vehicles to cut out traction motor when battery voltage is low and/or trip a warning device. Timing circuit prevents sensor from responding to short-duration voltage drops. Delay can be set by R4 between 15 and 40 s. Override S1 permits driving to nearest charging station on low battery.—"Rectifier Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1969, p 221.


0.5
120 W
Q1
MCR-2918-1
MDA-972-1
D1 THRU D4
T1
117 V
50-60 Hz
STANCOR
P-6379
R1
3.9 k
Q2
2N4871
R2
1 k
SPRAGUE
11Z12
D5
1N753
6.2 V
C1
0.25 µF
R3
5.1 k
A
V
12 V

12-V CHARGER CONTROL—Protects battery from overcharging or reverse charging and protects itself and/or separate charging supply from damage by short-circuits. Rated at 16 A.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–41.

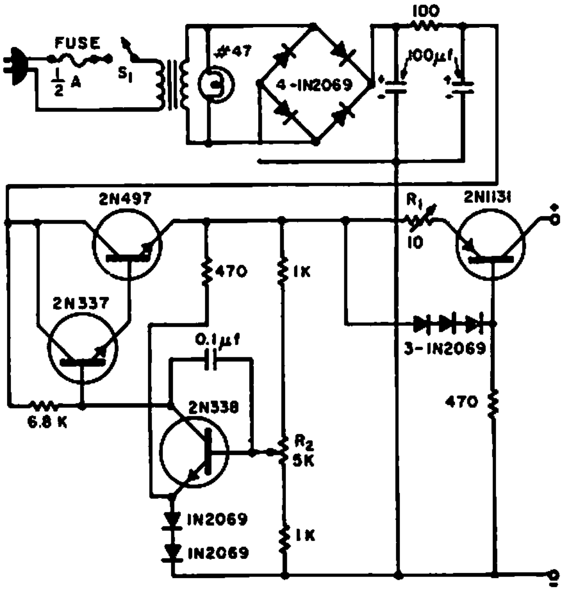

220V/100W
220V
50Hz
500
turns
BYX42
50 turns
10A
50 turns
BYX42
+
4A
output
−
core: "E" and "I" laminations
size 90×108 sq mm
stacking height: 38mm

4 A WITH CURRENT-LIMITING LAMPS—Circuit is readily adapted for charging either 6-V or 12-V batteries from 115-V a-c line. On 220 V, maximum output current for direct short is 7 A. 10-A fuse protects against reverse connection of battery.—"Rectifier Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1969, p 217.

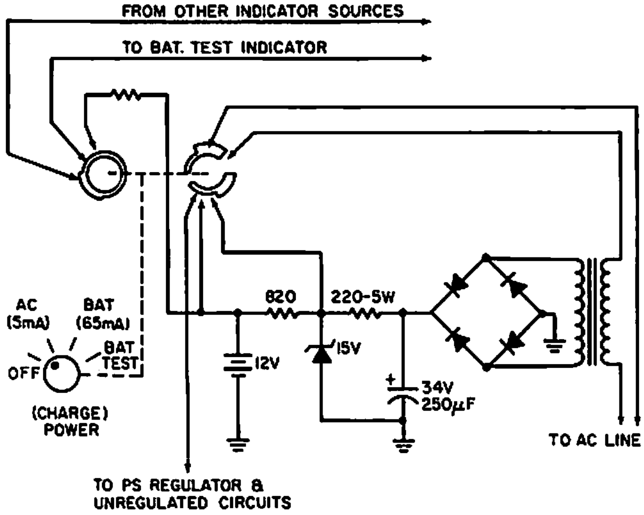

R2
2
25 W
No. 47
KD 2103
KD2103
F
1A
S1
T1
1
8
12.2 V
9
2
5
120 V
60 Hz
10
12.2 V
6
11
KD 2103
2103
2100
KD 2104
C1
50 μF
V
R6
33
KD 2101
KD 2102
R4
470
R3
150
R5
1800
R1
10000
CUTOUT
ADJUST
BATTERY UNDER CHARGE

LOAD	VOLTS—DC
CURRENT	1 5
NO CURRENT	0.8

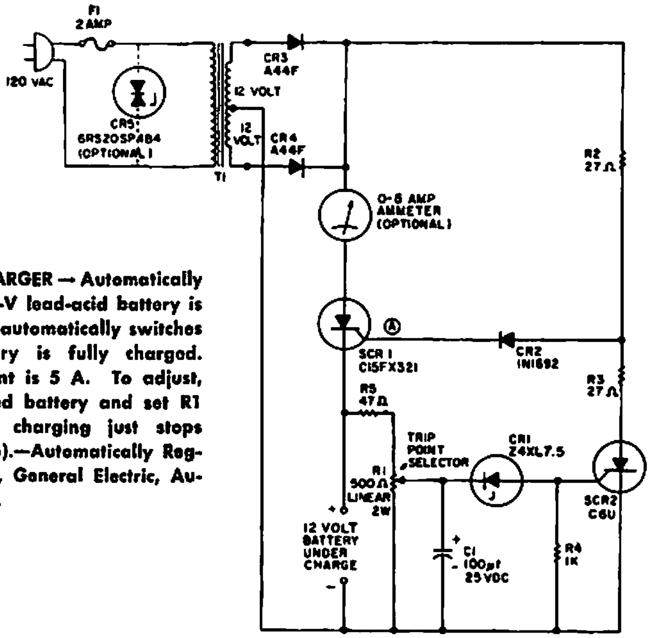
6-V CHARGER WITH 150-MA TRICKLE—Silicon rectifiers in full-wave center-tapped connection provide 3.2 A for charging, with R2 limiting current to safe value if battery is dead. Two-transistor regenerative switch at right opens scr when battery is fully charged, and passes 150-mA trickle charge through battery and indicator lamp. R1 is adjusted so lamp just begins to brighten for fully charged battery (reading 7.15 V across its terminals).—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 76.


FUSE
1/2 A
S1
#47
4-1N2069
100
100μf
2N497
2N337
470
1K
R1
10
2N1131
+
0.1μf
2N338
3-1N2069
470
6.8 K
R2
5K
1N2069
1N2069
1K
−

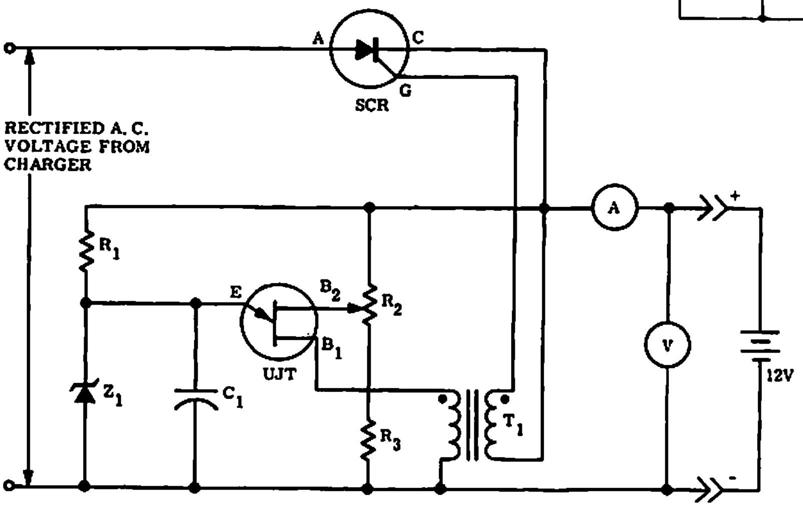
PROTECTION FOR NICKEL-CADMIUM CELLS—Uses constant-current source to provide recommended maximum charge rate of 120 mA for small three-cell rechargeable nickel-cadmium battery, and simple series voltage regulator for holding voltage limit down to 4.5 V so maximum charge voltage of 1.5 V per cell is never exceeded. R1 is adjusted for 120 mA while output is shorted with ammeter having appropriate current range, and open-circuit voltage is similarly adjusted with R2 and voltmeter across output.—R. M. Mann, Battery Charger Protects Small Nickel-Cadmium Cells, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 210.


FROM OTHER INDICATOR SOURCES
TO BAT. TEST INDICATOR
AC
(5mA)
BAT
(65mA)
BAT
TEST
OFF
(CHARGE)
POWER
820
220-5W
12V
15V
34V
250μF
TO AC LINE
TO PS REGULATOR &
UNREGULATED CIRCUITS

BATTERY-FAILURE PROTECTION — Battery-charging circuit for 12-V nickel-cadmium battery doubles as 12-V d-c power supply if battery fails. With switch at AC, charger furnishes 5-mA trickle current to battery and low-ripple 15-V d-c to regulator. With switch at BAT, 820-ohm trickle-charge resistor is shorted out and regulator operates directly from 12-V battery. Fast battery charging is obtained by plugging in a-c line cord with switch at BAT position. At BAT TEST position, battery is checked while under load but with a-c power removed.—J. Collins and W. Whitaker, Fail-Safe Unit Operates from NiCad Batteries or A-C Line, *Electronic Design*, Oct. 11, 1967, p 98 and 100.


F1
2 AMP
120 VAC
CR5:
6RS20SP4B4
(OPTIONAL)
T1
12 VOLT
12 VOLT
CR3
A44F
CR4
A44F
R2
27 Ω
0-6 AMP
AMMETER
(OPTIONAL)
Ⓐ
SCR 1
C15FX321
CR2
1N1692
R3
27 Ω
R5
47 Ω
TRIP
POINT
SELECTOR
CR1
Z4XL7.5
R1
500 Ω
LINEAR
2W
+
12 VOLT
BATTERY
UNDER
CHARGE
-
C1
100μf
25 VDC
R4
1K
SCR2
C6U

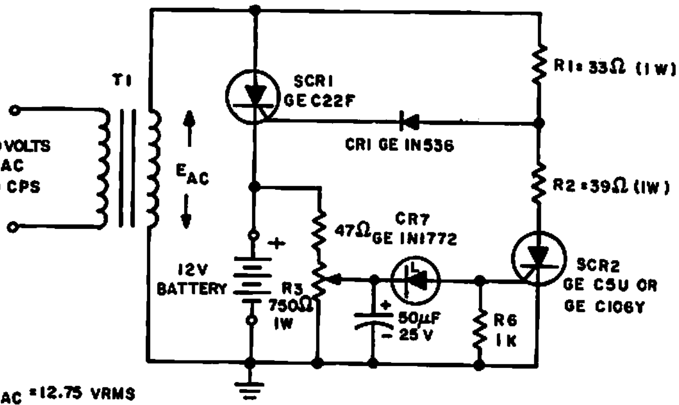
SELF-SWITCHING CHARGER—Automatically turns itself on when 12-V lead-acid battery is in need of charge, and automatically switches itself off when battery is fully charged. Maximum charge current is 5 A. To adjust, connect to fully charged battery and set R1 to position at which charging just stops (ammeter drops to zero).—Automatically Regulated Battery Charger, General Electric, Auburn, N.Y., No. 630.15.


A
C
G
SCR
RECTIFIED A. C.
VOLTAGE FROM
CHARGER
A
+
R_1
E
B_2
R_2
UJT
B_1
V
12V
Z_1
C_1
R_3
T_1
-

R_1-3.9K, 1/2 W
R_2-1K, POT.
R_3-5.1K, 1/2 W
C_1-.25 μf
Z_1-1N753, 6.2V

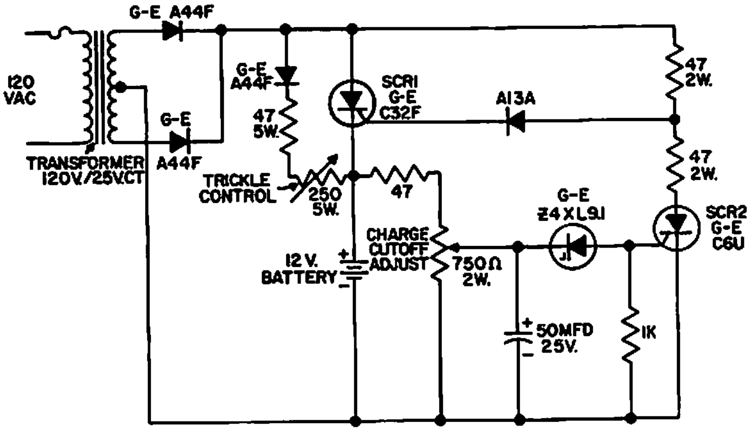
SCR-MCR808-3
UJT-2N2646
T_1-PR_1, 30_T, #22
SEC, 45T, #22
CORE: FERROX CUBE
203F181-303

12-V CLAMPED-EMITTER UJT SENSING—Will not operate unless battery is properly connected to charger. Charging stops when zener in ujt circuit senses that battery is properly charged. Triggering pulses for scr are generated by ujt oscillator when battery voltage is low.—"Zener Diode Handbook," Motorola, Phoenix, Ariz., May 1967, p 8-7.

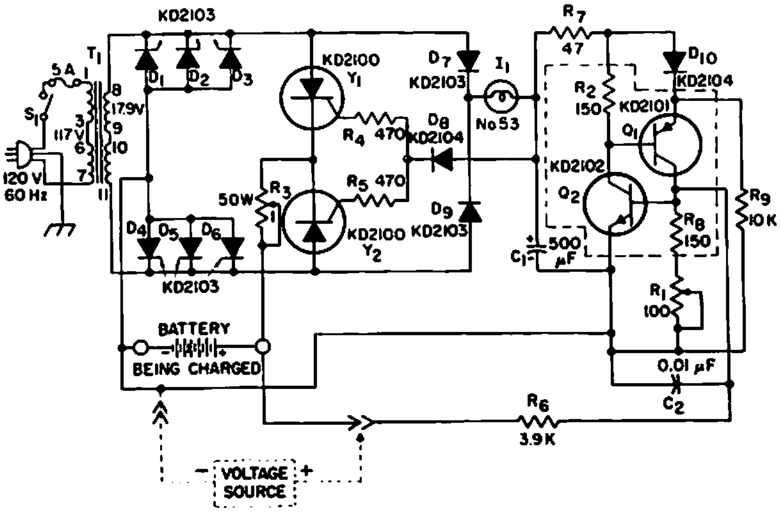

T1
120 VOLTS
AC
60 CPS
E_{AC}
SCR1
GE C22F
R1 = 33Ω (1 W)
CR1 GE 1N536
R2 = 39Ω (1W)
47Ω
CR7
GE 1N1772
+
12V
BATTERY
R3
750Ω
1W
+
50μF
25 V
R6
1 K
SCR2
GE C5U OR
GE C106Y

T_1 : - E_{AC} = 12.75 VRMS
(OPEN CKT)
& L_S = 1.2 MH

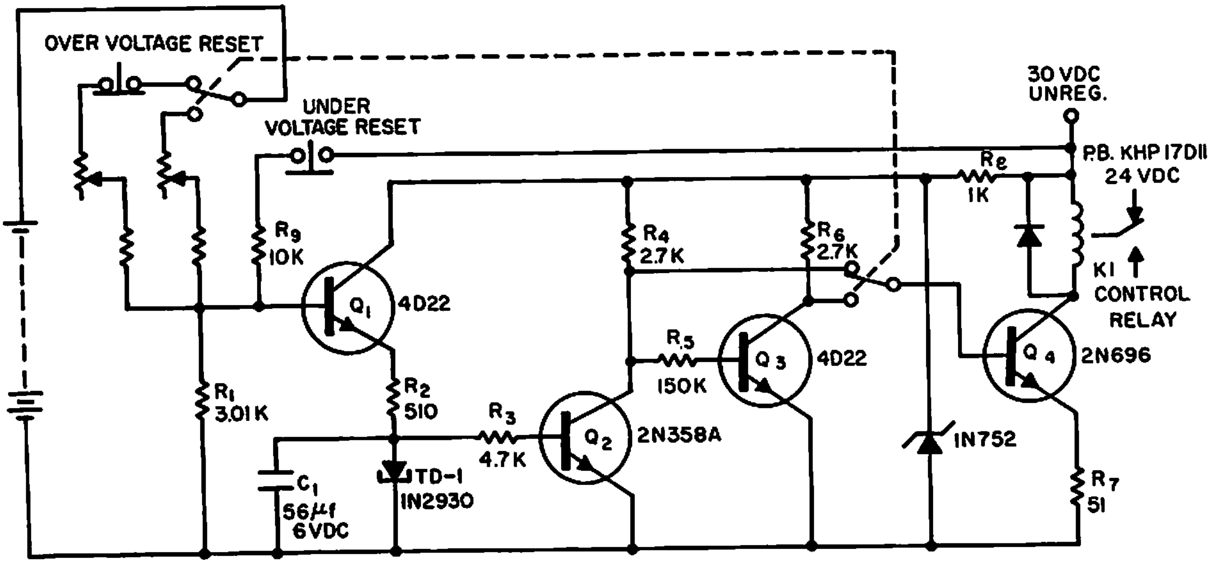
SCR CHARGER FOR 12 V—Maximum charging current depends on scr used for SCR1; article gives design equations and design procedures for several types of chargers for batteries from 12 to 400 V.—D. R. Grafham, Regulated Battery Chargers Using the Silicon Controlled Rectifier, General Electric, Syracuse, N.Y., No. 200.33, 1967.


G-E A44F
120 VAC
TRANSFORMER 120V./25V.CT
G-E A44F
G-E A44F
47 5W.
SCR1 G-E C32F
A13A
47 2W.
47 2W.
TRICKLE CONTROL
250 5W.
47
G-E Z4XL9.1
SCR2 G-E C6U
12 V. BATTERY
CHARGE CUTOFF ADJUST
750Ω 2W.
50MFD 25V.
1K

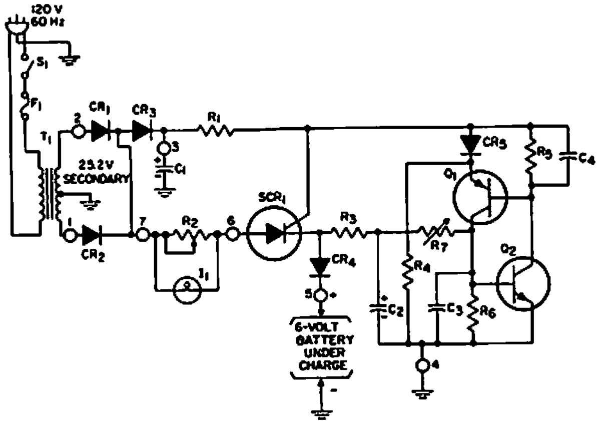
15-A CHARGER WITH REGULATOR—Charges 12-V battery from a-c line. Changes automatically to trickle charge when battery voltage reaches preset level, and starts heavy charging again when voltage falls below preset level. Ideal for use on trailers and boats, for emergency power systems, and for recharging automotive batteries.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 7.


KD2103
T1
5A
S1
120 V 60 Hz
117V
17.9V
8
9
10
11
3
6
7
D1
D2
D3
KD2100 Y1
D7 KD2103
I1 No53
R4 470
D8 KD2104
R5 470
50W
R3
D9 KD2103
KD2100 Y2
D4 D5 D6
KD2103
R7 47
D10 KD2104
R2 150
KD2101 Q1
KD2102 Q2
C1 500 μF
R8 150
R9 10K
R1 100
BATTERY BEING CHARGED
0.01 μF C2
R6 3.9K
VOLTAGE SOURCE

12 V AT 5 A—Regenerative switch Q1-Q2 conducts and turns on full-charge indicator lamp when battery is charged to predetermined desired level of 14 V as set by R1. Regenerative switch resets automatically when charger power switch S1 is open.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 80.


OVER VOLTAGE RESET
UNDER VOLTAGE RESET
30 VDC UNREG.
P.B. KHP 17D11 24 VDC
R8 1K
R9 10K
Q1 4D22
R4 2.7K
R6 2.7K
K1 CONTROL RELAY
R1 3.01K
R2 510
R3 4.7K
Q2 2N358A
R5 150K
Q3 4D22
Q4 2N696
1N752
TD-1 1N2930
C1 56μf 6VDC
R7 51

AUTOMATIC CHARGER SWITCH—Voltage detector circuit using tunnel diode operates relay to disconnect charger at preselected battery overvoltage value. In discharge mode, battery is disconnected from load when preselected undervoltage condition exists. Repeatability is within 0.1 V over temperature range of 32 to 90 F. Voltage-divider network values depend on voltages to be detected.—H. Layte, Ideas For Design, *Electronic Design*, Aug. 30, 1965, p 44.



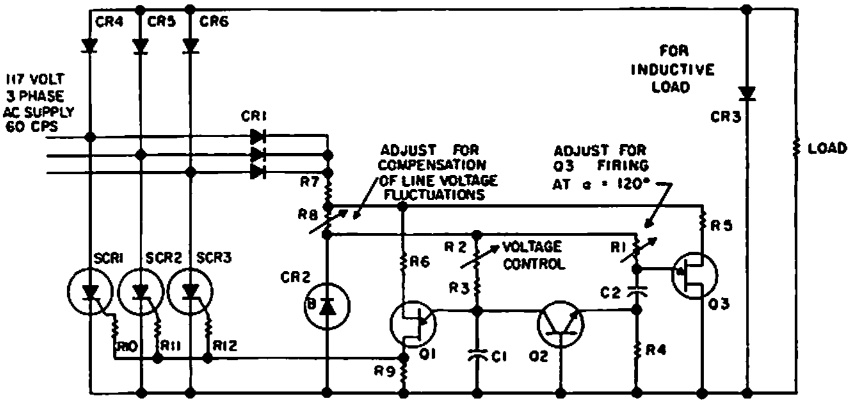
C_1 = 500 microfarads, 25 volts, electrolytic
C_2 = 100 microfarads, 12 volts, electrolytic
C_3C_4 = 0.01 microfarad, ceramic disc
CR_1 through CR_5 = silicon rectifier, RCA SK3030
F_1 = fuse, 1 ampere, 125 volts
I_1 = lamp, No. 47
Q_1 = transistor, RCA SK3005
Q_2 = transistor, RCA SK3020
R_1 = 330 ohms, 1/2 watt, 10%
R_2 = adjustable resistor, 5 ohms, 10 watts, 10%
R_3 = 4700 ohms, 1/2 watt, 10%
R_4 = 10,000 ohms, 1/2 watt, 10%
R_5 = 150 ohms, 1/2 watt, 10%
R_6 = 470 ohms, 1/2 watt, 10%
R_7 = miniature trimmer control, 5000 ohms, Mallory No. MTC-1 or equivalent
SCR_1 = silicon controlled rectifier, RCA SK2100
S_1 = switch, 125 volts, 1 ampere, single-pole, single-throw
T_1 = transformer, primary 117 volts, secondary 25.2 volts at 1 ampere, Stancor No. TP-4 or equivalent.

6-V CHARGER—For motorcycle and photoflash storage batteries. Charging rate of 1 A is automatically terminated when battery is fully charged. Adjust R7 in voltage-sensing circuit at right so scr is turned off for fully charged battery, which is 7 V for lead-acid batteries.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 114.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 9

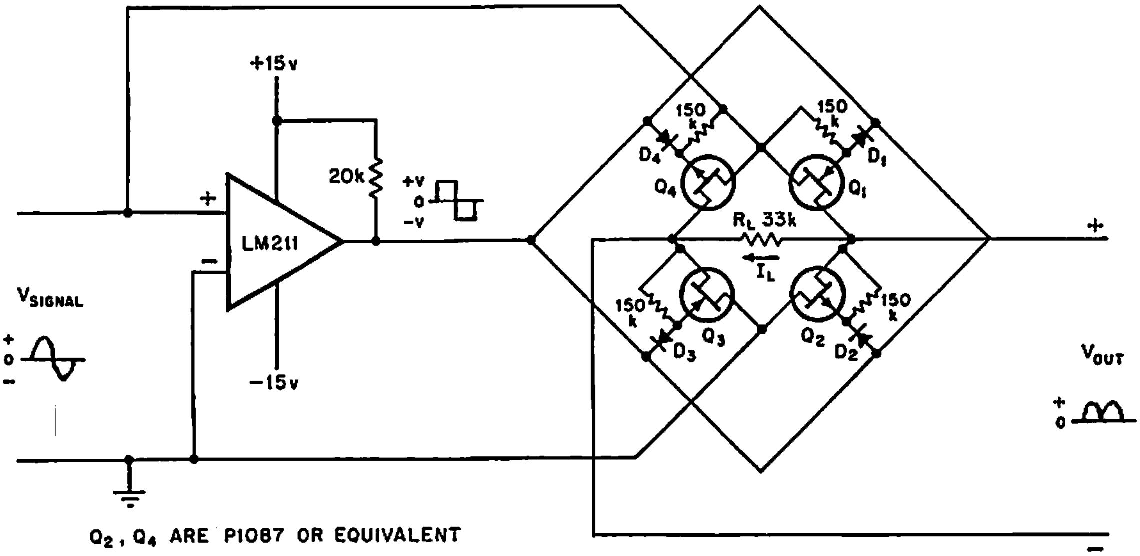
Bridge Circuits


CR4
CR5
CR6
117 VOLT
3 PHASE
AC SUPPLY
60 CPS
CR1
FOR
INDUCTIVE
LOAD
CR3
LOAD
ADJUST FOR
COMPENSATION
OF LINE VOLTAGE
FLUCTUATIONS
ADJUST FOR
Q3 FIRING
AT α = 120°
R7
R8
R5
R2
VOLTAGE
CONTROL
R1
R6
R3
C2
SCR1
SCR2
SCR3
CR2
Q3
R10
R11
R12
Q1
C1
Q2
R4
R9

CR1 — (3) G E 1N1695
CR2 — 20 VOLT, 1 WATT ZENER DIODE, 1N1527
CR3, CR4, CR5, CR6 — AS REQUIRED FOR LOAD (e g 1N2156)
SCR1, SCR2, SCR3 — AS REQUIRED FOR LOAD (e g C35B1
Q1, Q3 – G E 2N2646   Q2 – G E 2N2923
R1 – 10K POT
R2 – 20K POT
R3 – 470 Ω

R4 – 100 Ω
R5, R6 – 390 Ω
R7 – 3.3K, 2W
R8 – 500 Ω POT, 2W
R9 – 100 Ω
R10, R11, R12 – 25 Ω
C1 – 0.5 MFD
C2 – 1.0 MFD

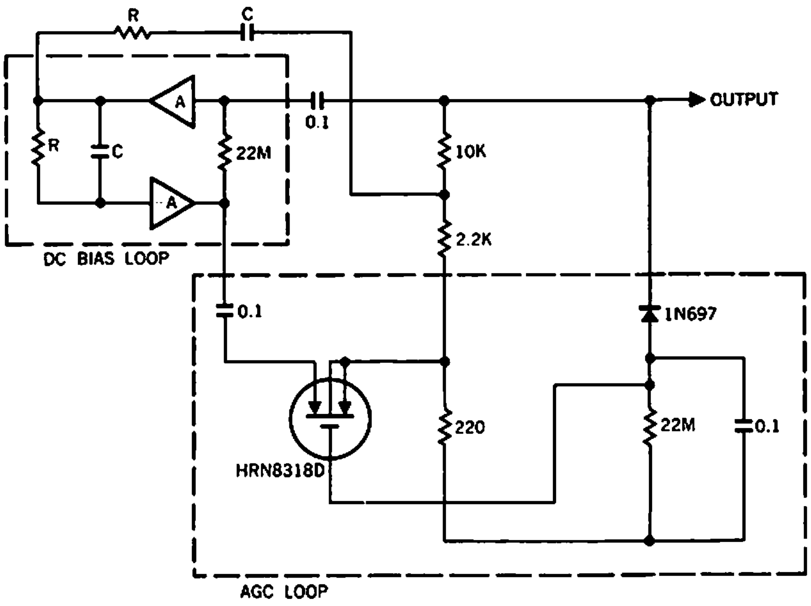
THREE-PHASE SCR CONTROL—Simple three-transistor scr firing circuit provides stepless control of d-c output voltage of three-phase bridge between 25% and 100% of maximum output voltage, or from 40 to 150 V. With 93-V output for line voltage of 130 V a-c, drop to 100 V a-c reduces d-c output only 1 V.—"SCR Manual," 4th Edition, General Electric, 1967, p 202–204.


+15v
20k
+V
0
−V
+
−
LM211
−15v
VSIGNAL
+
0
−
150 k
150 k
D4
D1
Q4
Q1
RL 33k
IL
150 k
150 k
D3
Q3
Q2
D2
+
VOUT
+
0
−

Q_2, Q_4 ARE P1087 OR EQUIVALENT

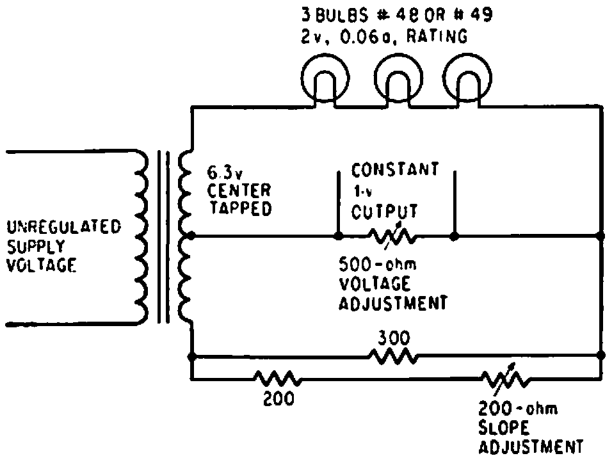
Q_1, Q_3 ARE U1899 OR EQUIVALENT D_1 THRU D_4 ARE 1N3064 OR EQUIVALENT

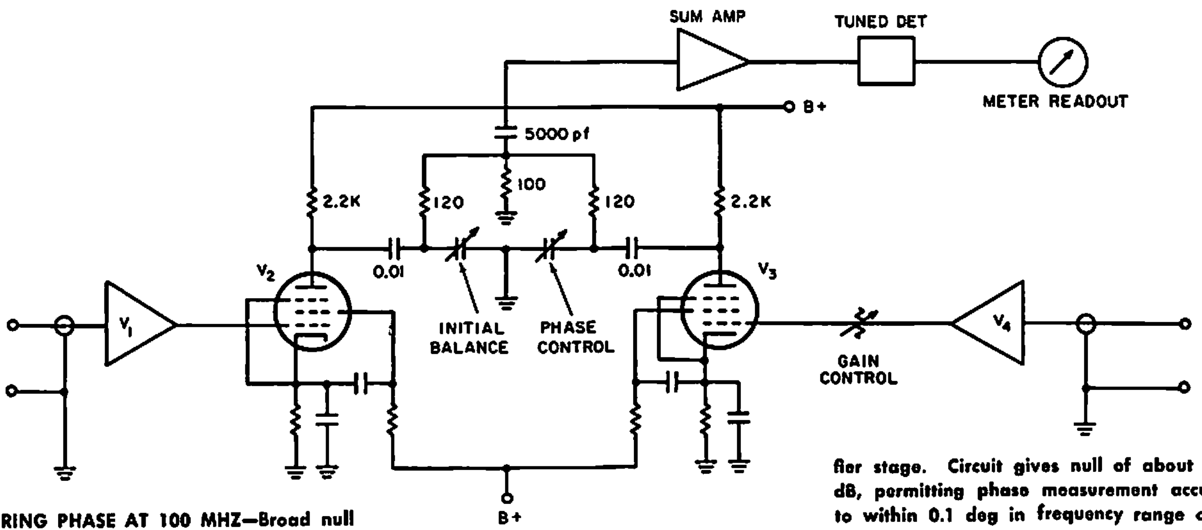
COMPARATOR-CONTROLLED FET BRIDGE—Diodes have secondary role of simply switching fet's. With zero offset voltage for fet's, output closely follows or inverts half of sine-wave input signal, to give full-wave rectification with no distortion.—L. Accardi, Diode-Switched FET's Rectify the Full Wave, *Electronics*, Aug. 3, 1970, p 76.


R
C
A
A
0.1
OUTPUT
R
C
22M
10K
2.2K
DC BIAS LOOP
0.1
1N697
HRN8318D
220
22M
0.1
AGC LOOP

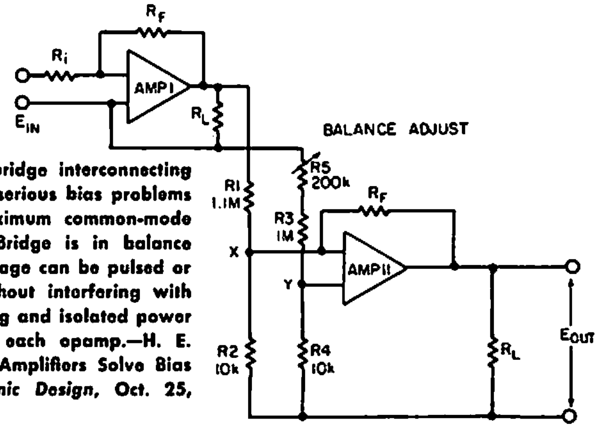
WIEN-BRIDGE OSCILLATOR—Mosfet is used as linear resistance whose value depends on level of oscillator output signal. Increase in output level gives bias voltage for mosfet by detection of peak negative value, for controlling gain in oscillator automatically.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 29.

LAMPS REGULATE 1-V A-C—Inexpensive voltage-regulating bridge depends on ballast action of 2-V lamps operated at about 0.6 V to give 1-V a-c output that varies only 0.25% for line voltage change of 105 to 125 V. Regulation is independent of frequency over range of 25 to 800 Hz. Thermal inertia makes correction slow, so large input change may require almost 1 s for full correction, but this is usually not serious drawback. Bulbs should be soldered into circuit.—D. Kelly, Small Lamp Bridge Regulates Line Voltage, *Electronics,* March 20, 1967, p 89–90.

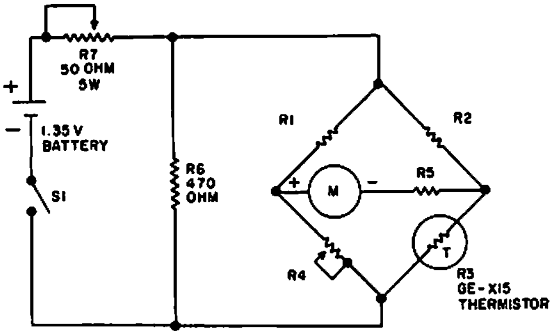

3 BULBS # 48 OR # 49
2v, 0.06a, RATING
UNREGULATED SUPPLY VOLTAGE
6.3v CENTER TAPPED
CONSTANT 1-v OUTPUT
500-ohm VOLTAGE ADJUSTMENT
300
200
200-ohm SLOPE ADJUSTMENT


SUM AMP
TUNED DET
METER READOUT
B+
5000 pf
100
2.2K
120
120
2.2K
0.01
0.01
V2
V3
V1
INITIAL BALANCE
PHASE CONTROL
GAIN CONTROL
V4
B+

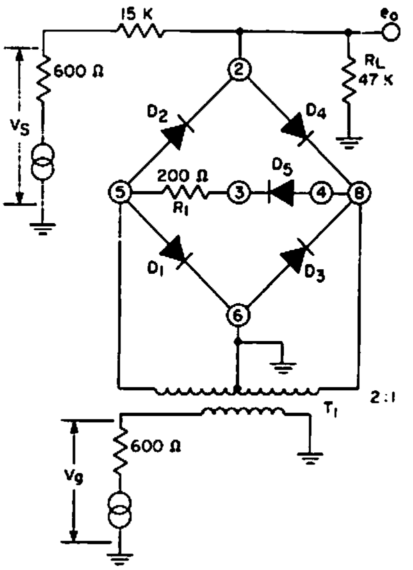
MEASURING PHASE AT 100 MHZ—Broad null of conventional balanced bridge is sharpened in Teltronics PD-200 phase detector by using two similar channels exactly 180 deg out of phase. Pentode types for V2 and V3 are not critical, and component values for tube circuits are those of conventional pentode amplifier stage. Circuit gives null of about −55 dB, permitting phase measurement accuracy to within 0.1 deg in frequency range of 15 to 100 MHz.—R. O. Goodwin, Unbalanced Bridge Simplifies Phase Measurements, *Electronic Design,* March 15, 1965, p 52–53.


R_F
R_i
AMP I
E_IN
R_L
BALANCE ADJUST
R5 200k
R_F
R1 1.1M
R3 1M
X
Y
AMP II
R2 10k
R4 10k
R_L
E_OUT

OPAMP BIAS—Resistor bridge interconnecting two opamps eliminates serious bias problems without regard for maximum common-mode input voltage rating. Bridge is in balance at X and Y, so bias voltage can be pulsed or continuously varied without interfering with signal. Separate floating and isolated power supply is required for each opamp.—H. E. Weber, IC Operational Amplifiers Solve Bias Level Problems, *Electronic Design*, Oct. 25, 1969, p 109 and 111.

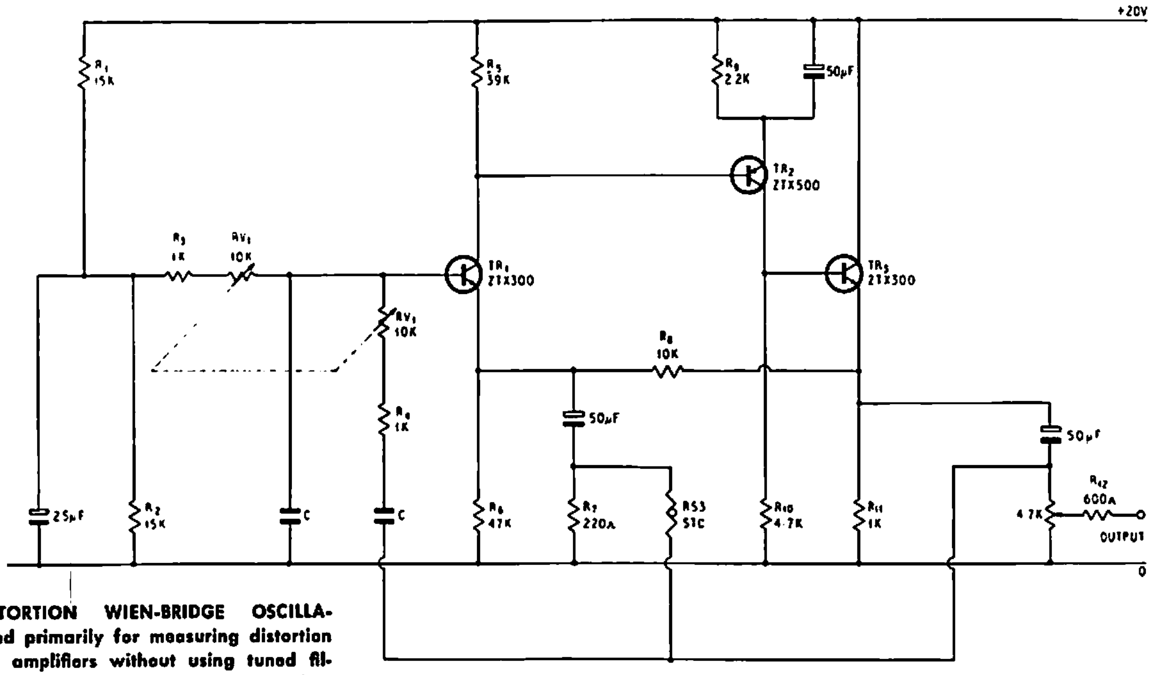

R7
50 OHM
5W
+
-
1.35 V
BATTERY
S1
R6
470
OHM
R1
R2
+
M
-
R5
T
R4
R3
GE-X15
THERMISTOR

THERMISTOR THERMOMETER—Will indicate on meter the temperature inside deep freeze, solution temperature in darkroom, or any other temperature measurable with thermistor that can be connected into bridge-meter circuit shown. For range of 32 to 122 F, R1 and R2 are 1,000, R4 is 5,000, and R5 is 9,500 ohms. For low-temperature range of −40 to +32 F, R1 and R2 are 7,300, R4 is 50,000, and R5 is 4,850 ohms, with battery changed to 1.5-V mercury cell. Both ranges use 50-µA d-c meter (GE type DW-91 having 1,500 ohms resistance). Resistor values in bridge are critical. Calibrate with crushed ice in water and with calibrating resistors supplied with thermistor.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 150.


15 K
e_o
600 Ω
V_S
R_L
47 K
2
D_2
D_4
200 Ω
R_I
D_5
5
3
4
8
D_1
D_3
6
2:1
T_1
600 Ω
Vg

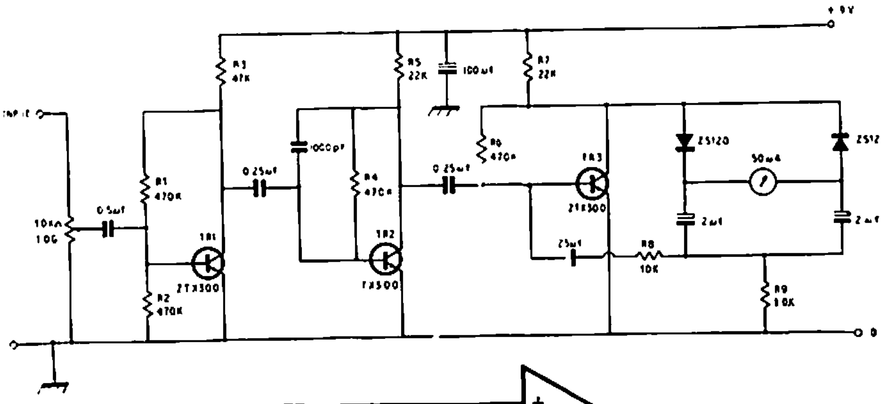
T₁—TECHNITROL No. 851166 OR EQUIV.

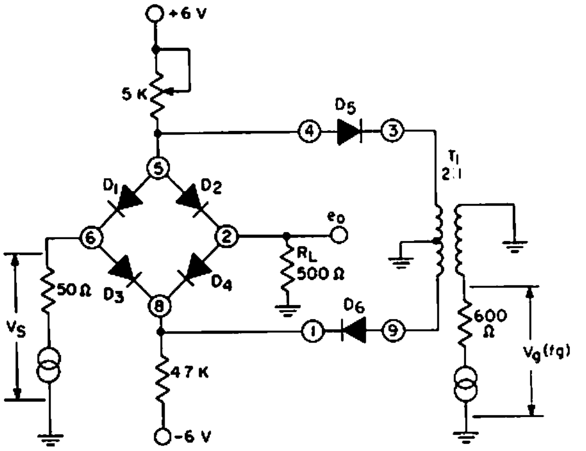
SHUNT GATE—Uses CA3019 diode IC array with diode bridge shunting load resistance and balancing out gating signal to provide pedestal-free output. When gating voltage Vg is of sufficient amplitude, bridge conducts for half of each gating cycle and prevents input signal Vs from reaching output. Gating voltage should be 0.8 to 1.2 V rms at 1 to 100 kHz, and input signal 0 to 1 V rms from d-c to 500 kHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 303.


+20V
R1 15K
R5 39K
R9 2.2K
50µF
TR2 ZTX500
R3 1K
RV1 10K
TR1 ZTX300
TR3 ZTX300
RV1 10K
R4 1K
R8 10K
50µF
50µF
R12 600Ω
4.7K
OUTPUT
25µF
R2 15K
C
C
R6 47K
R7 220Ω
R53 51Ω
R10 4.7K
R11 1K
0

LOW-DISTORTION WIEN-BRIDGE OSCILLATOR—Used primarily for measuring distortion in audio amplifiers without using tuned filters. Delivers pure sine wave with very low distortion. Values of R3 and R4 determine frequency ratio covered on each range; 1K gives maximum to minimum frequency ratio of 11:1, for small overlap on decade ranges. Output is 1 V rms into 600 ohms over frequency range of 10 Hz to 100 kHz.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 36.

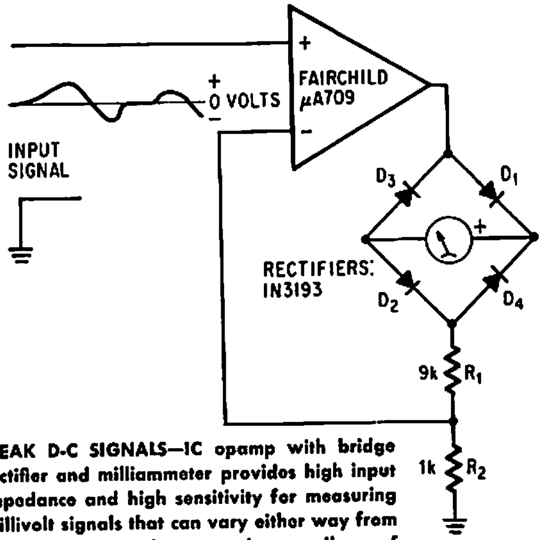
BRIDGE BALANCE DETECTOR—Design goal is simplest circuit giving sufficient sensitivity and linearity, since gain stability is unimportant for application. Report gives design procedure.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 38.


+9V
INPUT
10kΩ LOG
0.5µF
R1 470K
R2 470K
TR1
ZTX300
R3 47K
0.25µF
1000pF
R4 470K
TR2
ZTX300
R5 22K
100µF
R6 470K
0.25µF
R7 22K
TR3
ZTX300
25µF
R8 10K
ZS120
ZS120
50µA
2µF
2µF
R9 10K
0


+6 V
5 K
D5
4
3
T1
2:1
5
D1
D2
6
2
e0
RL
500 Ω
50 Ω
D3
D4
8
D6
1
9
600 Ω
Vg (fg)
VS
47 K
-6 V

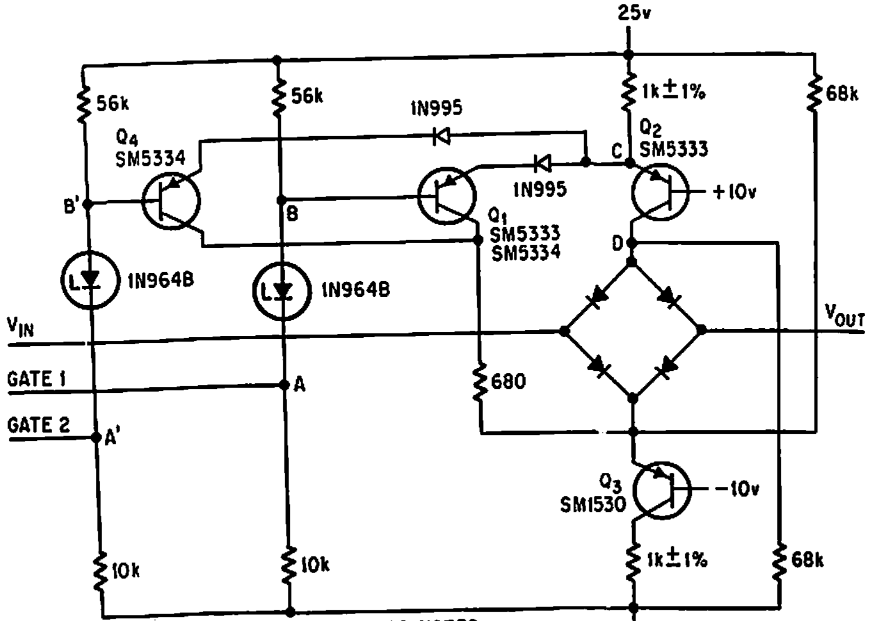
T1—TECHNITROL No 85II66 OR EQUIV.

SERIES GATE—Uses CA3019 four-diode IC array in diode-quad bridge that balances out undesired gating signal at output and reduces pedestal to extent that bridge is balanced. Gating voltage should be 1 to 3 V rms at 1 to 500 kHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 301.


+
FAIRCHILD
µA709
-
+
0 VOLTS
-
INPUT SIGNAL
D3
D1
+
RECTIFIERS:
IN3193
D2
D4
9k
R1
1k
R2

WEAK D-C SIGNALS—IC opamp with bridge rectifier and milliammeter provides high input impedance and high sensitivity for measuring millivolt signals that can vary either way from zero. Meter reads upward regardless of input polarity. Full-scale sensitivity is 1 V. R1 insures that meter overload will not exceed 5%. For measuring a-c voltages, meter indicates average value of rectified waveform; for rms readings, reduce R2 by 11%.—J. P. Budlong, Bridge and Amplifier Monitor D-c Level, *Electronics*, Sept. 2, 1968, p 71–72.

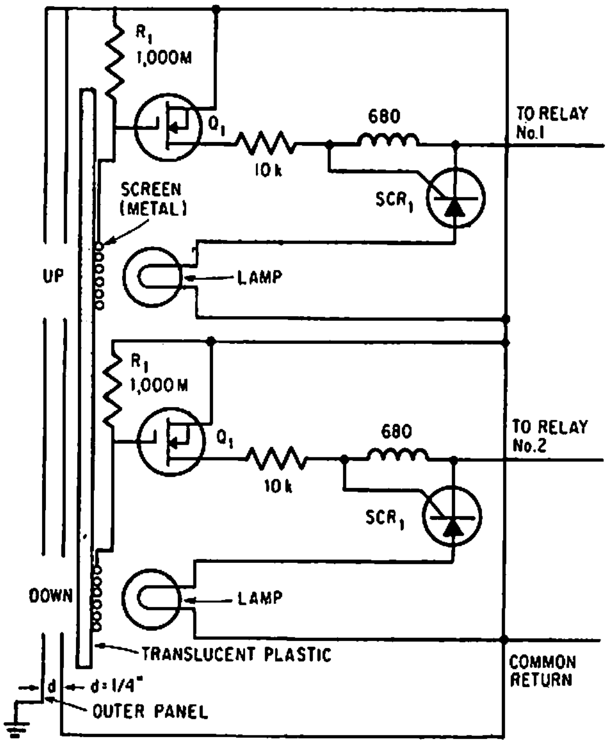
DIAMOND GATE—Used in Paramatrix system for preprocessing analog information, chiefly photos and graphs, while converting to digital signals under computer control. System can enlarge or shrink picture, move it around, rotate it, correct blurs, and fill in gaps. Cuts computer requirements by factor of 10. Can also be applied to automatic drafting. Article presents theory and many block diagrams along with examples of results achieved. Circuit shown is used in interpolator, and requires input signals at both gates before diode bridge transmits analog voltage.—W. J. Poppelbaum, M. Faiman, and E. Carr, Paramatrix Puts Digital Computer In Analog Picture, And Vice Versa, *Electronics*, Sept. 4, 1967, p 99–108.


25v
56k
56k
1k±1%
68k
IN995
Q4
SM5334
Q2
SM5333
C
IN995
+10v
B'
B
Q1
SM5333
SM5334
D
IN964B
IN964B
VIN
VOUT
GATE 1
A
680
GATE 2
A'
Q3
SM1530
-10v
10k
10k
1k±1%
68k
-25v

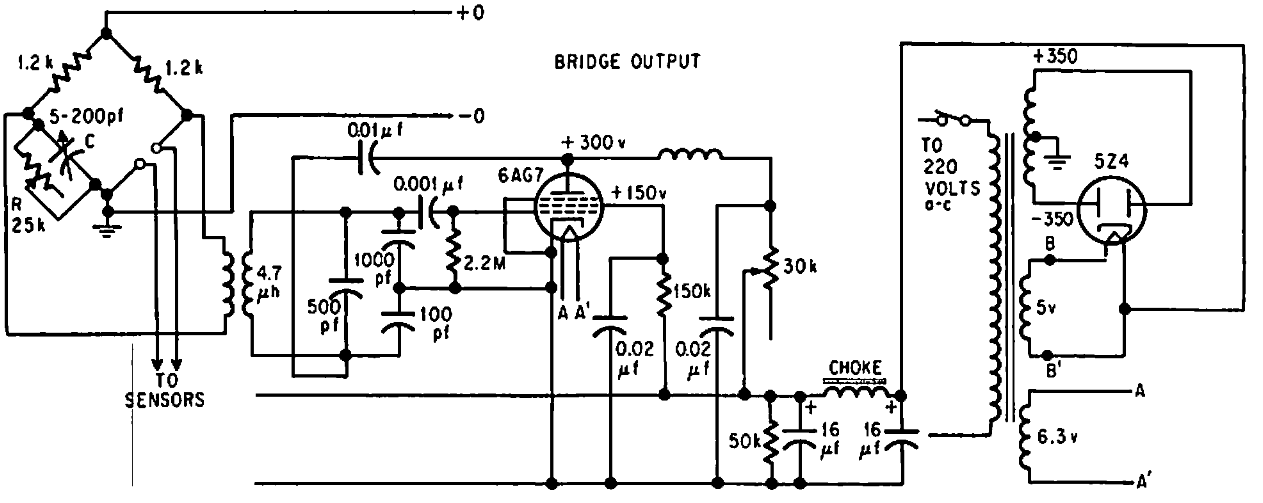
RESISTORS ±5% EXCEPT AS NOTED
BRIDGE DIODES ARE SG5428

CHAPTER 10

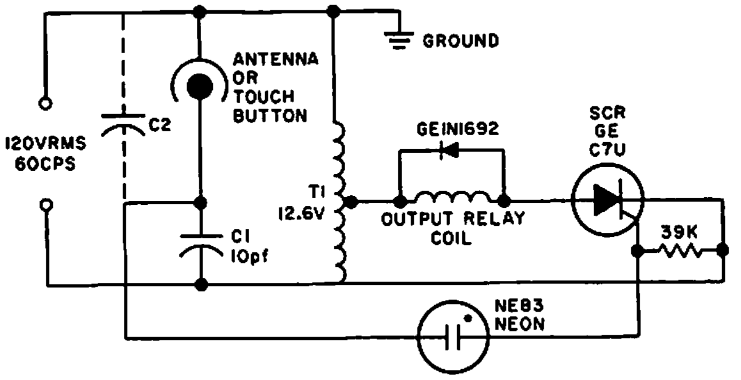
Capacitance Control Circuits


R$_1$
1,000M
Q$_1$
680
10k
TO RELAY No.1
SCREEN (METAL)
SCR$_1$
UP
LAMP
R$_1$
1,000M
Q$_1$
680
10k
TO RELAY No.2
SCR$_1$
DOWN
LAMP
TRANSLUCENT PLASTIC
COMMON RETURN
d
d = 1/4"
OUTER PANEL

NO-PUSH ELEVATOR BUTTON—Finger near button, even if gloved, actuates appropriate relay in modern elevator control system and turns on lamp behind button. Screen behind button picks up hum signal from building ground, capacitively coupled through body of person. This signal is passed to MEM511 mosfet which in turn makes GE C106 scr turn on No. 1829 lamp and relay.—F. G. Geil, MOS FET Takes the Push Out of Elevator Push Button, *Electronics*, Oct. 30, 1967, p 70–71.

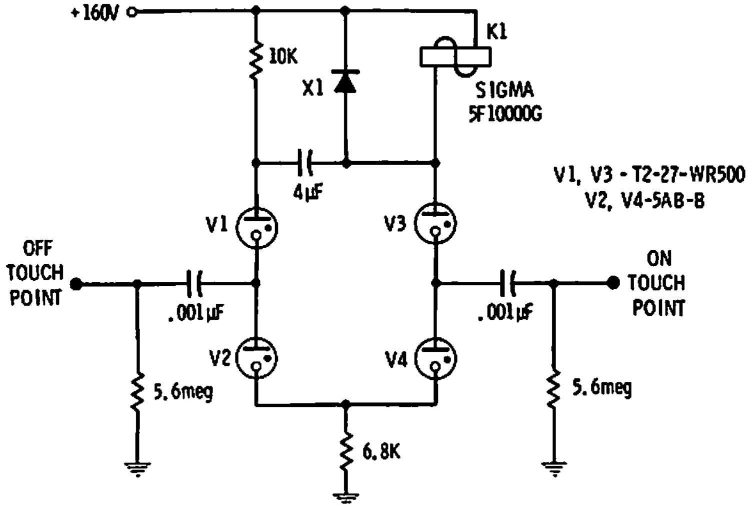

+0
1.2k
1.2k
BRIDGE OUTPUT
5-200pf
C
-0
R
25k
0.01 μf
+300v
0.001 μf
6AG7
+150v
+350
TO 220 VOLTS a-c
5Z4
-350
B
4.7 μh
1000 pf
2.2M
30k
500 pf
100 pf
A A'
150k
5v
0.02 μf
0.02 μf
B'
TO SENSORS
CHOKE
A
16 μf
16 μf
50k
6.3v
A'

LIQUID LEVEL IN TANK—Movement of liquid in glass gage tube outside tank changes capacitance between liquid and metal-band sensor around glass. Sensor is connected in one arm of bridge, which is first balanced by adjusting C and R with liquid at top of the two sensor electrode rings. Bridge receives 10-V excitation from 3.2-MHz oscillator using 6AG7 tube. Article gives detection sensitivity for ten different liquids.—P. K. Mital, Capacitance Sensor Monitors Stored Liquid Levels, *Electronics*, Oct. 30, 1967, p 71–72.

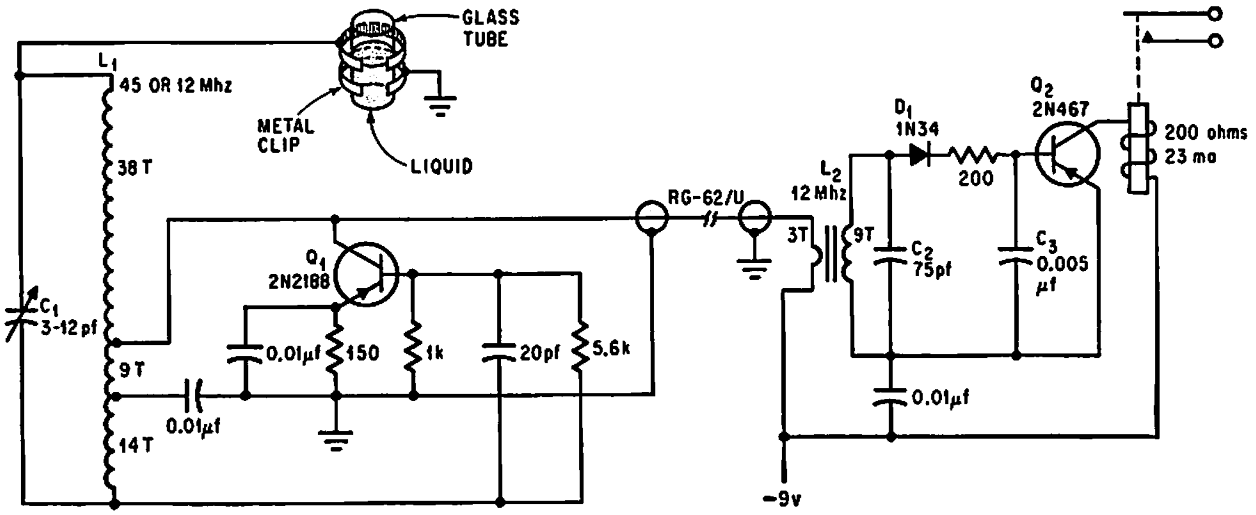

GROUND
ANTENNA OR TOUCH BUTTON
C2
120VRMS 60CPS
GEIN1692
SCR GE C7U
T1 12.6V
OUTPUT RELAY COIL
C1 10pf
39K
NE83 NEON

T1 :- 117/12.6 VOLT AUTO TRANSFORMER (OR FILAMENT TRANSFORMER)

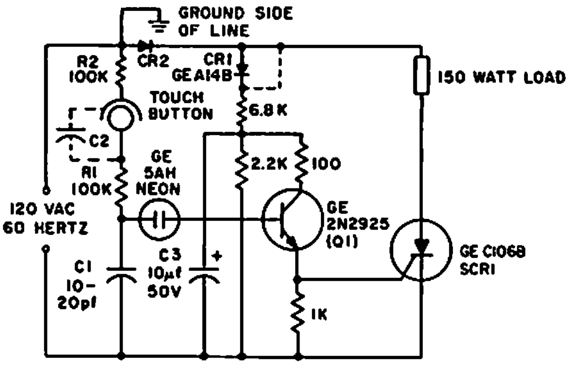
PROXIMITY SWITCH—Can be used for elevator call buttons, supermarket and other door controls, burglar alarms, and other applications where load is to be energized by momentary touch of finger on button. C2 represents capacitance between touch button and ground that is provided by body of person. Size of touch button or sensing plate depends on distance to object being sensed; if distance is small, as with touch control, sensing plate need be no larger than a penny. For latching action, drive scr anode circuit only with d-c.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 30.


+160V
10K
X1
K1
SIGMA 5F10000G
4µF
V1
V3
V1, V3 - T2-27-WR500
V2, V4-5AB-B
OFF TOUCH POINT
.001µF
.001µF
ON TOUCH POINT
V2
V4
5.6meg
5.6meg
6.8K

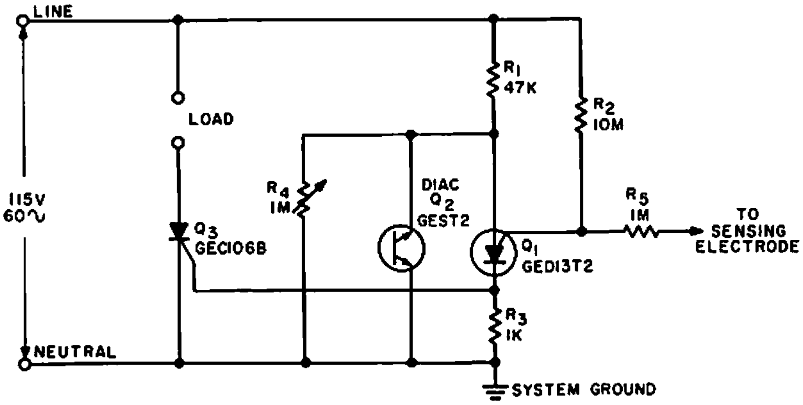
BODY-CAPACITANCE CONTROL—Bistable neon mvbr is triggered by momentary finger contact with ON touch point, to pull in relay. Relay releases when other point is touched. Chief requirement is sufficient capacitance between circuit and ground. With a-c/d-c supply, ground side of power line should go to circuit ground. With battery supply, larger touch points are needed and circuit ground should be metal chassis.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 74.


GLASS TUBE
METAL CLIP
LIQUID
L_1
45 OR 12 Mhz
38 T
C_1 3-12 pf
9 T
14 T
Q_1 2N2188
0.01µf
150
1k
20pf
5.6k
0.01µf
RG-62/U
L_2 12 Mhz
3T
9T
D_1 1N34
200
C_2 75pf
C_3 0.005 µf
Q_2 2N467
200 ohms 23 ma
0.01µf
-9v

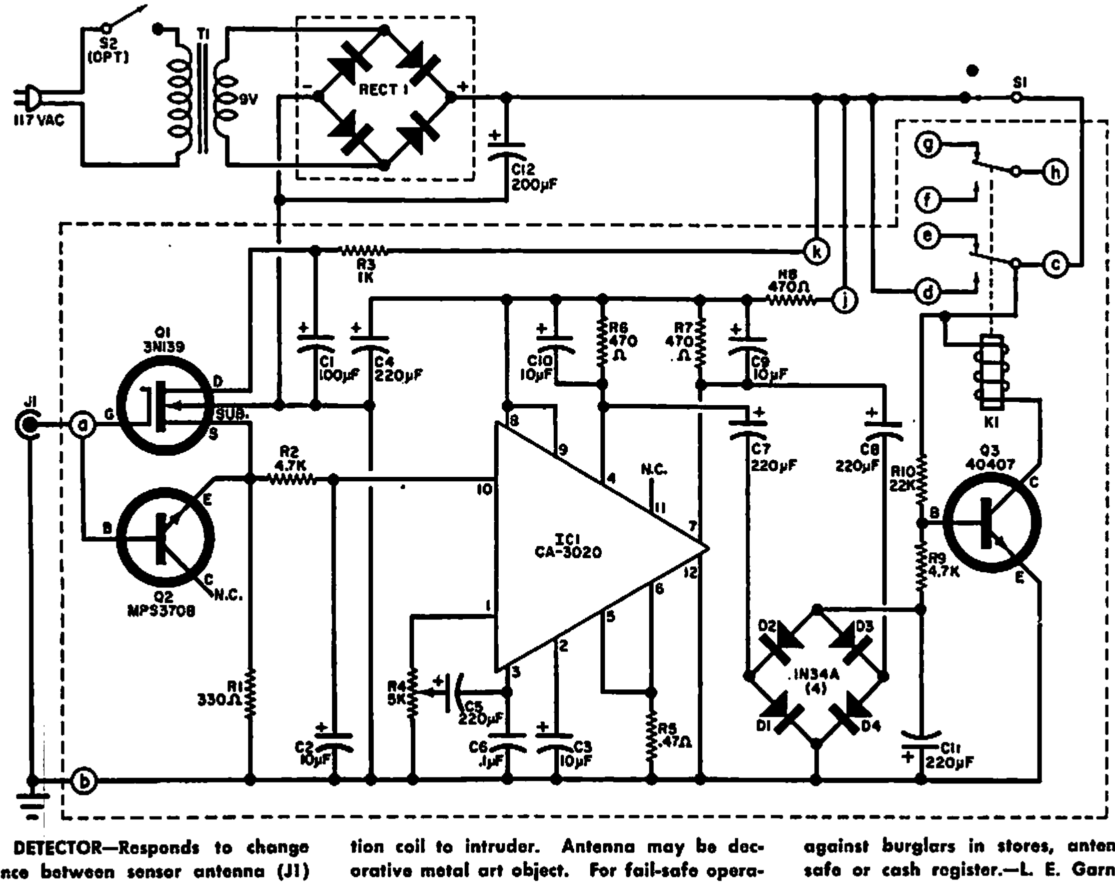
LIQUID-SENSING CAPACITOR—Conventional Hartley oscillator resonates at 45 MHz when glass tube is empty. When liquid reaches critical level inside metal bands surrounding tube, increased dielectric constant of liquid column changes capacitance enough to reduce frequency to 12 MHz. Circuit will trigger reliably with differential capacitance of 0.1 pF between sensing point and ground.—J. K. Marsh, Two-Frequency Oscillator Detects Level of Liquid, *Electronics*, March 20, 1967, p 90.


GROUND SIDE OF LINE
R2 100K
CR2
CR1 GE A14B
TOUCH BUTTON
6.8 K
150 WATT LOAD
C2
R1 100K
GE 5AH NEON
2.2K
100
GE 2N2925 (Q1)
GE C106B SCR1
120 VAC 60 HERTZ
C1 10-20pf
C3 10μf 50V
1K

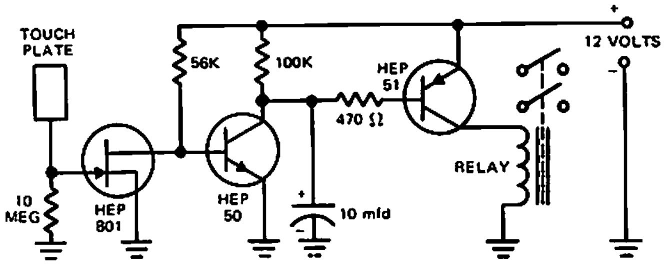
PROXIMITY SWITCH—Load is energized as long as button of sensor plate capacitor C2 is touched. When button is released, load is de-energized. Latching action can be obtained by replacing CR1 with connection shown as dashed line. Reset will then require auxiliary contact in series with SCR1. Used for door safety controls and floor selector buttons in elevators, supermarket door control, safe monitor in banks, flow switches, and conveyor counting systems.—"SCR Manual," 4th Edition, General Electric, 1967, p 169.


LINE
LOAD
115V 60∿
NEUTRAL
Q3 GEC106B
R4 1M
DIAC Q2 GEST2
R1 47K
R2 10M
R5 1M
Q1 GED13T2
R3 1K
TO SENSING ELECTRODE
SYSTEM GROUND

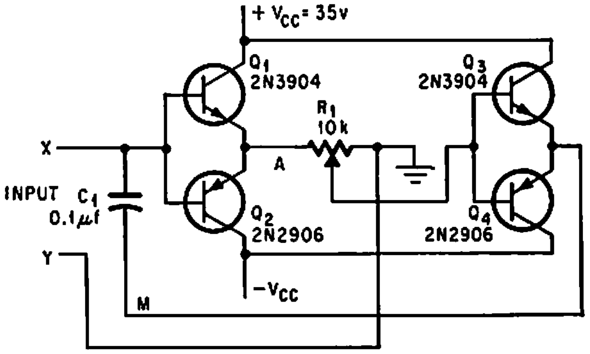
100-W A-C PROXIMITY SWITCH—High sensitivity of D13T2 programmable ujt makes triggering of circuit possible with only about 10 pF capacitance between sensing electrode and ground. This means that finger does not have to touch sensing button. Circuit is nonlatching, and will therefore open when body or other capacitance is removed. R4 adjusts sensitivity. Applications include counting freshly painted objects moving past on conveyor line.—E. K. Howell, Small Scale Integration in Low Cost Control Circuits, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 19.


S2 (OPT)
T1
117 VAC
9V
RECT 1
C12 200μF
S1
R3 1K
R8 470Ω
Q1 3N139
C1 100μF
C4 220μF
C10 10μF
R6 470 Ω
R7 470 Ω
C9 10μF
K1
J1
SUB.
R2 4.7K
C7 220μF
C8 220μF
R10 22K
Q3 40407
Q2 MPS3708
N.C.
IC1 CA-3020
R9 4.7K
D2
D3
.1N34A (4)
D1
D4
R1 330Ω
R4 5K
C5 220μF
C2 10μF
C6 .1μF
C3 10μF
R5 .47Ω
C11 220μF
a b c d e f g h j k
D G S B E C

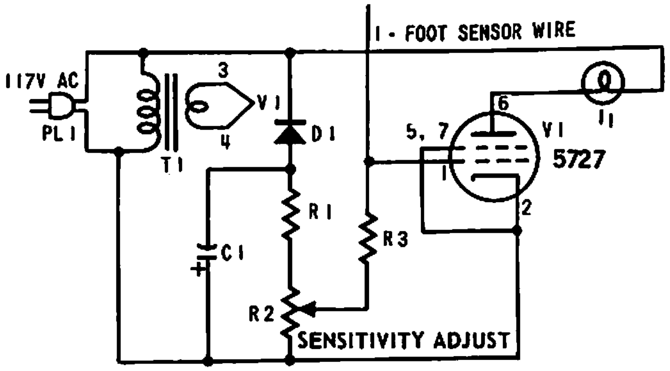
INTRUSION DETECTOR—Responds to change in capacitance between sensor antenna (J1) and ground when person is within several feet of antenna, to energize relay that trips local or remote alarm, turns on lights, summons guard, or applies output of auto ignition coil to intruder. Antenna may be decorative metal art object. For fail-safe operation, Q3 may be biased to energize relay under normal conditions. Presence of intruder or failure of power will then release relay and set off alarm. For protection against burglars in stores, antenna can be safe or cash register.—L. E. Garner, Jr., The Amazing "People Detector," *Popular Electronics*, June 1968, p 27–32 and 93.


TOUCH PLATE
56K
100K
HEP 51
470 Ω
+ 12 VOLTS −
RELAY
10 MEG
HEP 801
HEP 50
10 mfd

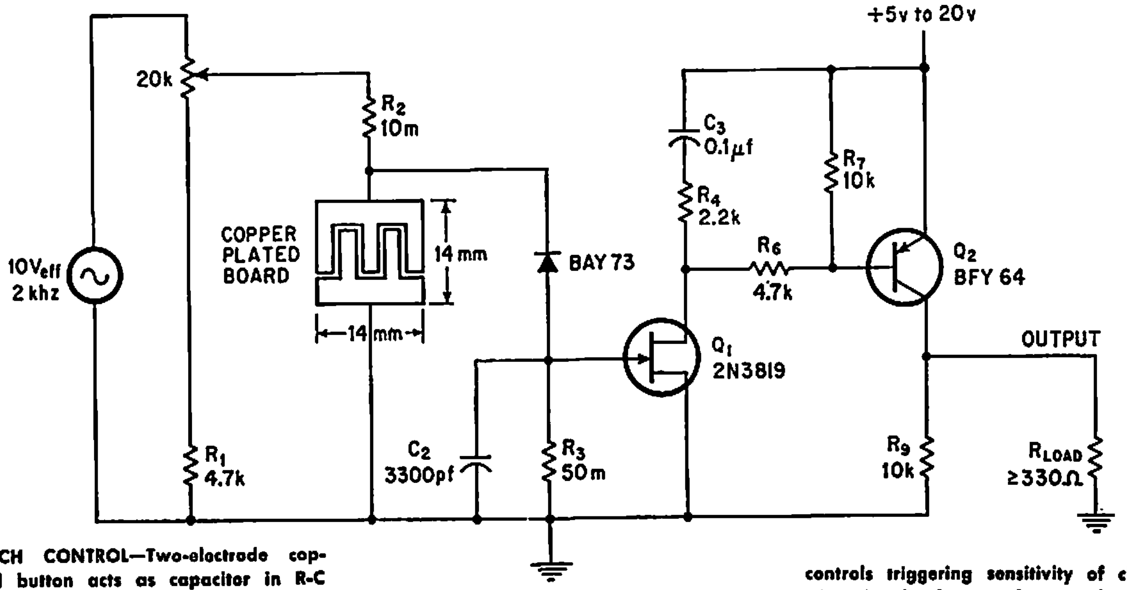
TOUCH SWITCH—Can be used to turn on or off variety of circuits, depending on type of relay used. Touching metal plate, which should be kept close to gate of fet, operates relay.—"Tips on Using FET's," Motorola, Phoenix, Ariz., HMA-33, 1969.


+ V_{CC} = 35v
Q_1 2N3904
Q_3 2N3904
R_1 10k
X
A
INPUT C_1 0.1μf
Q_2 2N2906
Q_4 2N2906
Y
M
$-V_{CC}$

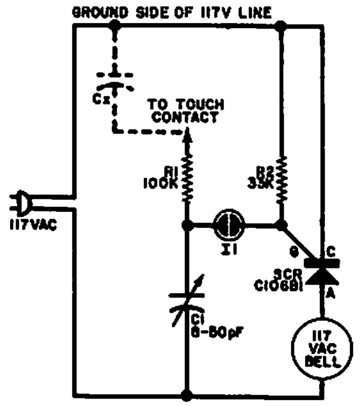
1,000:1 VARIABLE CAPACITOR—Potentiometer R1, buffered on both sides by complementary emitter-followers, reduces effective value of fixed capacitor C1 over much greater range than with conventional variable capacitors. Useful for capacitive tuning of tank circuits over wide frequency ranges.—J. Gaon, Feedback Turns Fixed Capacitor into Variable Capacitance, *Electronics*, Nov. 28, 1966, p 80—81.


I - FOOT SENSOR WIRE
117V AC
PL1
3
V1
4
T1
D1
5, 7
6
V1
5727
I1
1
2
R1
C1
R3
R2
SENSITIVITY ADJUST

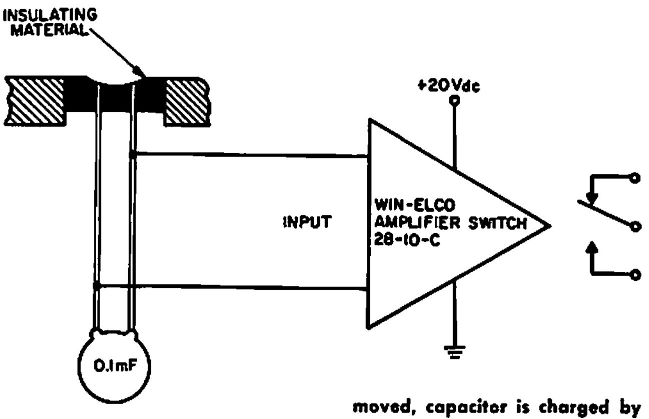
PROXIMITY DETECTOR—Turns on light when person approaches sensor wire. R2 should be well insulated because it is connected to one side of power line when at lower end of range. Values are: I1 10-W lamp; T1 Stancor P-6134; D1 125-V 65-mA selenium rectifier; C1 10 μF; R1 39K; R2 15K pot; R3 3.9 meg.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 144.


+5v to 20v
20k
R_2 10m
C_3 0.1μf
R_7 10k
R_4 2.2k
COPPER PLATED BOARD
14 mm
14 mm
BAY73
R_6 4.7k
Q_2 BFY 64
$10V_{eff}$ 2 khz
OUTPUT
Q_1 2N3819
R_1 4.7k
C_2 3300pf
R_3 50m
R_9 10k
R_{LOAD} ≥330Ω

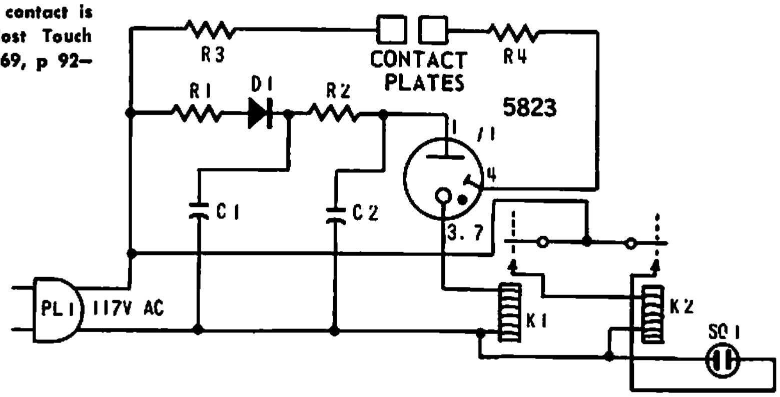
SOFT-TOUCH CONTROL—Two-electrode copper-plated button acts as capacitor in R-C reactive bleeder circuit connected to 2-kHz 10-V source. With button not touched, fet Q1 and transistor Q2 are off and output is at ground or logic zero. When button is touched, its capacitance increases about five times, triggering both transistors on and giving positive output voltage or logic one. Pot controls triggering sensitivity of circuit and triggering level. May be used for elevators, typewriters, and computers.—F. Minder, Touch-Activated Switch Built With Copper-Plated Board, *Electronics*, Sept. 1, 1969, p 79.


GROUND SIDE OF 117V LINE
Cx
TO TOUCH CONTACT
R1 100K
R2 33K
117VAC
I1
G
C
SCR C106B1
A
C1 8-80pF
117 VAC BELL

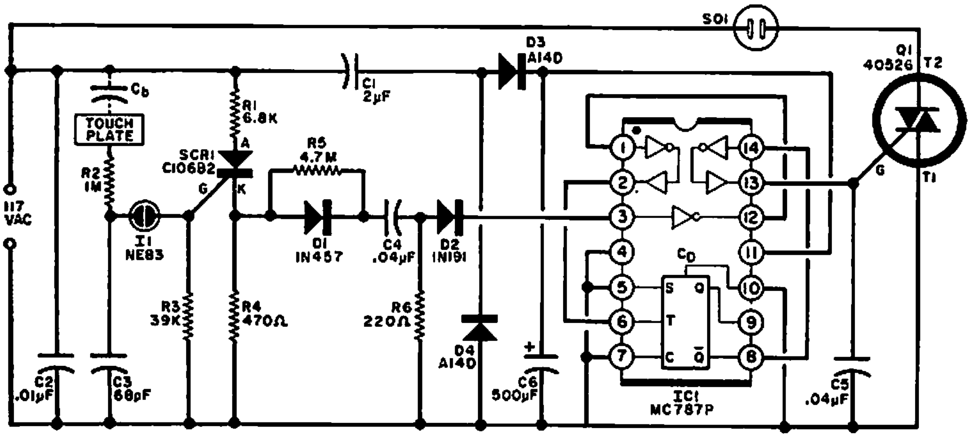
TOUCH ALARM—When intruder touches metal plate or other metal object connected to free end of R1, scr is triggered on and alarm is energized. May be connected to doorknob, metal screen door, foil strip on window sill, or other metal object that is not too large. Object must not be grounded through building structure, because alarm depends on change in capacitance between R1 and ground. Alarm stops when touch contact is broken.—R. F. Graf, Build Low-Cost Touch Alarm, *Popular Electronics*, Feb. 1969, p 92–93.


INSULATING MATERIAL
+20Vdc
INPUT
WIN-ELCO AMPLIFIER SWITCH 28-10-C
0.1mF

TOUCH SWITCH—Finger in depression of switch plate discharges capacitor and energizes double Darlington amplifier driving reed switch. Relay remains energized as long as finger makes contact. When finger is removed, capacitor is charged by IC and relay stays energized for about 10 s until charging current drops below threshold current of amplifier.—J. H. Still, Time Delay Touch Switch Uses Body Stray Voltage, *Electronic Design*, July 19, 1967, p 106.


R3
CONTACT PLATES
R4
R1
D1
R2
5823
1
1
4
C1
C2
3. 7
PL1
117V AC
K1
K2
SO1

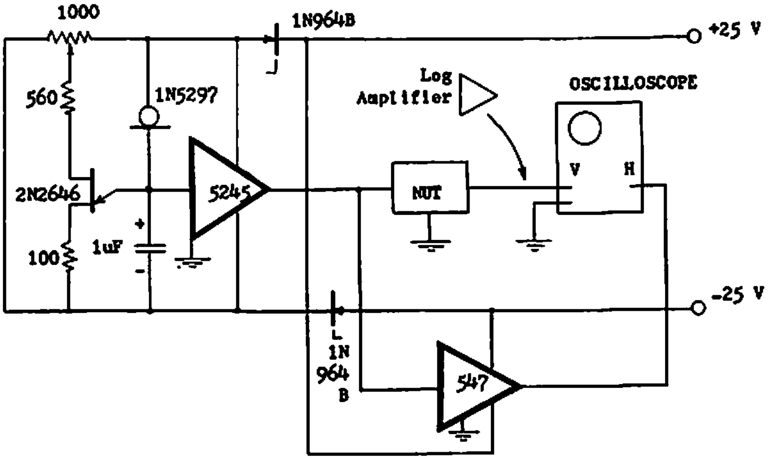
TOUCH CONTROL—Lamp, appliance, tv, or stereo set can be turned on simply by touching two small pieces of tin foil or metal with finger to bridge gap between them. Uses grid-glow tube. Relays are 2.5K. When V1 pulls in K1, its contacts pull in K2 to apply power to lamp or other appliance plugged into socket. Once fired, V1 stays on and relays remain energized until power from a-c line is interrupted. Values are: D1 125-V 65-mA selenium rectifier; C1 0.47 μF; C2 2μF; R1 27; R2 110K; R3 1.1 meg; R4 110K. Warning: if R3 is shorted or much smaller resistor used, circuit can be dangerous for one position of plug because one contact plate goes to a-c line.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 140.


SO1
D3 A140
Q1 40526
T2
Cb
TOUCH PLATE
C1 2μF
R1 6.8K
A
SCR1 C106B2
G
K
R5 4.7M
R2 1M
117 VAC
I1 NE83
D1 IN457
C4 .04μF
D2 IN191
R3 39K
R4 470Ω
R6 220Ω
D4 A140
C2 .01μF
C3 68pF
C6 500μF
+
1
2
3
4
5
6
7
8
9
10
11
12
13
14
CD
S
Q
T
C
Q̄
IC1 MC787P
G
T1
C5 .04μF

TOUCH SWITCH—Body capacitance is sufficient to trigger scr through neon and energize load through IC and triac Q1, which will handle up to 150 W. Alternate touches of metal plate will turn load on and off. Reversing line cord plug at wall outlet may improve operation.—J. Bechtold, TC Switch For Remote Control, *Popular Electronics*, April 1970, p 52–55.

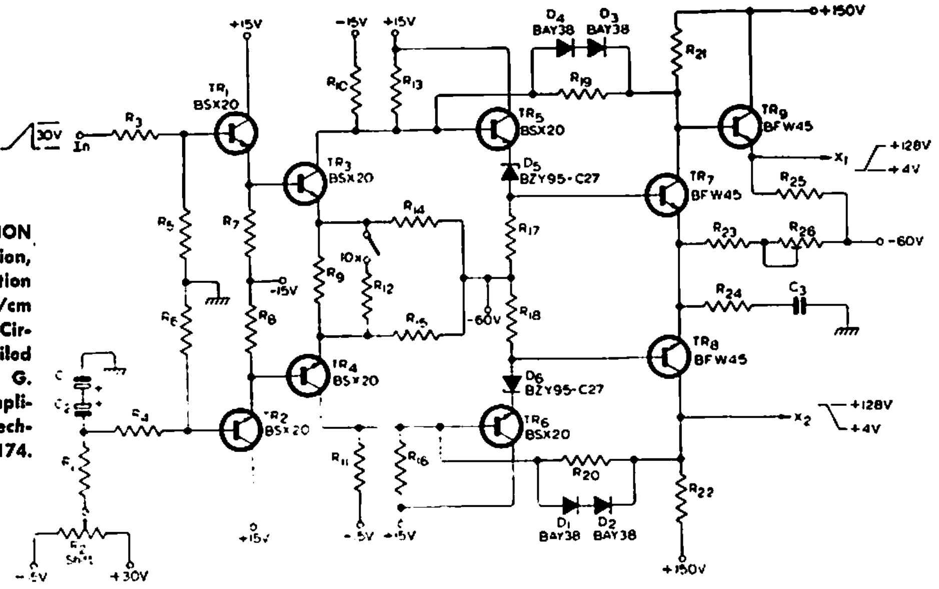
CHAPTER 11

Cathode-Ray Circuits

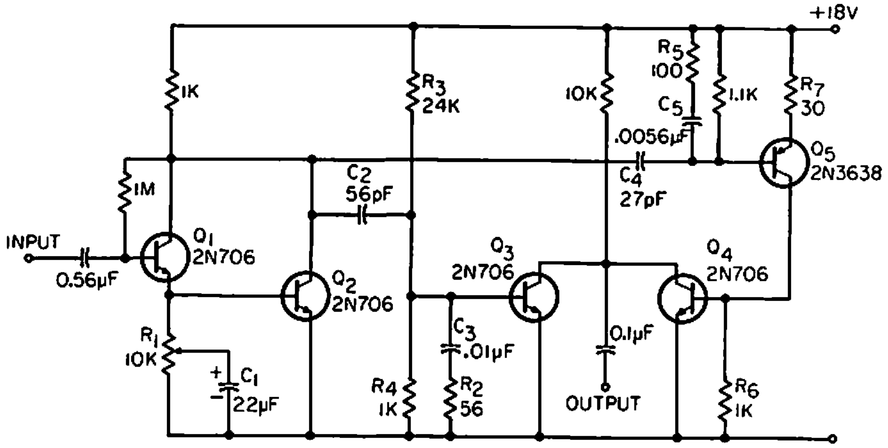

1000
1N964B
+25 V
560
1N5297
Log Amplifier
OSCILLOSCOPE
2N2646
5245
NUT
V
H
100
1uF
-25 V
1N 964 B
547

SWEEP GENERATOR—Uses OEI Model 5245 voltage-frequency transducer having output frequency range of 10 Hz to 100 kHz for input of 0 to 5 V. Output is pseudo-sinusoidal, adequate for driving L-C and R-C filter-type networks under test (NUT). OEI 547 frequency-voltage transducer has log response, with d-c output equal to log of input over frequency range of 1 Hz to 100 kHz. Ujt generates low-frequency sawtooth that slows output frequency of 5245 over entire audio spectrum. Arrangement gives log-log display on cro, but with modifications will give lin-lin display.—A Wide Range Sweep Generator, Optical Electronics, Tucson, Ariz., No. 10100.

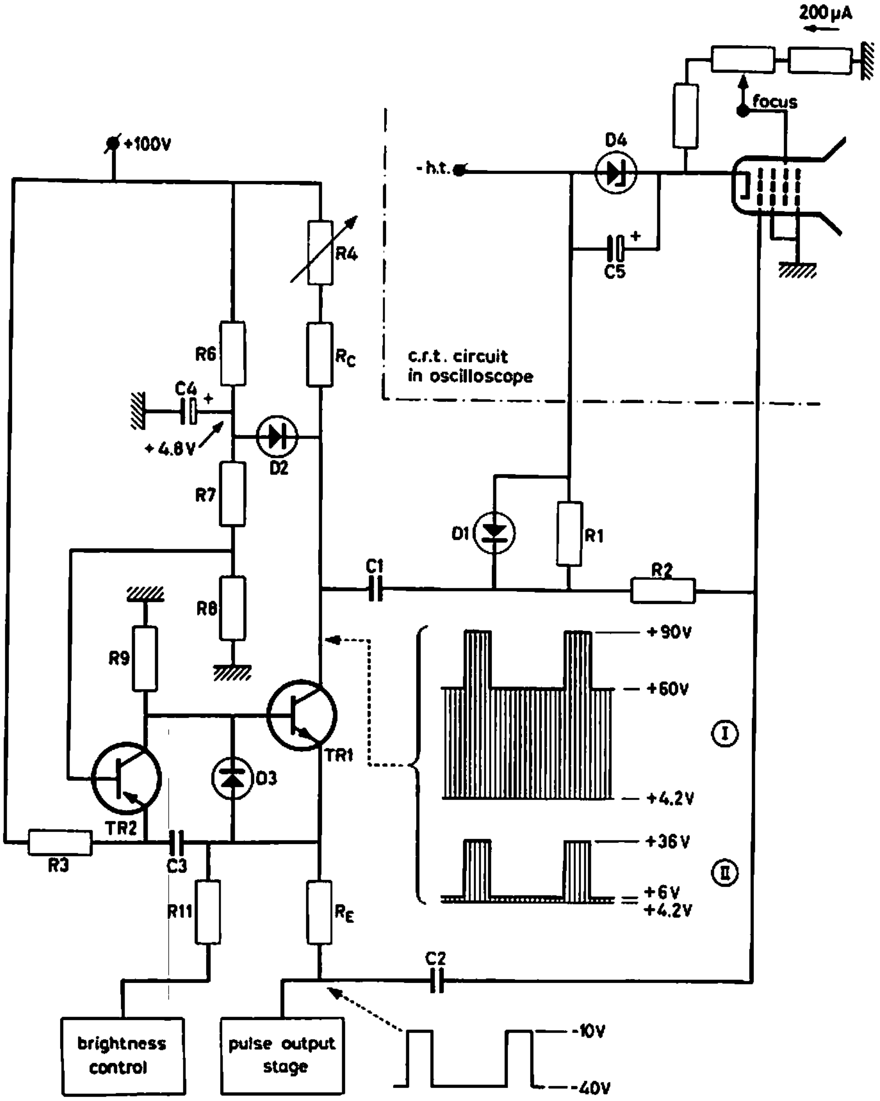
150-MHZ CRO HORIZONTAL DEFLECTION AMPLIFIER—Provides linear 13-cm deflection, with provision for expanding selected portion of trace tenfold. Writing speed of 5 ns/cm is available at maximum rate of output. Circuit is broadly symmetrical, with long-tailed pairs used in all stages.—K. Hart and F. G. Oude Moleman, Horizontal Deflection Amplifier for 150 MHz Oscilloscopes, *Mullard Technical Communications*, Sept. 1968, p 167—174.


+15V
TR1 BSX20
30V In
R3
-15V
+15V
RC
R13
D4 BAY38
D3 BAY38
R19
+150V
R21
TR5 BSX20
TR9 BFW45
TR3 BSX20
D5 BZY95-C27
X1
+128V
+4V
TR7 BFW45
R25
R14
R5
R7
R17
R23
R26
-60V
10x
R9
R12
-15V
R24
C3
R6
R8
R15
-60V
R18
TR8 BFW45
TR4 BSX20
D6 BZY95-C27
C1
C2
R4
R2 BSX20
TR6 BSX20
X2
+128V
+4V
R11
R16
R20
R1
R22
D1 BAY38
D2 BAY38
R2 Shift
+15V
-5V
+5V
+150V
-5V
+30V

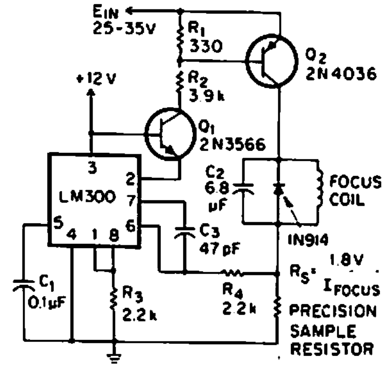
R_1	1·5kΩ,	¼W	R_{11}	3·9kΩ,	¼W	R_{21}	3·3kΩ,	5·5W
R_2	5 kΩ,	pot. w.w.	R_{12}	75 Ω,	¼W, ±1%	R_{22}	3·3kΩ,	5·5W
R_3	7·5kΩ,	¼W	R_{13}	1 kΩ,	¼W	R_{23}	680 Ω,	½W
R_4	2·4kΩ,	¼W	R_{14}	7·5kΩ,	¼W	R_{24}	68 Ω,	¼W
R_5	910 Ω,	¼W	R_{15}	7·5kΩ,	¼W	R_{25}	18 kΩ,	5·5W
R_6	910 Ω,	¼W	R_{16}	1 kΩ,	¼W	R_{26}	250 Ω,	pot. w.w.
R_7	1·8kΩ,	¼W	R_{17}	2·2kΩ,	1W	C_1	50 μF,	25V
R_8	1·8kΩ,	¼W	R_{18}	15 kΩ,	¼W	C_2	50 μF,	25V
R_9	750 Ω,	¼W, ±1%	R_{19}	20 kΩ,	1W, ±1%	C_3	470 pF,	700V
R_{10}	3·9kΩ,	¼W	R_{20}	20. kΩ,	1W, ±1%			


+18V
1K
R3
24K
10K
R5
100
C5
.0056μF
1.1K
R7
30
Q5
2N3638
1M
C2
56pF
C4
27pF
INPUT
0.56μF
Q1
2N706
Q2
2N706
Q3
2N706
Q4
2N706
R1
10K
C1
22μF
R4
1K
C3
.01μF
R2
56
0.1μF
OUTPUT
R6
1K

AUTOMATIC TRACE INTENSITY CONTROL—Differentiating circuit, with output feeding cathode of crt, gives increased gain at high frequencies to compensate for loss of brightness. With input of 50 mV rms, output is 17 V peak above 100 MHz. Below 100 MHz, output voltage decreases in direct proportion to frequency. Gain control R1 is used to balance intensity initially for vertical and horizontal deflections.—W. J. Godsey, Differentiating Amplifier Intensifies Scope Trace, *EEE*, Jan. 1967, p 115–116.

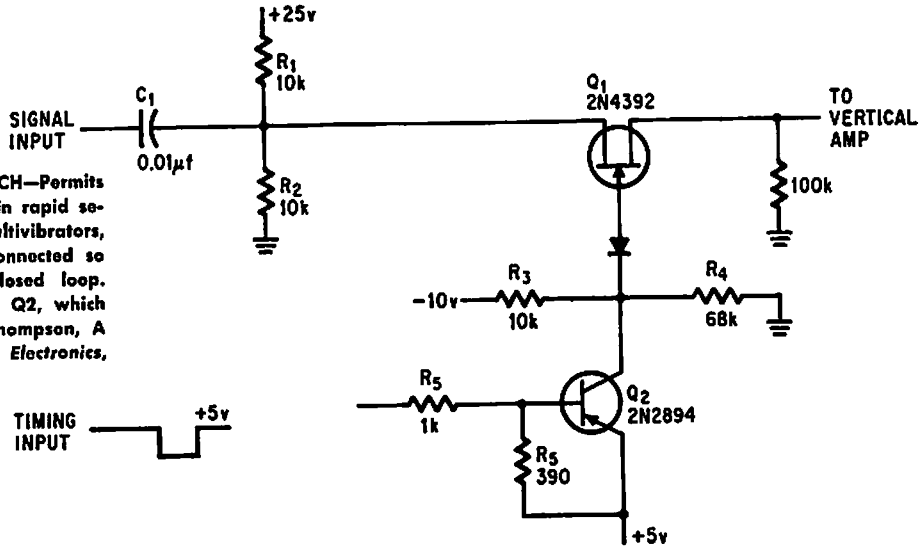

200μA
focus
+100V
-h.t.
D4
C5
R4
R6
Rc
C4
+4.8V
D2
c.r.t. circuit
in oscilloscope
R7
D1
R1
C1
R2
R8
R9
+90V
+60V
+4.2V
TR1
I
TR2
D3
+36V
II
+6V
+4.2V
R3
C3
R11
RE
C2
brightness control
pulse output stage
-10V
-40V

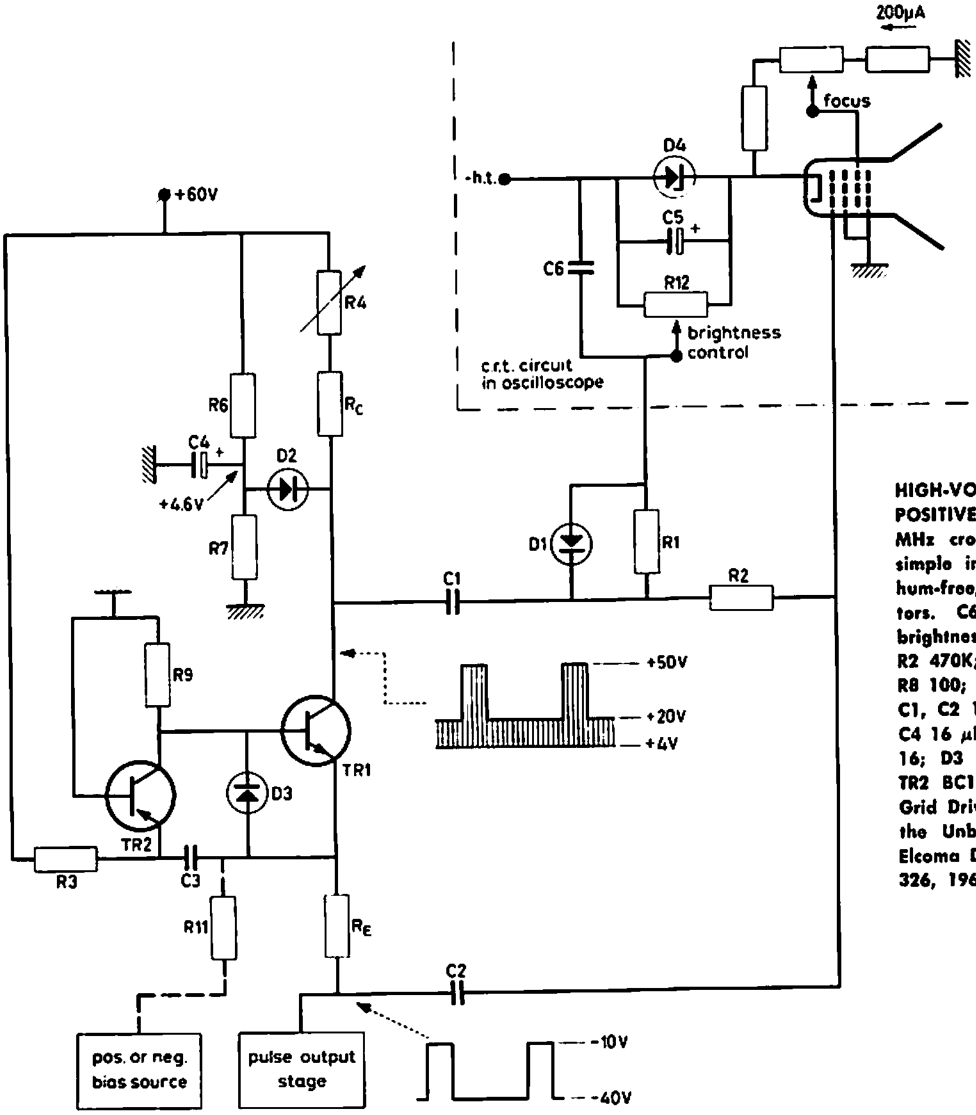
D-C RESTORER WITH POSITIVE CRT GRID DRIVE—Used with inexpensive D7-190 crt in oscilloscope having bandwidth up to 10 MHz. Brightness control adjusts grid drive over range of 2 to 36 V during unblanking periods. Values are: R1 1 meg; R2 470K; R3 120K; R4 4.7K; R6 22K; R7 1K; R8 100; R9 470; R11 15K; RE, RC 15K; C1, C2 180 pF; C3 3.3 nF; C4 16 μF; C5 6.4 μF; D1, D2 BAX16; D3 OA79; D4 BZY95/C75; TR1 BSX21; TR2 BC187.—G. W. Broekema, A New CRT-Grid Drive Circuit Using D. C. Restoration of the Unblanking Signal, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 326, 1968.


EIN
25-35V
R1
330
Q2
2N4036
+12 V
R2
3.9k
Q1
2N3566
3
2
LM300
7
5
4 1 8
6
C2
6.8
μF
FOCUS
COIL
C3
47pF
IN914
1.8V
RS = IFOCUS
C1
0.1μF
R3
2.2k
R4
2.2k
PRECISION
SAMPLE
RESISTOR

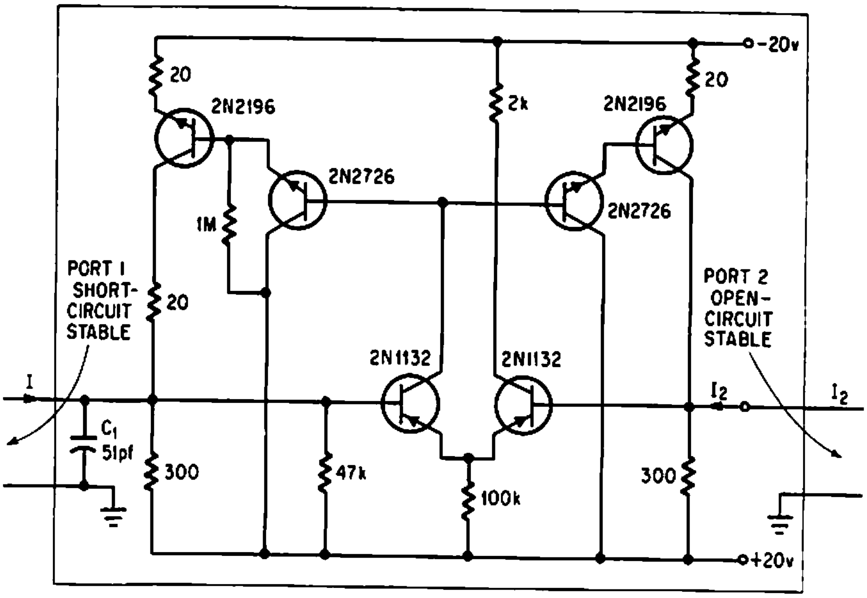
FOCUS CURRENT REGULATOR—Regulates control current through focus coil of cathode-ray tube. Use of separate supply for National Semiconductor IC current regulator makes it unnecessary to restrict unregulated input voltage to maximum 30-V rating of IC. Line regulation is better than 0.02% and load regulation better than 0.05%. Intended for focus coils within 10% of 400 ohms and maximum focus current of 50 mA.—W. G. Jung, An Efficient Focus-Current Regulator Using the LM300, *EEE*, Feb. 1969, p 113–114.

DISPLAY-CHANGING FET SWITCH—Permits displaying three or more signals in rapid sequence on cro. Monostable multivibrators, one for each input signal, are connected so each one drives the next in closed loop. Mvbr output is timing signal for Q2, which in turn controls fet switch.—P. Thompson, A Single-Channel 'Multitrace' Scope, *Electronics*, Sept. 29, 1969, p 113–114.

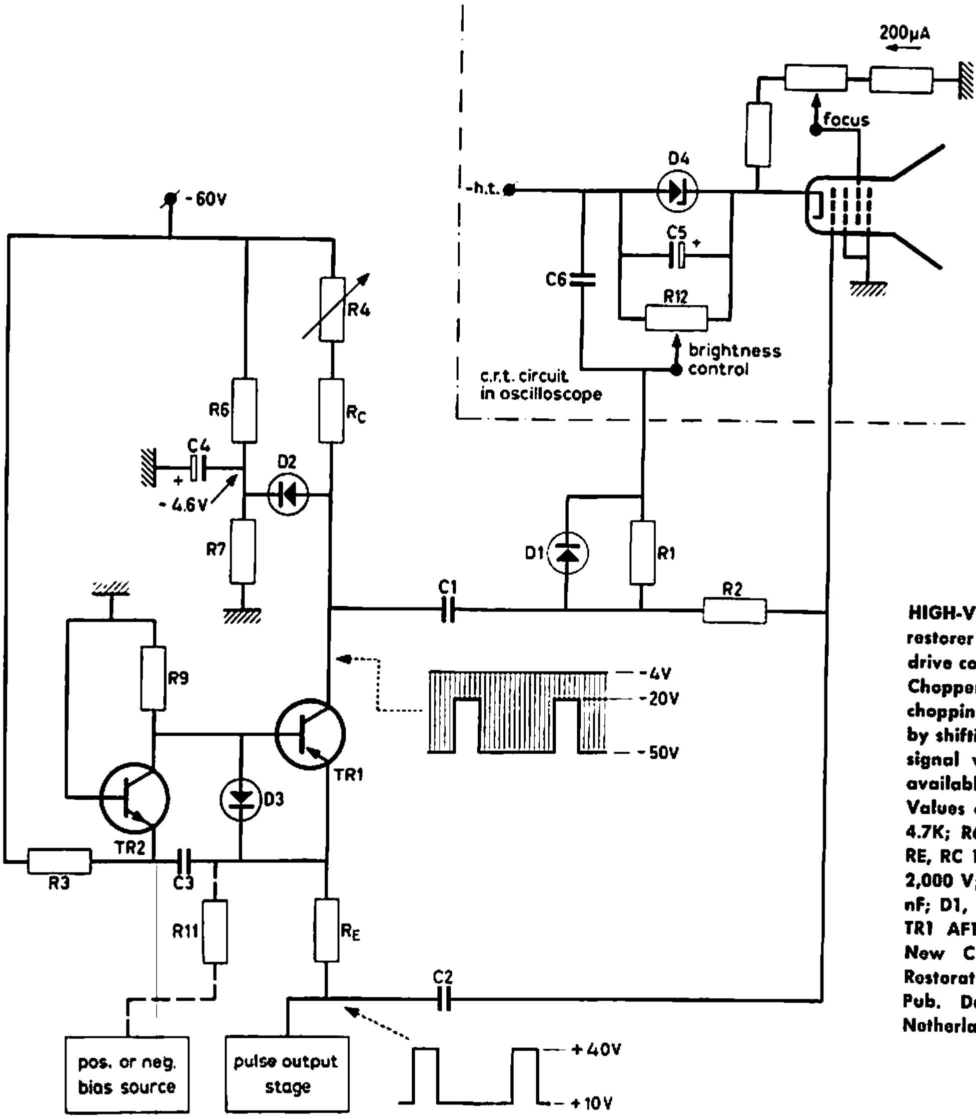

+25v
R1 10k
C1
SIGNAL INPUT
0.01μf
R2 10k
Q1 2N4392
TO VERTICAL AMP
100k
R3 10k
-10v
R4 68k
R5 1k
Q2 2N2894
R5 390
+5v
TIMING INPUT
+5v


200μA
focus
D4
-h.t.
C5
C6
R12
brightness control
c.r.t. circuit in oscilloscope
+60V
R4
R6
Rc
C4
+4.6V
D2
R7
D1
R1
C1
R2
R9
+50V
+20V
+4V
TR1
D3
TR2
R3
C3
R11
RE
C2
pos. or neg. bias source
pulse output stage
-10V
-40V

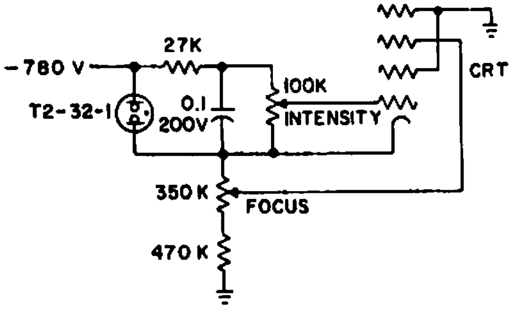
HIGH-VOLTAGE BRIGHTNESS CONTROL FOR POSITIVE GRID—D-c restorer circuit for 10-MHz cro having positive crt grid drive is simple in design, easy to adjust, relatively hum-free, and uses only inexpensive capacitors. C6 bypasses chopped signal around brightness control. Values are: R1 1 meg; R2 470K; R3 100K; R4 4.7K; R6 12K; R7 1K; R8 100; R9 470; R11, RE, RC 15K; R12 470K, C1, C2 180 pF ceramic 2,000 V; C3 3.3 nF; C4 16 μF; C5 6.4 μF; C6 22 nF; D1, D2 BAX-16; D3 OA79; D4 BZY95/C75; TR1 BSX21; TR2 BC187.—G. W. Broekema, A New CRT-Grid Drive Circuit Using D. C. Restoration of the Unblanking Signal, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 326, 1968.


-20v
20
2N2196
2k
2N2196
20
2N2726
2N2726
1M
PORT 1 SHORT-CIRCUIT STABLE
20
PORT 2 OPEN-CIRCUIT STABLE
2N1132
2N1132
I
I_2
I_2
C_1 51pf
300
47k
100k
300
+20v

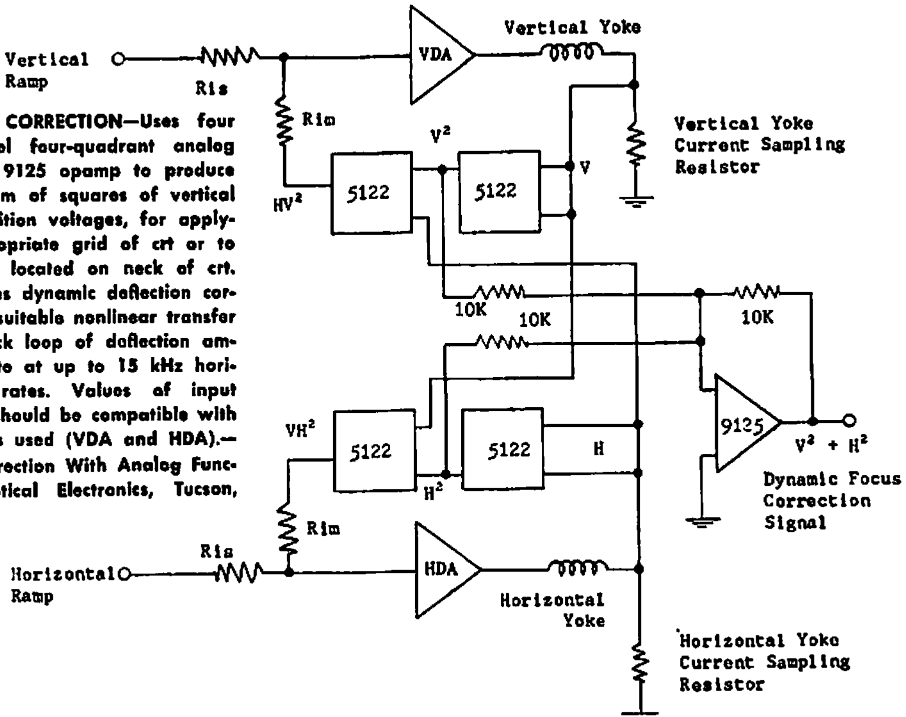
CHARACTERISTIC CURVE ROTATOR—Inexpensive two-port negative-impedance converter varies characteristic curve of component by revolving it about an origin. Oscilloscope at input port displays rotated characteristic curve, as aid to designer in building new circuits having functions not attainable with conventional components. Article gives design criteria and equations for R, L, and C rotators and examples of curves that can be obtained.—L. O. Chua, A Good Turn for Old Components, *Electronics*, May 29, 1967, p 109—122.


200µA
focus
D4
-h.t.
C5
C6
R12
brightness control
c.r.t. circuit in oscilloscope
-60V
R4
R6
Rc
C4
D2
-4.6V
R7
D1
R1
C1
R2
R9
-4V
-20V
-50V
TR1
D3
TR2
R3
C3
R11
RE
C2
pos. or neg. bias source
pulse output stage
+40V
+10V

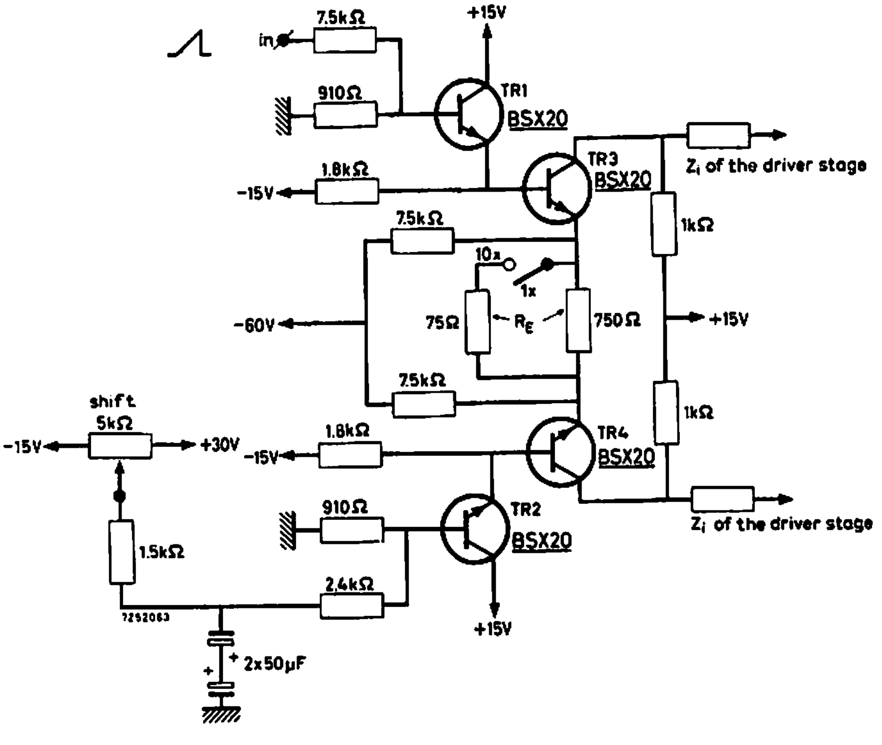
HIGH-VOLTAGE BRIGHTNESS CONTROL—D-c restorer circuit for crt having negative grid drive controls brightness at high-voltage level. Chopper supply voltage is only 60 V, because chopping pulses are not varied in magnitude by shifting chopped signal. Instead, chopped signal varies symmetrically about center of available collector voltage swing for TR1. Values are: R1 1 meg; R2 470K; R3 100K; R4 4.7K; R6 12K; R7 1K; R8 100; R9 470; R11, RE, RC 15K; R12 470K; C1, C2 180 pF ceramic 2,000 V; C3 3.3 nF; C4 16 µF; C5 1 µF; C6 22 nF; D1, D2 BAX16; D3 OA79; D4 BZY95/C30; TR1 AF118; TR2 BF194.—G. W. Broekema, A New CRT-Grid Drive Circuit Using D. C. Restoration of the Unblanking Signal, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 326, 1968.


-780 V
27K
T2-32-1
0.1
200V
100K
INTENSITY
CRT
350 K
FOCUS
470 K

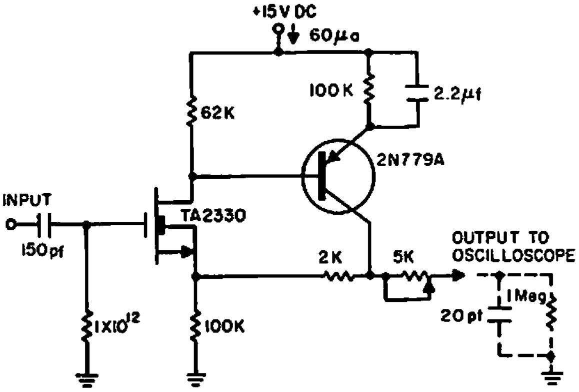
PILOT LIGHT AND BIAS REGULATOR—Single neon lamp acts both as pilot light and as bias regulator for grid 1 of the crt.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 151.


Vertical Ramp
Ris
Rim
VDA
Vertical Yoke
V²
V
HV²
5122
5122
Vertical Yoke Current Sampling Resistor
10K
10K
10K
9125
V² + H²
Dynamic Focus Correction Signal
VH²
5122
5122
H
H²
Rim
Ris
Horizontal Ramp
HDA
Horizontal Yoke
Horizontal Yoke Current Sampling Resistor

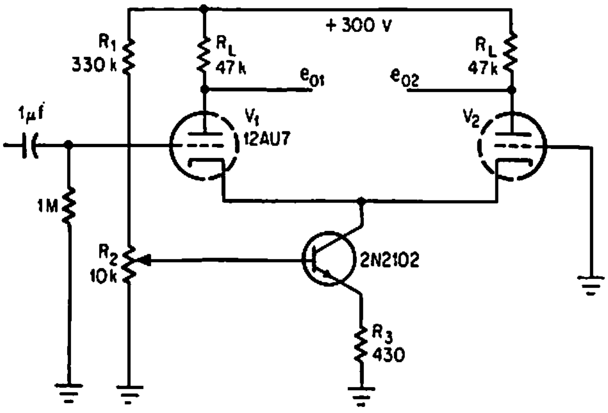
DYNAMIC FOCUS CORRECTION—Uses four OEI 5122 low-level four-quadrant analog multipliers feeding 9125 opamp to produce output equal to sum of squares of vertical and horizontal position voltages, for applying either to appropriate grid of crt or to dynamic focus coil located on neck of crt. Circuit also provides dynamic deflection correction by placing suitable nonlinear transfer function in feedback loop of deflection amplifier. Will operate at up to 15 kHz horizontal deflection rates. Values of input summing resistors should be compatible with deflection amplifiers used (VDA and HDA).—Dynamic Focus Correction With Analog Function Modules, Optical Electronics, Tucson, Ariz., No. 10127.


in
7.5kΩ
+15V
910Ω
TR1
BSX20
TR3
BSX20
1.8kΩ
-15V
Zᵢ of the driver stage
7.5kΩ
10x
1x
1kΩ
-60V
75Ω
R_E
750Ω
+15V
7.5kΩ
1kΩ
shift
5kΩ
-15V
+30V
-15V
1.8kΩ
TR4
BSX20
910Ω
TR2
BSX20
Zᵢ of the driver stage
1.5kΩ
2.4kΩ
7252063
+15V
2x50μF

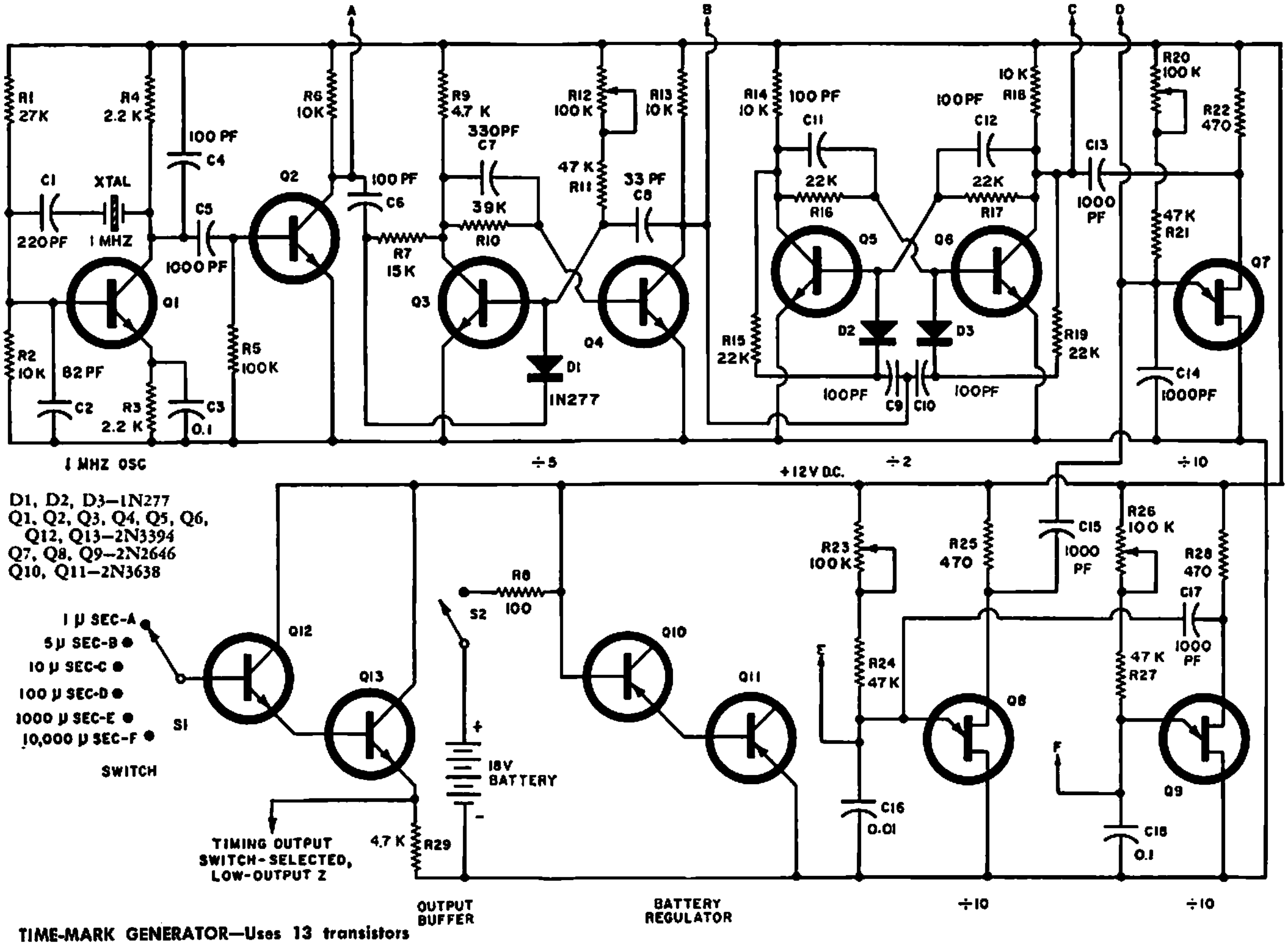
HORIZONTAL PREAMP—Used in wide-band cro having maximum sweep rate of 5 ns per cm. Includes switch for expanding chosen part of horizontal scan ten times. Symmetrical emitter-follower stages provide required impedance transformation without distortion of sawtooth input or horizontal shift input.—F. G. Oude-Moleman and K. Hart, A Transistorized Horizontal Deflection Amplifier for Wide-Band Oscilloscopes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 317, 1967.


+15 V DC
60μa
100K
2.2μf
62K
2N779A
INPUT
TA2330
150pf
2K
5K
OUTPUT TO OSCILLOSCOPE
1 Meg
20 pf
1×10^{12}
100K

MILLION-MEG SCOPE PROBE—Insulated-gate fet as input stage of oscilloscope probe gives unusually high input impedance of 1,000,000 meg in parallel with 2 pF, although at expense of higher output noise than when using junction fet in probe. Gain is unity.—E. J. Kennedy, FET Used For Unity-Gain, High-Impedance Scope Probe, *Electronic Design*, Aug. 30, 1965, p 46–47.

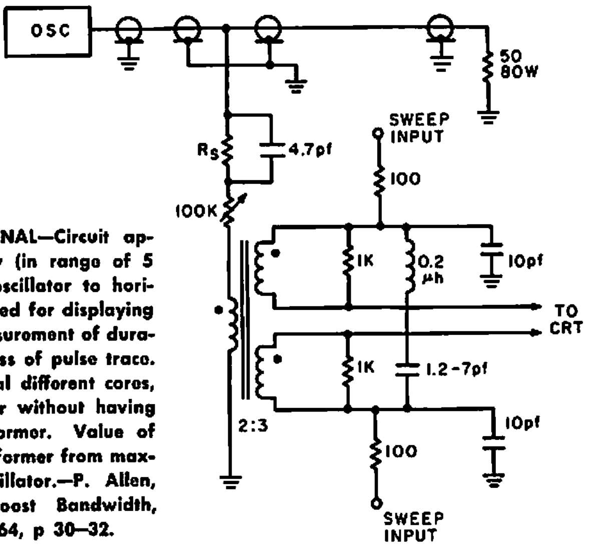

+300 V
R_1 330 k
R_L 47 k
e_{01}
e_{02}
R_L 47 k
1 μf
V_1 12AU7
V_2
1 M
R_2 10 k
2N2102
R_3 430

PARAPHASE AMPLIFIER—Adding transistor eliminates need for negative supply voltage and improves balance of output signal amplitudes for electrostatic cathode-ray tubes.—P. Salomon, Transistor Replaces Supply in CRT Amplifier, *Electronics*, Nov. 13, 1967, p 102–103.

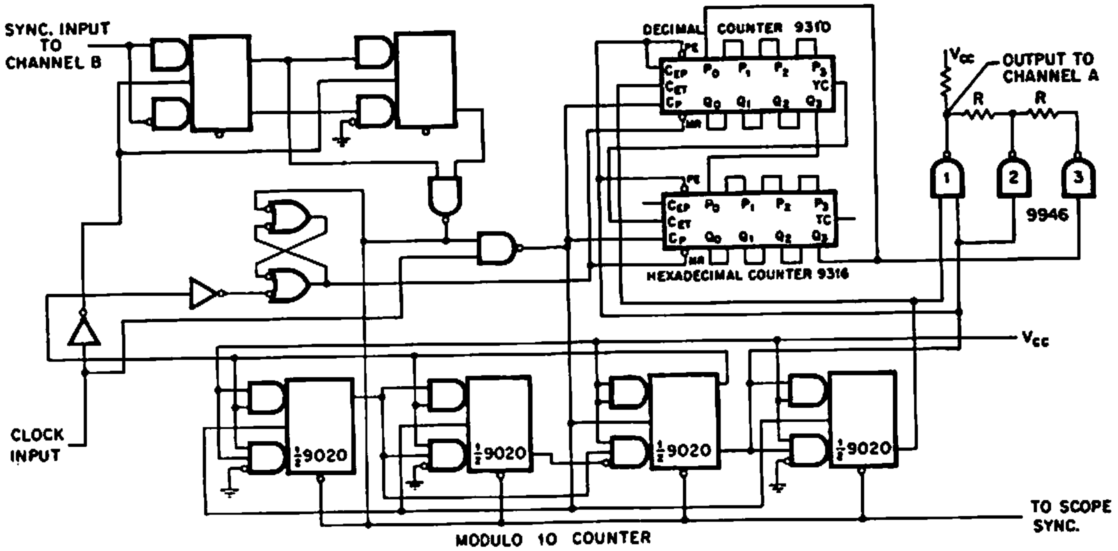

A
B
C
D
R1 27K
R4 2.2 K
100 PF C4
C1
XTAL
220PF
1 MHZ
C5
1000 PF
Q1
Q2
R2 10K
82 PF
C2
R3 2.2 K
C3 0.1
R5 100K
R6 10K
100 PF C6
R7 15K
R9 4.7 K
330PF C7
39K R10
Q3
D1 1N277
R12 100K
47 K R11
R13 10K
33 PF C8
Q4
R14 10 K
100 PF C11
22K R16
Q5
R15 22K
D2
100PF C9
C10 100PF
D3
Q6
100PF C12
22K R17
10 K R18
R19 22K
C13 1000 PF
R20 100 K
R22 470
47K R21
Q7
C14 1000PF
1 MHZ OSC
÷5
+12V DC.
÷2
÷10
1 μ SEC-A
5 μ SEC-B
10 μ SEC-C
100 μ SEC-D
1000 μ SEC-E
10,000 μ SEC-F
S1
SWITCH
Q12
Q13
S2
R8 100
+
18V BATTERY
-
Q10
Q11
TIMING OUTPUT SWITCH-SELECTED, LOW-OUTPUT Z
4.7 K R29
R23 100K
R24 47K
E
C16 0.01
R25 470
C15 1000 PF
Q8
R26 100 K
R28 470
C17 1000 PF
47 K R27
F
C18 0.1
Q9
OUTPUT BUFFER
BATTERY REGULATOR
÷10
÷10

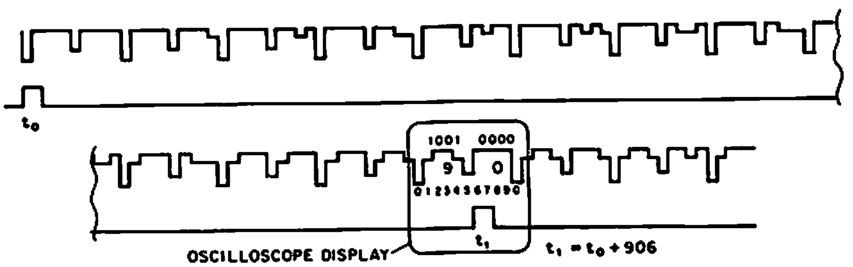
D1, D2, D3—1N277
Q1, Q2, Q3, Q4, Q5, Q6, Q12, Q13—2N3394
Q7, Q8, Q9—2N2646
Q10, Q11—2N3638

TIME-MARK GENERATOR—Uses 13 transistors to provide accurate calibration points of 1, 5, 10, 100, 1,000, and 10,000 μs for calibrating horizontal sweep of oscilloscope. Primary accuracy is provided by 1-MHz crystal oscillator Q1. Regulator transistors Q10 and Q11 can be omitted if mercury battery or regulated power supply is used.—R. G. Teeter, Scope Sweep Generator, *Electronics World*, Feb. 1967, p 80–81.

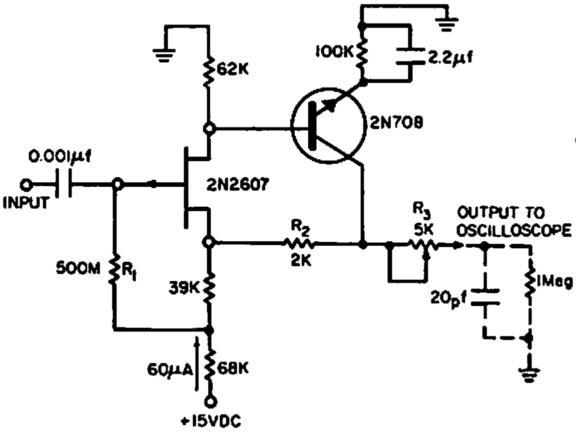

OSC
50
80W
SWEEP INPUT
100
Rs
4.7pf
100K
1K
0.2 μh
10pf
TO CRT
1K
1.2-7pf
2:3
10pf
100
SWEEP INPUT

SUPERIMPOSED TIMING SIGNAL—Circuit applies known fixed frequency (in range of 5 to 200 MHz) from crystal oscillator to horizontal sweep of crt being used for displaying burst data, for accurate measurement of duration, amplitude, and steepness of pulse trace. Transformer used has several different cores, to permit changing oscillator without having to change tuned r-f transformer. Value of Rs is chosen to protect transformer from maximum 20-W power of oscillator.—P. Allen, Multi-Core Transformers Boost Bandwidth, *Electronic Design*, Feb. 3, 1964, p 30–32.

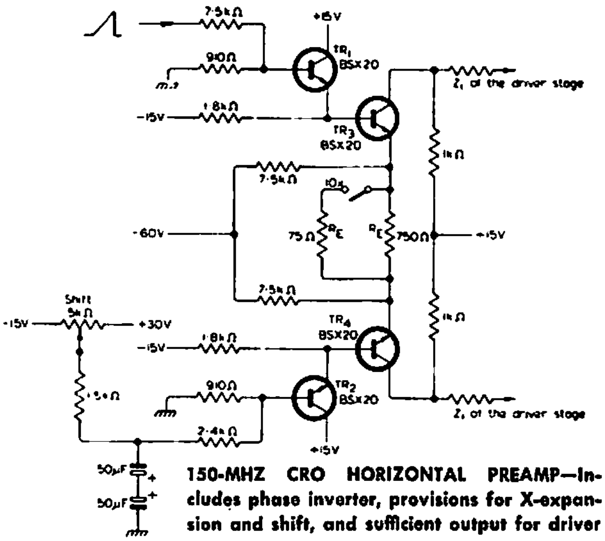

SYNC. INPUT TO CHANNEL B
DECIMAL COUNTER 9310
PE
CEP P0 P1 P2 P3
CET TC
CP Q0 Q1 Q2 Q3
MR
HEXADECIMAL COUNTER 9316
Vcc
OUTPUT TO CHANNEL A
R
R
1
2
3
9946
Vcc
CLOCK INPUT
½9020
½9020
½9020
½9020
TO SCOPE SYNC.
MODULO 10 COUNTER


t0
1001 0000
9
0
0 1 2 3 4 5 6 7 8 9 0
t1
OSCILLOSCOPE DISPLAY
t1 = t0 + 906

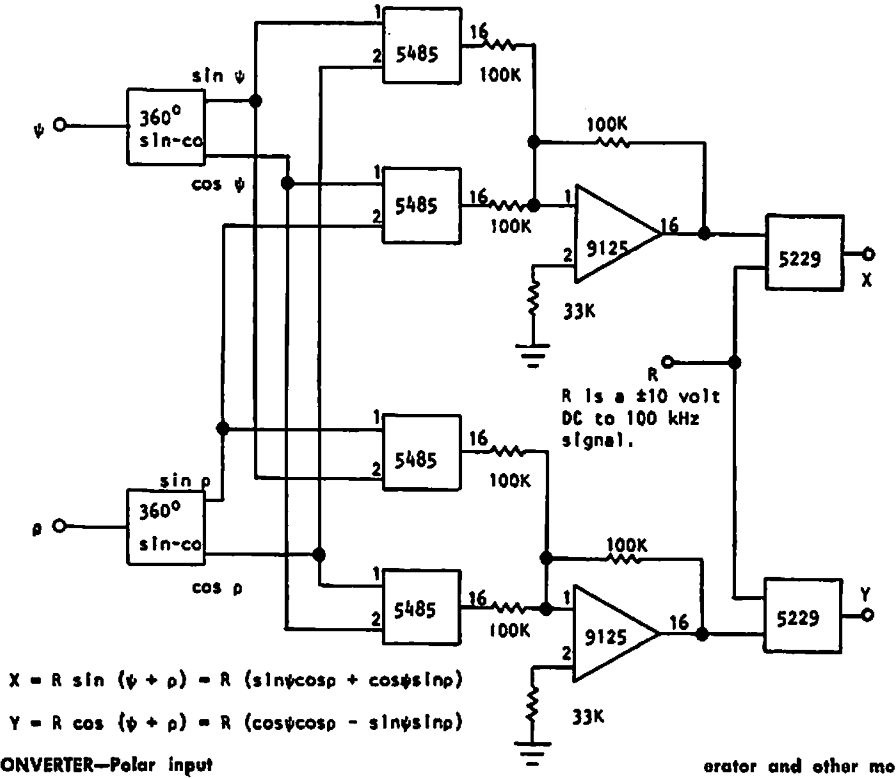
CODED REFERENCE WAVEFORM—Pulse generator connected to sync input of cro can be driven either by master clock of digital system or by any external signal source. If period in seconds of reference waveform is known, then delay in pulse on cro trace can be measured directly by projecting leading edge of pulse down to reference waveform and reading delay in increments of clock (in μs if clock is 1 MHz). Reference waveform, as generated by IC units shown, has long pulse marking beginning of each period. Following four bit positions determine most significant digit in hexadecimal code. Two more four-bit decimal codes follow.—J. L. Nichols, Reference Waveform Adds to Scope's Measuring Capability, *Electronics*, Dec. 22, 1969, p 77–78.


62K
100K
2.2μf
2N708
0.001μf
INPUT
2N2607
R_3
5K
OUTPUT TO
OSCILLOSCOPE
R_2
2K
500M
R_1
39K
20pf
1Meg
60μA
68K
+15VDC

1,200-MEG SCOPE PROBE—Bootstrap action of transistor pair gives effective input impedance of 1,200 meg in parallel with 3.5 pF for unity-gain probe to be used in extremely high impedance circuits. Can handle up to 2-V input signals of either polarity without appreciable distortion. Low power drain of input fet permits battery operation.—E. J. Kennedy, FET Used For Unity-Gain, High-Impedance Scope Probe, *Electronic Design*, Aug. 30, 1965, p 46–47.


7·5kΩ
+15V
910Ω
TR_1
BSX20
1·8kΩ
-15V
TR_3
BSX20
Z_i of the driver stage
1kΩ
7·5kΩ
10x
-60V
75Ω
R_E
R_E
750Ω
+15V
7·5kΩ
Shift
5kΩ
-15V
+30V
TR_4
BSX20
1·8kΩ
-15V
1kΩ
910Ω
TR_2
BSX20
1·5kΩ
2·4kΩ
+15V
Z_i of the driver stage
50μF
50μF

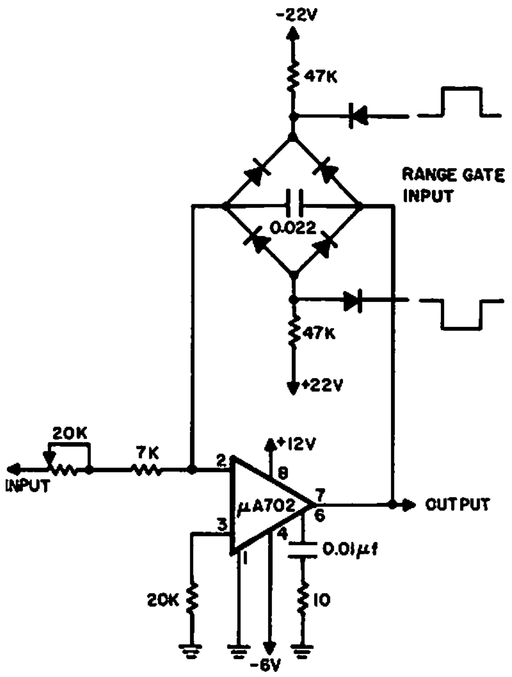
150-MHZ CRO HORIZONTAL PREAMP—Includes phase inverter, provisions for X-expansion and shift, and sufficient output for driver stage of horizontal amplifier in oscilloscope having sufficient bandwidth for detailed study of fast transients. Requires sawtooth with 3.26 V p-p and peak current of 3.58 mA at input going to base of TR1.—K. Hart and F. G. Oude Moleman, Horizontal Deflection Amplifier for 150 MHz Oscilloscopes, *Mullard Technical Communications*, Sept. 1968, p 167–174.


sin ψ
ψ
360°
sin-co
cos ψ
5485
1
2
16
100K
100K
9125
33K
5229
X
R
R is a ±10 volt
DC to 100 kHz
signal.
sin ρ
ρ
360°
sin-co
cos ρ
Y

$X = R \sin(\psi + \rho) = R(\sin\psi\cos\rho + \cos\psi\sin\rho)$

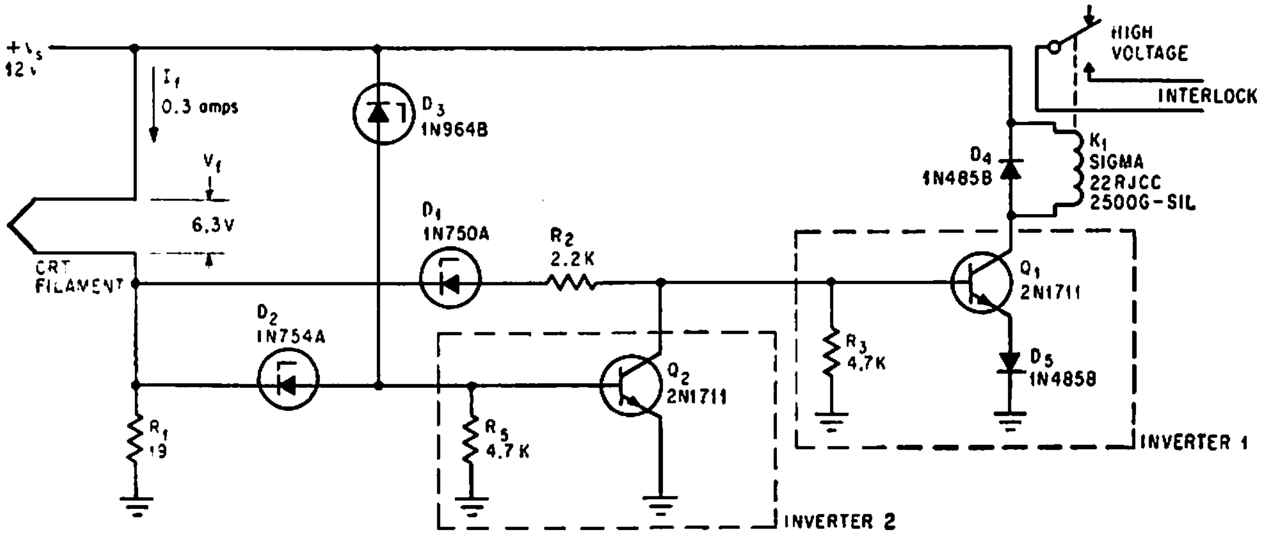
$Y = R \cos(\psi + \rho) = R(\cos\psi\cos\rho - \sin\psi\sin\rho)$

PPI TO X-Y SCAN CONVERTER—Polar input from radar ppi display consists of azimuth heading angle psi, direction angle rho of radar antenna with respect to direction of target travel, and range or distance R. Output voltages X and Y, each up to 10 V full-scale in either polarity, are derived from polar coordinates with OEI sine function modules in 360-deg sine-cosine function generator and other modules shown, in accordance with trig relationship given below circuit. —Polar Coordinates to Rectangular Coordinates Scan Converter, Optical Electronics, Tucson, Ariz., No. 10155.

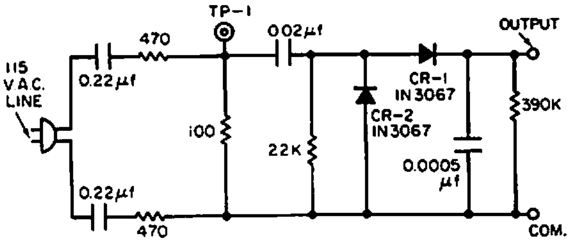

-22V
47K
RANGE GATE
INPUT
0.022
47K
+22V
20K
7K
INPUT
2
+12V
8
µA702
7
6
OUTPUT
3
4
1
0.01µf
20K
10
-6V

INPUT	OUTPUT
SIN ωt	X
COSωt	Y

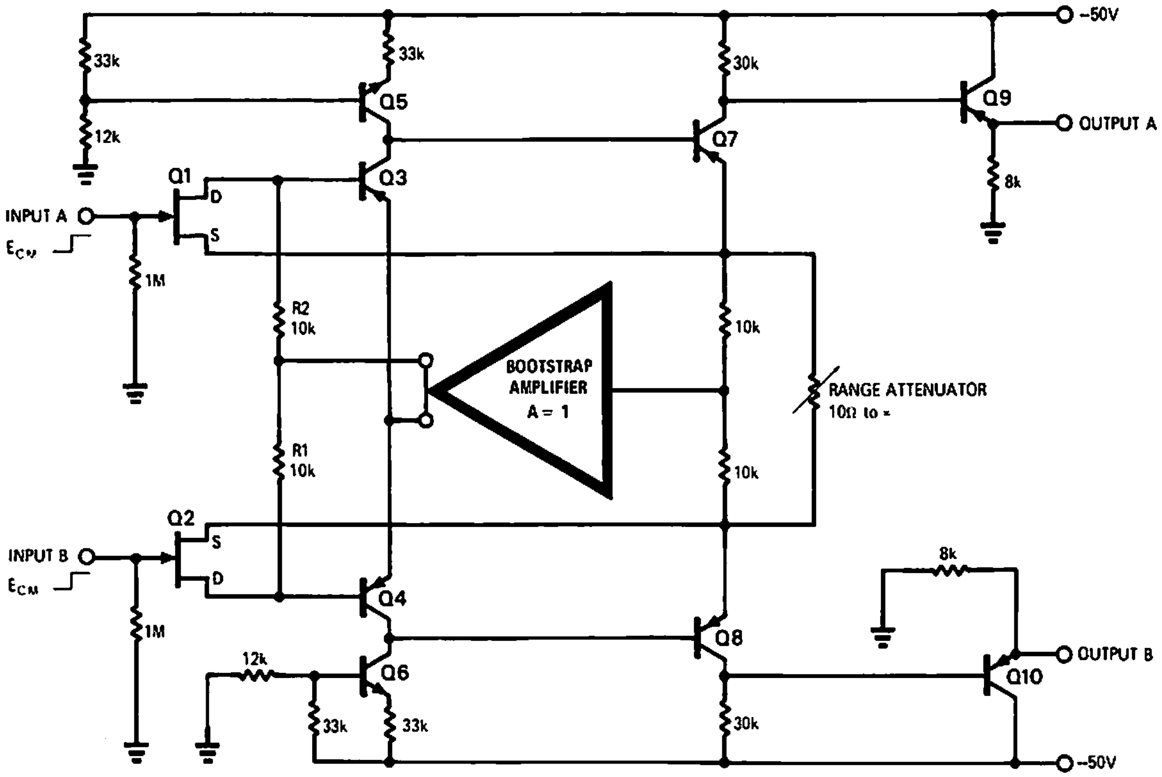
PPI SWEEP GENERATOR—Two Fairchild IC opamps connected identically for X and Y axes (only one shown) generate waveforms required for radial plan position indicator display. Advantages are high linearity, uniform bilateral integration, rapid reset time, and sufficient output for deflection driver. IC opamp is connected as independent integrator that is diode-clamped to zero until range-gate pulse arrives and allows sweep waveform to start. Values shown give several thousand radial sweeps for 40-rpm antenna.—D. E. Lancaster, The Integrated Operational Amplifier: A Versatile and Economical Circuit, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 189–194.


+V_s
12 V
I_f
0.3 amps
V_f
6.3V
CRT
FILAMENT
D_3
1N964B
D_1
1N750A
R_2
2.2K
D_2
1N754A
R_1
19
R_5
4.7 K
Q_2
2N1711
INVERTER 2
HIGH
VOLTAGE
INTERLOCK
K_1
SIGMA
22RJCC
2500G-SIL
D_4
1N485B
R_3
4.7K
Q_1
2N1711
D_5
1N485B
INVERTER 1

PROTECTIVE INTERLOCK—Protective circuit is activated, to prevent application of high voltage to cathode-ray tube, for four possible system faults: (1) Low filament supply voltage; (2) High filament supply voltage; (3) Open filament feed lines; (4) Shorted filament feed lines.—K. E. Springer, Interlock Protects Display Tube, *Electronics*, Sept. 19, 1966, p 125–126.


TP-1
470
0.02μf
OUTPUT
115 V.A.C. LINE
0.22μf
CR-1 IN3067
CR-2 IN3067
390K
100
22K
0.0005 μf
0.22μf
470
COM.

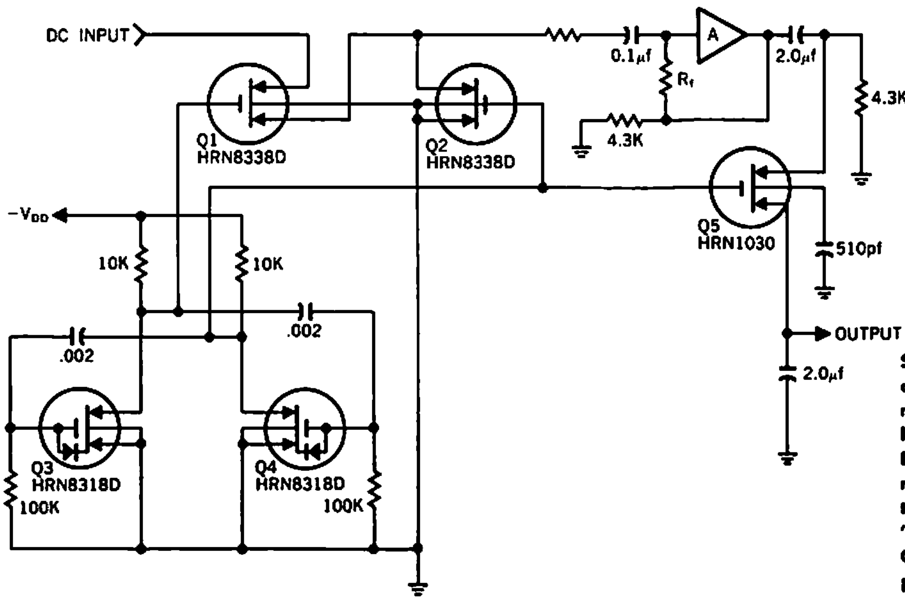
TRANSIENT-WIDENING NETWORK—Simple, inexpensive differentiator and voltage doubler together serve to detect and widen narrow and fast nonrepetitive transients that may occur on either side of a-c power line. Storage capacitor at right of diodes charges almost completely in 400 ns and holds its charge for over 200 μs to give at least 500-to-1 widening and brightening of scope trace.—P. Lefferts, Differentiator-Divider Network Analyzes Power-Line Transients, *Electronic Design*, Dec. 6, 1965, p 52 and 54.


33k
33k
30k
-50V
Q5
Q9
OUTPUT A
12k
Q7
Q1
Q3
D
INPUT A
S
ECM
8k
1M
R2 10k
BOOTSTRAP AMPLIFIER A = 1
10k
RANGE ATTENUATOR 10Ω to ∞
R1 10k
10k
Q2
S
INPUT B
D
ECM
8k
Q4
1M
Q8
OUTPUT B
12k
Q6
Q10
33k
33k
30k
-50V

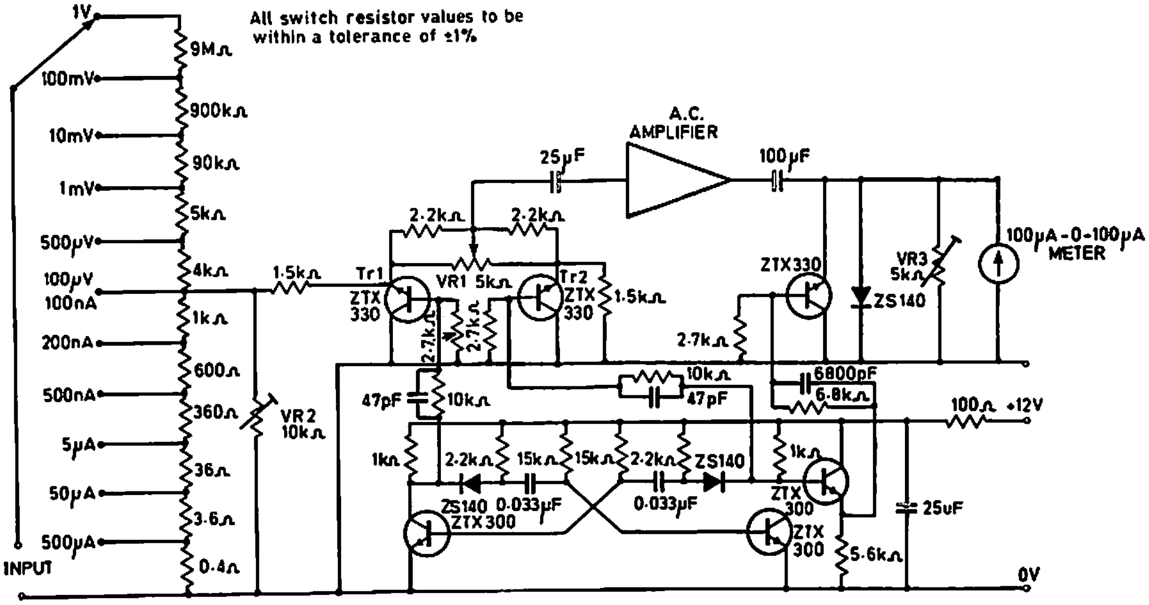
LOW-COST CRO VERTICAL PREAMP—Bootstrapping of differential fet-input preamp gives common-mode-rejection ratio of over 100,000 to 1 (100 dB), from d-c to 10 kHz. Designed for use in Hewlett-Packard Model 1200 series low-frequency oscilloscopes. Transistor types are not given in article. With unity-gain bootstrapped preamp, common-mode signal appears equally on each terminal of input fet, virtually nullifying amplification of this signal.—J. E. Kluge, Bootstrapped Preamp Exhibits High CMRR, *EDN*, Mar. 1, 1970, p 61–62.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

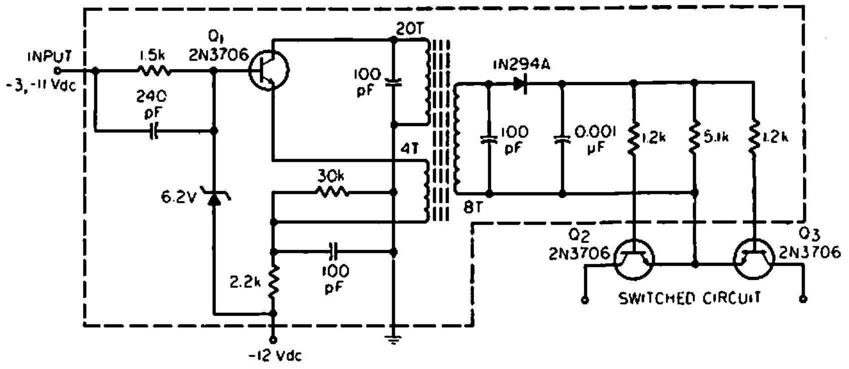
CHAPTER 12
Chopper Circuits


DC INPUT
0.1µf
R_f
A
2.0µf
4.3K
4.3K
Q1
HRN8338D
Q2
HRN8338D
Q5
HRN1030
510pf
−V_DD
10K
10K
.002
.002
OUTPUT
2.0µf
Q3
HRN8318D
100K
Q4
HRN8318D
100K

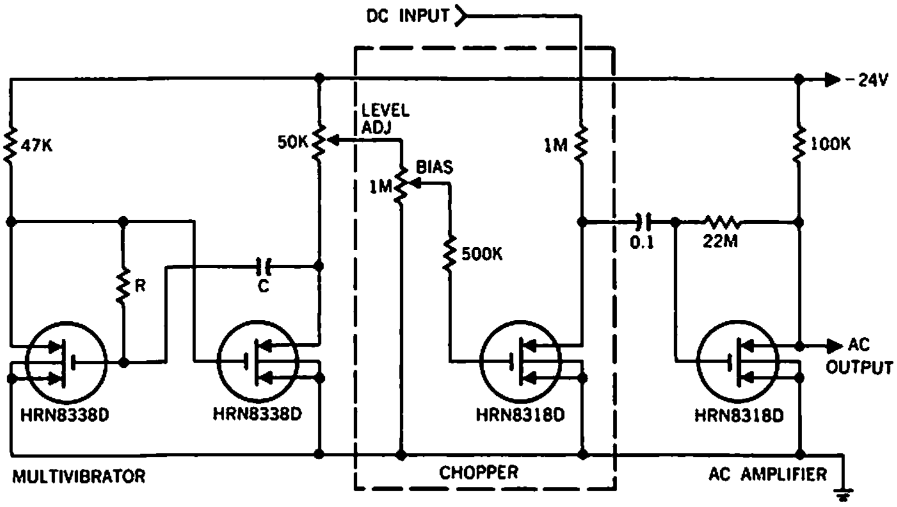
SERIES-SHUNT CHOPPER—Series switch Q1 and shunt switch Q2 are driven by astable mvbr Q3-Q4 for detection of signal levels as low as 30 µV and amplification by opamp. Demodulator Q5 is simple series switch. Arrangement gives stable and accurate detection of very small d-c signals.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 22.


All switch resistor values to be within a tolerance of ±1%
1V
100mV
10mV
1mV
500µV
100µV
100nA
200nA
500nA
5µA
50µA
500µA
INPUT
9MΩ
900kΩ
90kΩ
5kΩ
4kΩ
1kΩ
600Ω
360Ω
36Ω
3·6Ω
0·4Ω
VR2
10kΩ
1.5kΩ
Tr1
ZTX
330
VR1 5kΩ
Tr2
ZTX
330
1.5kΩ
2·2kΩ
2·2kΩ
25µF
A.C.
AMPLIFIER
100µF
100µA-0-100µA
METER
ZTX330
VR3
5kΩ
ZS140
2·7kΩ
2·7kΩ
2·7kΩ
47pF
10kΩ
10kΩ
47pF
6800pF
6·8kΩ
100Ω
+12V
1kΩ
2·2kΩ
15kΩ
15kΩ
2·2kΩ
ZS140
1kΩ
ZS140
0·033µF
ZTX300
0·033µF
ZTX
300
ZTX
300
25uF
5·6kΩ
0V

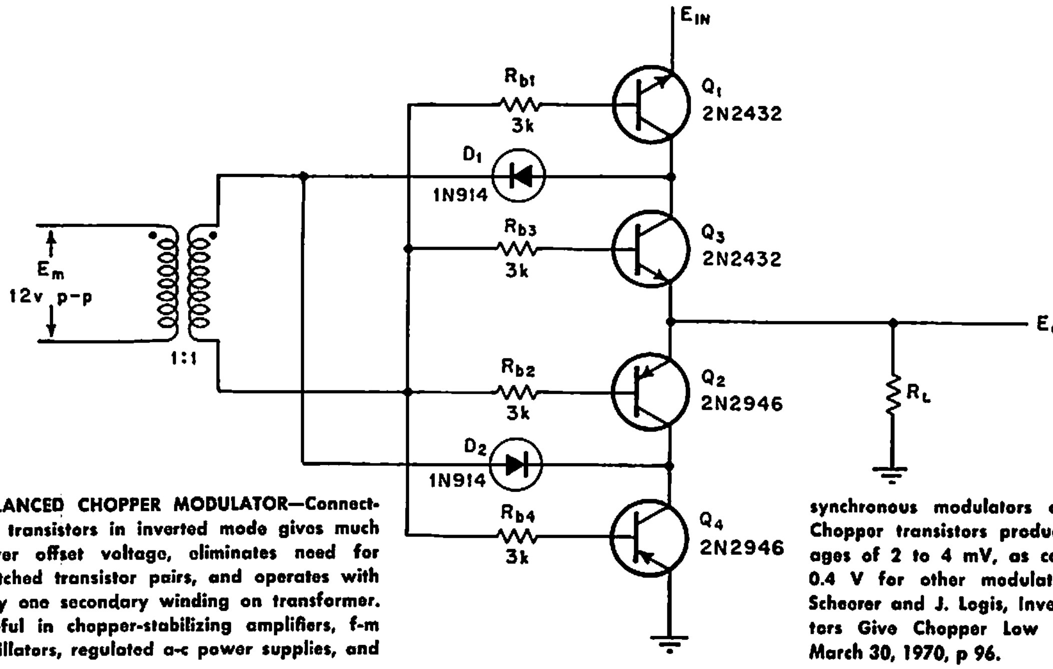
BALANCED CHOPPER—Used here as combination microvoltmeter and microammeter. A-c amplifier can be discrete components or IC having power gain of 86 dB, bandwidth of 20 Hz to 150 kHz at 3 dB down, and p-p noise less than 10 µV referred to input. Chopping frequency is 1.5 kHz. Input impedance on voltage ranges is 10 meg per V. Requires regulated power supply providing 12 V at about 35 mA. Accuracy depends on initial adjustment procedure, as given in report.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 46.


INPUT
-3,-11 Vdc
1.5k
Q1
2N3706
240 pF
6.2V
2.2k
30k
100 pF
100 pF
20T
4T
8T
1N294A
100 pF
0.001 μF
1.2k
5.1k
1.2k
Q2
2N3706
Q3
2N3706
SWITCHED CIRCUIT
-12 Vdc

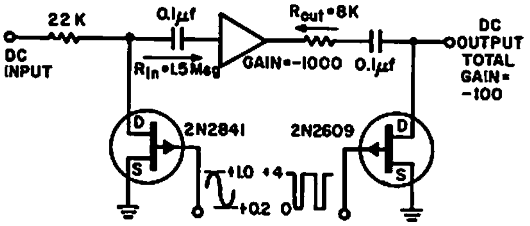
CHOPPER-DRIVER—Switches at rates from d-c to 10 kHz, with output completely isolated from input control signal just as in conventional relay. Q1 is 10-MHz common-base oscillator receiving bias from input logic signals. Rectified and filtered transformer secondary voltage controls bipolar switch Q2-Q3 having ON resistance of about 20 ohms and OFF leakage below 1 μA. Transformer is wound on Arnold A4-134P toroidal core.—J. E. Fracker, Solid-State Relay, *EEE*, June 1967, p 136.


DC INPUT
-24V
47K
50K
LEVEL ADJ
BIAS
1M
500K
1M
100K
R
C
0.1
22M
AC OUTPUT
HRN8338D
HRN8338D
HRN8318D
HRN8318D
MULTIVIBRATOR
CHOPPER
AC AMPLIFIER

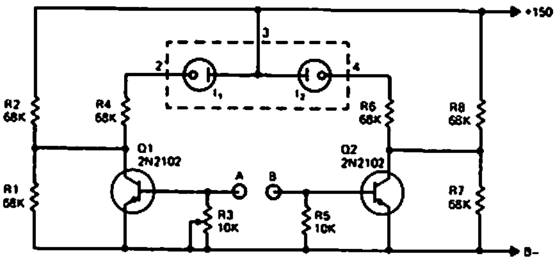
D-C MODULATOR—Useful for modulating or chopping low-level d-c signals for further amplification or for detection of d-c level. Left-hand pair of mosfets forms astable mvbr whose period of oscillation is determined by values of R and C used. Mvbr output drives simple shunt mosfet chopper switch, while mosfet at right provides signal gain and transforms high impedance of chopper to low impedance for a-c output.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 21.


E_{IN}
R_{b1}
3k
Q_1
2N2432
D_1
1N914
R_{b3}
3k
Q_3
2N2432
E_m
12v p-p
1:1
E_0
R_L
R_{b2}
3k
Q_2
2N2946
D_2
1N914
R_{b4}
3k
Q_4
2N2946

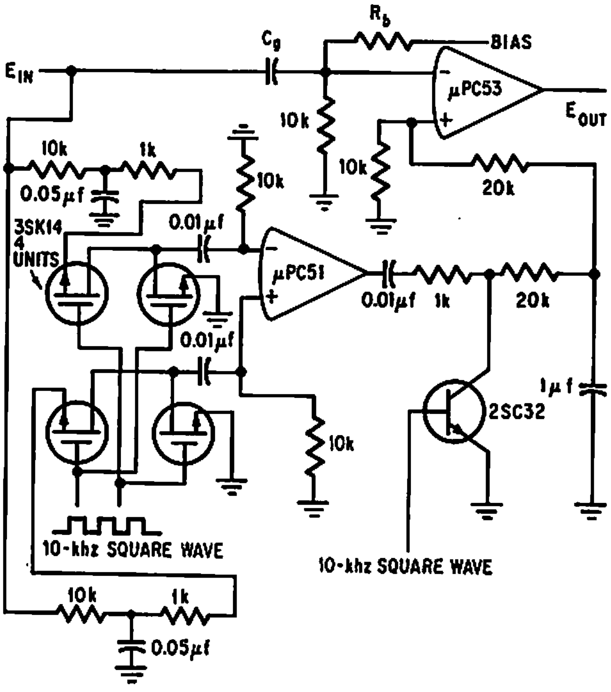
BALANCED CHOPPER MODULATOR—Connecting transistors in inverted mode gives much lower offset voltage, eliminates need for matched transistor pairs, and operates with only one secondary winding on transformer. Useful in chopper-stabilizing amplifiers, f-m oscillators, regulated a-c power supplies, and synchronous modulators and demodulators. Chopper transistors produce saturation voltages of 2 to 4 mV, as compared to 0.2 to 0.4 V for other modulator designs.—R. C. Scheerer and J. Logis, Inverted-Mode Transistors Give Chopper Low Offset, *Electronics*, March 30, 1970, p 96.


22 K
DC INPUT
0.1µf
R_{in}=1.5Meg
GAIN=-1000
R_{out}=8K
0.1µf
DC OUTPUT TOTAL GAIN= -100
D
S
2N2841
+1.0
+0.2
+4
0
2N2609
D
S

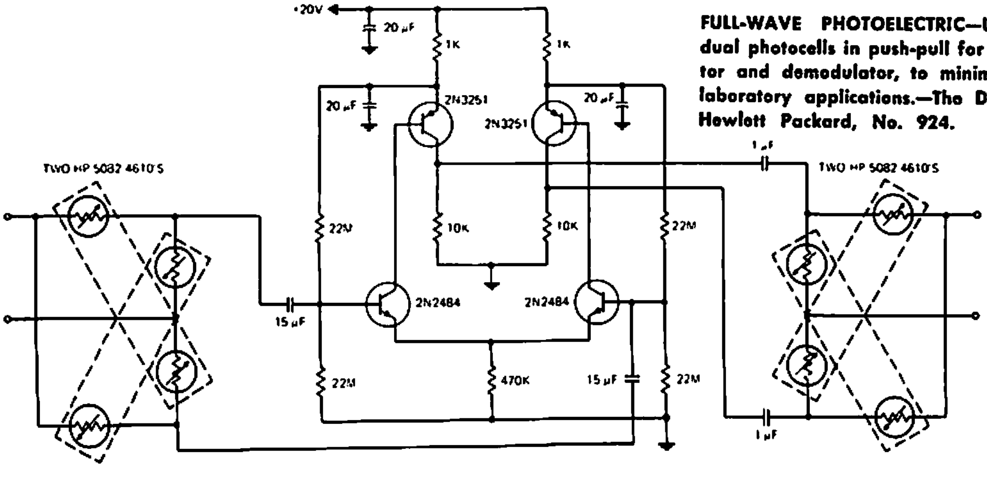
FET CHOPPERS GIVE GAIN OF 100—Input fet chopper is driven by sine wave, and output by 4-V p-p square wave. Input current is less than 20 pA, input impedance is 33K, and offset is less than 4.5 µV at room temperature. Any IC amplifier having gain of 1,000 can be used.—DC Amplifier With FET Chopper, *Electronic Design*, April 13, 1964, p 66.


+150
3
2
4
I_1
I_2
R2 68K
R4 68K
R6 68K
R8 68K
Q1 2N2102
Q2 2N2102
A
B
R1 68K
R3 10K
R5 10K
R7 68K
B-

LAMP DRIVER FOR CHOPPER—Used with full-wave laboratory-type photoelectric chopper amplifier. Lamps are neons.—The Dual Photocell, Hewlett Packard, No. 924.

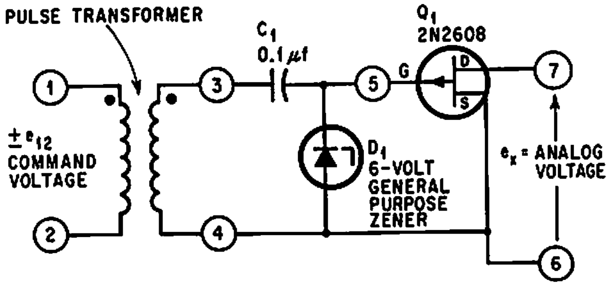

R_b
BIAS
C_g
E_{IN}
µPC53
E_{OUT}
10k
10k
20k
10k
1k
0.05µf
3SK14 4 UNITS
10k
0.01µf
µPC51
0.01µf
1k
20k
0.01µf
1µf
2SC32
10k
10-khz SQUARE WAVE
10-khz SQUARE WAVE
10k
1k
0.05µf

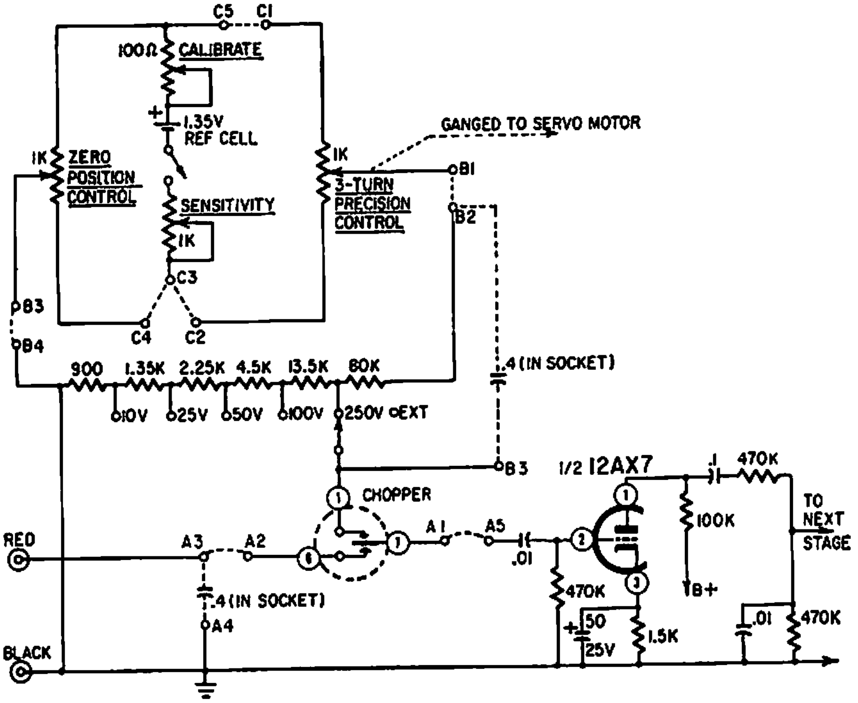
CHOPPER STABILIZATION—Four mosfet's in double-twin 10-kHz chopper are used to stabilize opamp integrator to give required accuracy of 0.1%, increase gain of opamp, and reduce drift. Integrator operates in 2 minutes for standard slow computing time, and in repetitive periods of 100, 50, 25, 12.5, 10, 5, and 2.5 ms for fast operation. Overall gain of chopper-stabilized opamp is 125 dB and input impedance is 20K. Used in IC analog computer.—K. Kurokawa, All-IC Hybrid Computer Eliminates the Patchwork from Programing, *Electronics*, March 17, 1969, p 100–107.


+20V
20 µF
1K
1K
20 µF
2N3251
2N3251
20 µF
1 µF
TWO HP 5082 4610'S
TWO HP 5082 4610'S
22M
10K
10K
22M
15 µF
2N2484
2N2484
22M
470K
15 µF
22M
1 µF

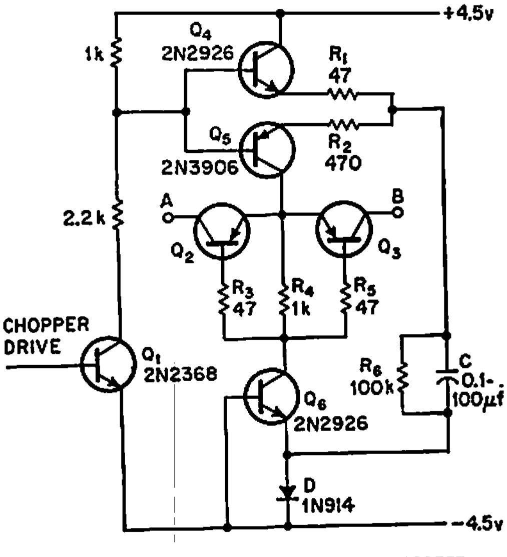
FULL-WAVE PHOTOELECTRIC—Uses pair of dual photocells in push-pull for both modulator and demodulator, to minimize noise for laboratory applications.—The Dual Photocell, Hewlett Packard, No. 924.

FAST SWITCH—Chops analog signals by using output of pulse-saving network (C1-D1) to switch fet on and off, without introducing common-mode noise. Pulse transformer can maintain 6-V on or off signals for over 100 ms. Transformer is Pulse Engineering Co. model 2228.—C. A. Walton, Pulse-Saving Network Permits Signal Switching, *Electronics*, Sept. 18, 1967, p 108–109.

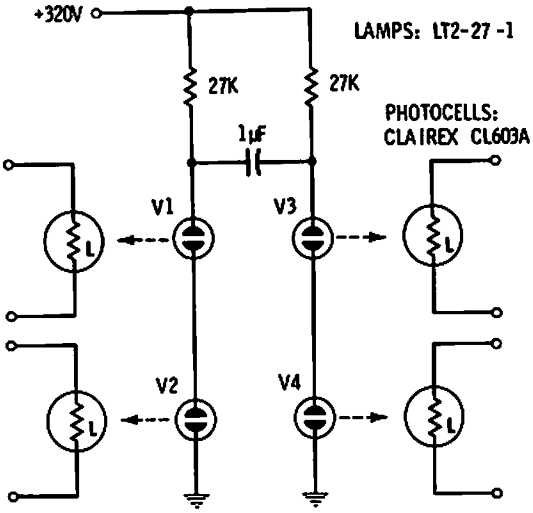

PULSE TRANSFORMER
①
②
③
④
⑤
⑥
⑦
±e12
COMMAND VOLTAGE
C1
0.1 μf
Q1
2N2608
G
D
S
D1
6-VOLT GENERAL PURPOSE ZENER
ex = ANALOG VOLTAGE


C5 C1
100Ω
CALIBRATE
1.35V REF CELL
1K
ZERO POSITION CONTROL
SENSITIVITY
1K
C3
C4 C2
1K
3-TURN PRECISION CONTROL
GANGED TO SERVO MOTOR
B1
B2
B3
B4
900 1.35K 2.25K 4.5K 13.5K 80K
10V 25V 50V 100V 250V EXT
.4 (IN SOCKET)
B3
CHOPPER
①
⑥
①
A3 A2
A1 A5
.01
.4 (IN SOCKET)
A4
RED
BLACK
1/2 12AX7
①
②
③
.1
470K
100K
B+
470K
50
25V
1.5K
.01
470K
TO NEXT STAGE

SERVO-DRIVEN PEN—Uses potentiometric metering system, in which input voltage is continuously compared with reference voltage from mercury cell by means of 3-turn slide-wire pot ganged to servo motor. Voltage difference is chopped, and resulting a-c voltage is amplified. Second pot, at left, is used to set marking pen at any desired point on strip chart paper for zero input voltage. Four stages of amplification round off corners of square-wave chopper output so drive for servo is practically sine wave.—E. Leslie, Low-Cost Strip-Chart Recorders, *Radio-Electronics*, June 1965, p 58–59.

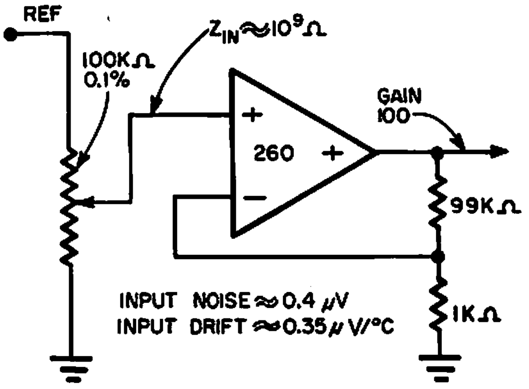

+4.5v
1k
Q4
2N2926
R1
47
Q5
2N3906
R2
470
2.2k
A
B
Q2
Q3
R3
47
R4
1k
R5
47
CHOPPER DRIVE
Q1
2N2368
R6
100k
C
0.1-
100μf
Q6
2N2926
D
1N914
−4.5v

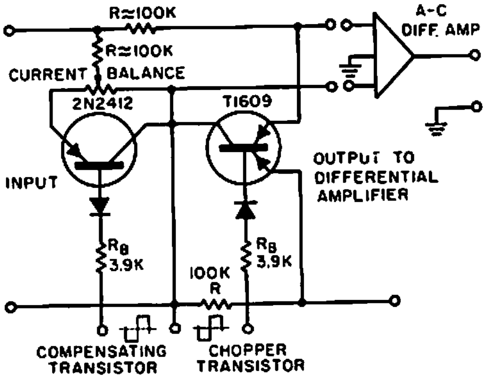
TRANSFORMERLESS WIDEBAND CHOPPER—Provides high isolation and reliable operation over wide range of mark-space ratios and repetition frequencies. During positive half-cycles of square-wave chopper drive, signals are transferred from A to B, but blocked during negative half-cycles.—H. Riddle, Transformer is Eliminated in Transistor Chopper, *Electronics*, Dec. 22, 1969, p 77.


+320V
LAMPS: LT2-27-1
27K
27K
1μF
PHOTOCELLS: CLAIREX CL603A
V1
V3
V2
V4
L
L
L
L

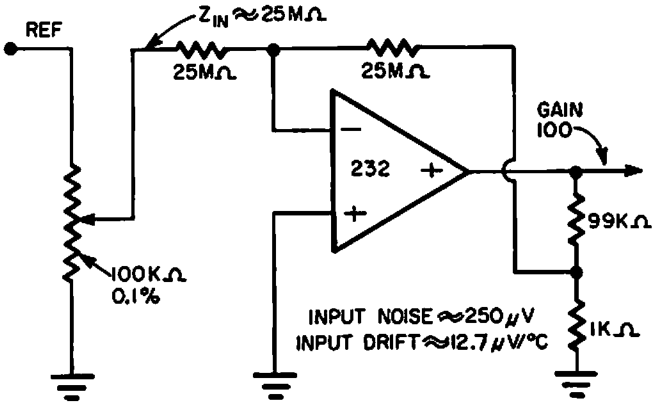
20-HZ PHOTOCHOPPER—Four neons in astable mvbr act on four photocells to provide synchronous chopping at 20 Hz. Developed for use in voltmeters and chopper-stabilized power supplies.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 68.

NONINVERTING CHOPPER OPAMP—Noninverting mode of operation gives greatly improved accuracy when handling signals from high-impedance sources. Applications include microvolt measurements in biological and research applications. Maximum current drift of opamp is 10 pA per degree C and common-mode rejection ratio is 300,000. Report also covers differential and off-ground applications, and use with bridge signals.—P. Zicko, Designing With Chopper Stabilized Operational Amplifiers, Analog Devices, Cambridge, Mass., 1970.

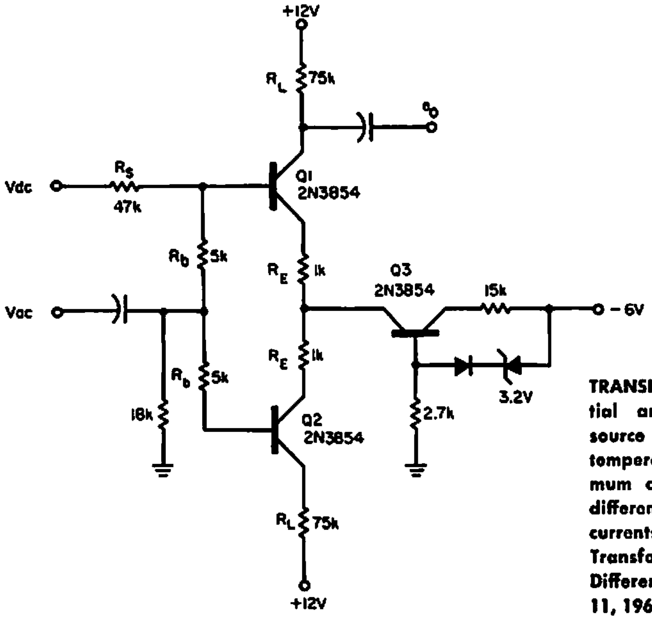

REF
$Z_{IN} \approx 10^9 \Omega$
100KΩ
0.1%
GAIN
100
260
+
−
99KΩ
1KΩ
INPUT NOISE ≈ 0.4 μV
INPUT DRIFT ≈ 0.35 μV/°C


R≈100K
R≈100K
CURRENT BALANCE
2N2412
T1609
A-C DIFF. AMP
INPUT
OUTPUT TO DIFFERENTIAL AMPLIFIER
R_B 3.9K
R_B 3.9K
100K R
COMPENSATING TRANSISTOR
CHOPPER TRANSISTOR

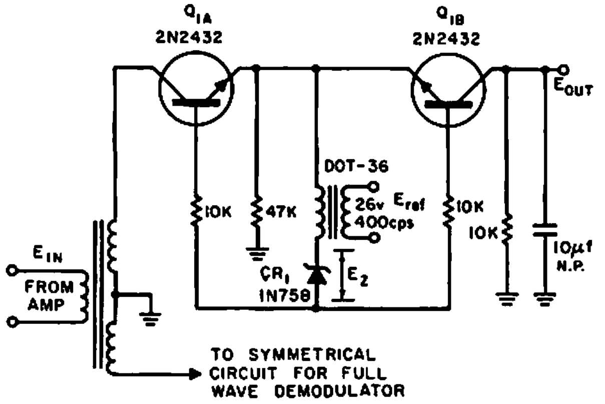
NOISE CANCELLER—Arrangement provides almost complete cancelling of switching spikes and voltage offsets. Dual emitters of chopper transistor convert these noise sources into common-mode noise, which is rejected by differential amplifier.—S. W. Holcomb, F. Opp, and J. A. Walston, Low-Noise Chopper, *Electronic Design,* Jan. 6, 1964, p 78.


REF
$Z_{IN} \approx 25 M\Omega$
25MΩ
25MΩ
GAIN
100
232
−
+
99KΩ
1KΩ
100KΩ
0.1%
INPUT NOISE ≈ 250 μV
INPUT DRIFT ≈ 12.7 μV/°C

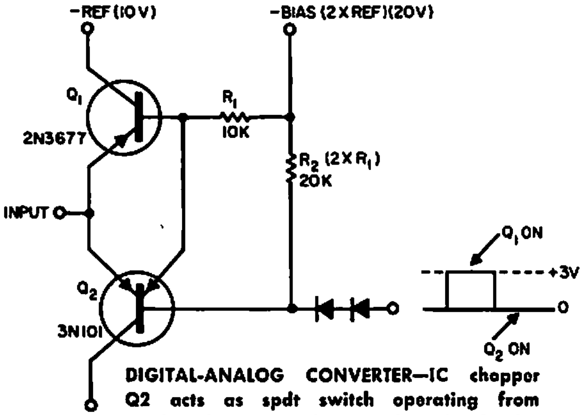
INVERTING-ONLY CHOPPER OPAMP—Used for high-accuracy low-level measurements where low noise and low drift are major requirements, as when measuring signals from 100K precision pot. Common-mode rejection ratio is 300,000.—P. Zicko, Designing With Chopper Stabilized Operational Amplifiers, Analog Devices, Cambridge, Mass., 1970.


+12V
R_L 75k
e_o
Vdc
R_s
47k
Q1 2N3854
R_b 5k
R_E 1k
Q3 2N3854
15k
−6V
Vac
R_E 1k
R_b 5k
3.2V
18k
2.7k
Q2 2N3854
R_L 75k
+12V

TRANSFORMERLESS CHOPPER—Uses differential amplifier Q1-Q2 and constant-current source Q3. Differential input stage has good temperature and drift stabilization. For optimum conversion of very small d-c signals, differential amplifier should be operated at currents of about 10 μA.—A. C. Caggiano, Transformerless Chopper Circuit Built With a Differential Amplifier, *Electronic Design,* Oct. 11, 1967, p 106.


Q1A
2N2432
Q1B
2N2432
EOUT
DOT-36
26v Eref
400cps
10K
47K
10K
10K
10μf
N.P.
EIN
FROM AMP
CR1
1N758
E2
TO SYMMETRICAL CIRCUIT FOR FULL WAVE DEMODULATOR

AMPLIFYING LOW-LEVEL D-C—Chopper-amplifier converts d-c signal to a-c at 400 Hz, passes signal through a-c narrow-band amplifier, and synchronously demodulates to give amplified d-c signal. Zener in chopper switching leg suppresses transients and minimizes drift and offset errors.—T. B. Hooker, Zener Diode Aids Chopper in Demodulator Application, *Electronic Design*, April 12, 1965, p 56–57.

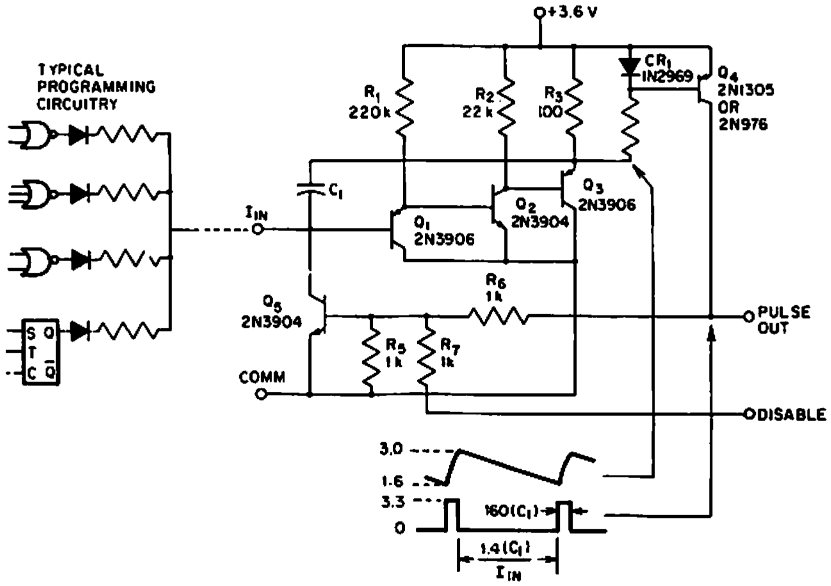

-REF (10V)
-BIAS (2XREF)(20V)
Q1
2N3677
R1
10K
R2 (2XR1)
20K
INPUT
Q2
3N101
Q1 ON
+3V
0
Q2 ON

DIGITAL-ANALOG CONVERTER—IC chopper Q2 acts as spdt switch operating from single-polarity drive between logic levels of 0 and +3 V, to give digital-to-analog conversion without complex drive circuit or multiplicity of supply voltages. Input terminal is connected to leg in ladder network, for switching between ground and minus reference voltage.—Integrated Chopper Forms Simple Digital-to-Analog Converter, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 135.

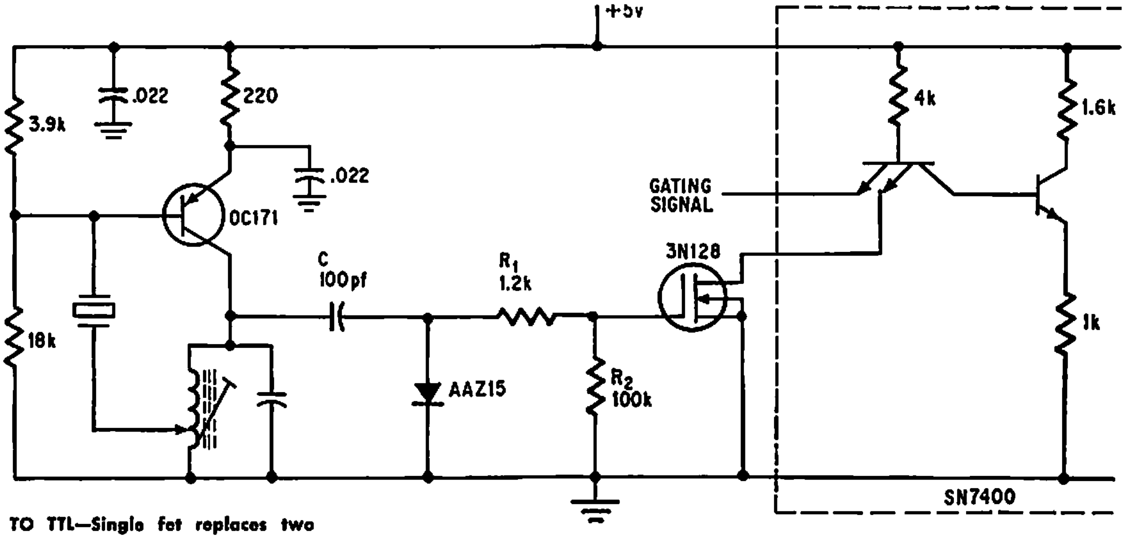
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 13

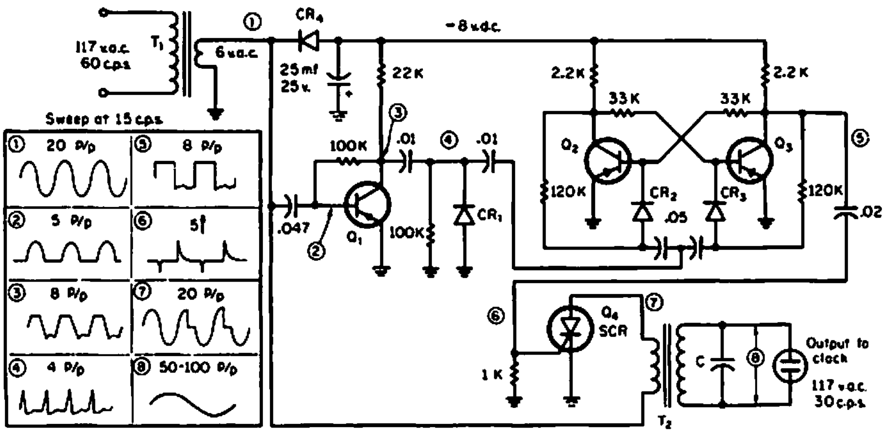
Clock Circuits


+3.6 V
TYPICAL PROGRAMMING CIRCUITRY
S Q
T
C Q̄
I_{IN}
C_1
R_1 220k
R_2 22k
R_3 100
CR_1 1N2969
Q_4 2N1305 OR 2N976
Q_1 2N3906
Q_2 2N3904
Q_3 2N3906
R_6 1k
Q_5 2N3904
R_5 1k
R_7 1k
COMM
PULSE OUT
DISABLE
3.0
1.6
3.3
0
160(C_1)
1.4(C_1) / I_{IN}

2–10,000 HZ PROGRAMMABLE—Repetition rate can be programmed over four decades by input current changes. Works with 3.6 V RTL logic. Linearity of current-frequency conversion is about 1% from 0.1 to 100 μA.—R. W. Fergus, Wide-Range Programmable Clock for Low-Voltage Logic, *EEE*, Sept. 1969, p 132–133.

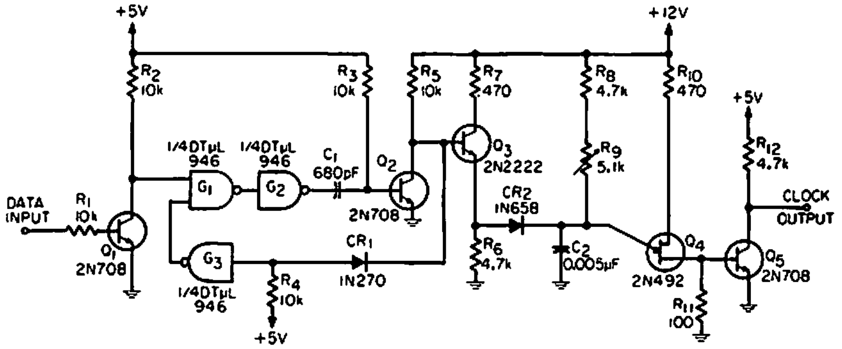

+5v
3.9k
.022
220
.022
OC171
18k
C 100pf
R_1 1.2k
AAZ15
R_2 100k
GATING SIGNAL
3N128
4k
1.6k
1k
SN7400

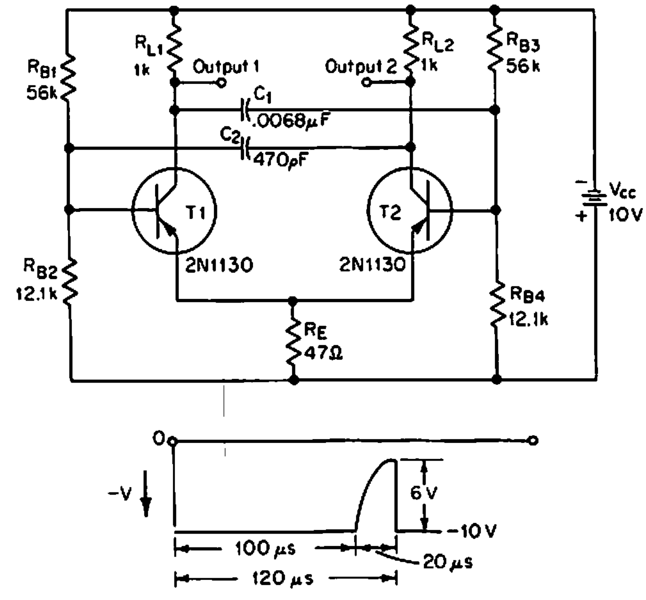
COUPLING TO TTL—Single fet replaces two or more driver stages and allows clock generator to operate from same 5-V supply as TTL. Crystal oscillator provides 4-V p-p sine wave at 12 MHz.—C. S. L Keay and I. C. Graham, FET Links Oscillator to TTL Circuit, *Electronics*, Feb. 17, 1969, p 97.


117 v.a.c.
60 c.p.s.
T1
6 v.a.c.
①
CR4
-8 v.d.c.
25 mf
25 v.
22K
2.2K
2.2K
33K
33K
Sweep at 15 c.p.s.
① 20 P/p
② 5 P/p
③ 8 P/p
④ 4 P/p
⑤ 8 P/p
⑥ 5†
⑦ 20 P/p
⑧ 50-100 P/p
③
④
.01
.01
100K
.047
②
Q1
100K
CR1
Q2
Q3
120K
120K
CR2
CR3
.05
⑤
.02
⑥
Q4
SCR
⑦
1K
C
⑧
Output to clock
117 v.a.c.
30 c.p.s.
T2

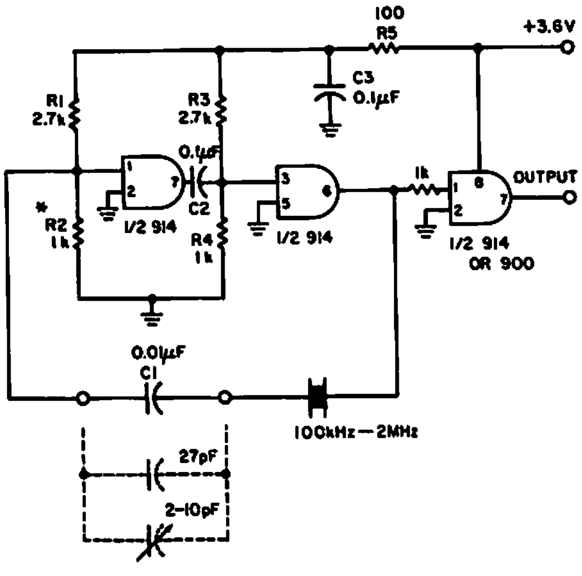
24-HOUR CLOCK—Frequency divider cuts 60-Hz line frequency to 30 Hz for driving standard electric clock at half speed, so hour hand takes 24 hours for one revolution. With appropriate change in clock face, Greenwich Mean Time can be read directly. CR4 is any top-hat diode rated at 400 piv and 750 mA. Other diodes are 1N34, Q1-Q3 2N404, and Q4 is International Rectifier 50-V 2-A scr. T2 is same as T1.—D. L. Jones, A 24-Hour Clock for the Shack, *CQ*, May 1970, p 20–21.

RESYNCHRONIZER—Ujt Q4, triggered by one-shot mvbr G1-G2-G3-Q2, reconstructs clock signal from incoming data, such as NRZ signal, that has no accompanying clock. NAND gates keep cost far below that of packaged one-shot. Designed for data rate of 30 kHz, though maximum operating frequency is 50 kHz.—F. Badal, UJT Oscillator Reconstructs Clock Signals, *EEE*, Aug. 1968, p 140.


+5V
+12V
R2
10k
R3
10k
R5
10k
R7
470
R8
4.7k
R10
470
+5V
R12
4.7k
1/4DTμL 946
1/4DTμL 946
C1
680pF
Q2
2N708
Q3
2N2222
R9
5.1k
CLOCK OUTPUT
DATA INPUT
R1
10k
G1
G2
G3
Q1
2N708
CR2
1N658
CR1
1N270
R6
4.7k
C2
0.005μF
Q4
2N492
Q5
2N708
1/4DTμL 946
R4
10k
+5V
R11
100

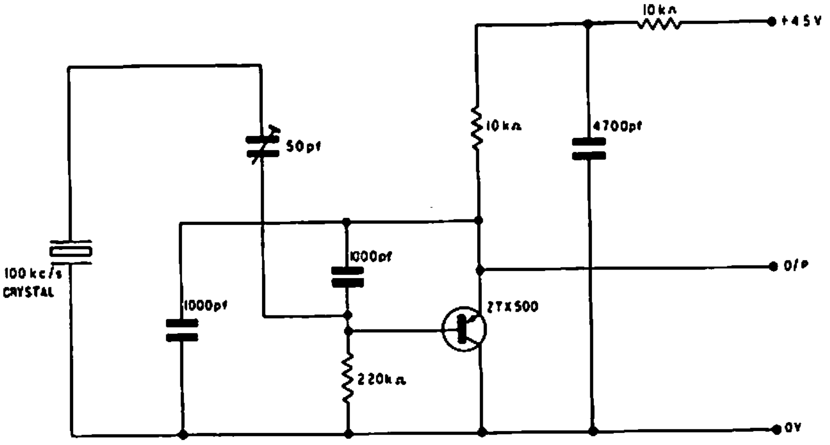

RB1
56k
RL1
1k
Output 1
Output 2
RL2
1k
RB3
56k
C1
.0068μF
C2
470pF
T1
T2
2N1130
2N1130
Vcc
10V
RB2
12.1k
RB4
12.1k
RE
47Ω
0
-V
6V
-10V
100 μs
20 μs
120 μs

NONSYMMETRICAL ASTABLE—As waveform indicates, transistor conducting times are made unequal by making cross-coupling capacitors C1 and C2 unequal. For values shown, one transistor conducts for only 20 μs out of total period time of 120 μs. Frequently used as clock for frequency control. Collector waveform is shown.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 213.

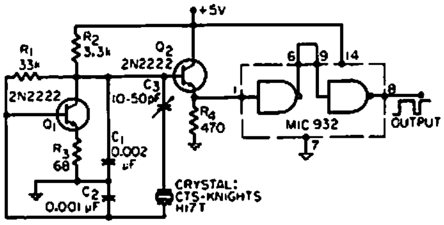

100
R5
+3.6V
C3
0.1μF
R1
2.7k
R3
2.7k
0.1μF
C2
*
R2
1k
R4
1k
1/2 914
1/2 914
1k
OUTPUT
1/2 914
OR 900
0.01μF
C1
27pF
2-10pF
100kHz—2MHz

*ADJUST R2 SLIGHTLY TO OBTAIN SYMMETRICAL WAVEFORM

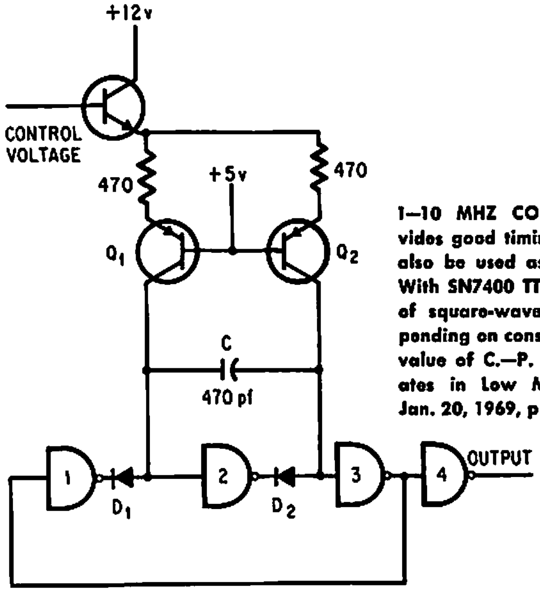
DIGITAL CLOCK—Provides square-wave output of 0.2 to 3.6 V at any frequency from 100 kHz to 2 MHz while requiring only 3.6-V d-c supply. Intended for digital logic applications. Stability approaches that of crystal used.—L. Roque, Accurate Digital Clock Uses Inexpensive IC Gates, *Electronic Design*, Aug. 16, 1969, p 242 and 244.


10kΩ
+45V
50pf
10kΩ
4700pf
1000pf
100kc/s CRYSTAL
0/P
1000pf
ZTX500
220kΩ
0V

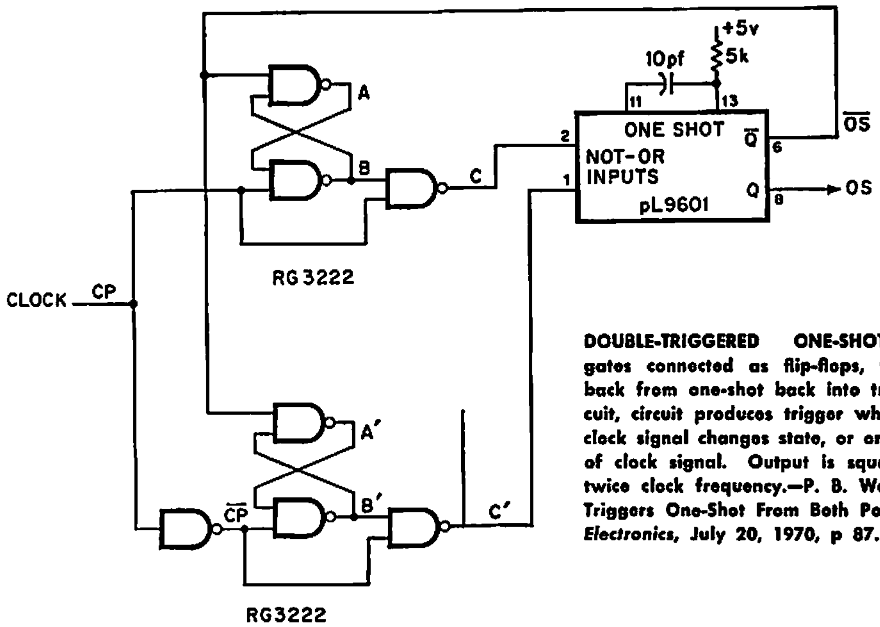
100-KHZ CRYSTAL FOR CLOCK—Used with ten frequency divider stages to give pulse every half-minute for driving ratchet mechanism of battery-powered clock. Accuracy is about 1 s per week. Report gives circuits for divider stages and ratchet coil drive.—A Crystal Clock Using Plastic Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 34, 1968.


+5V
R1 33k
R2 3.3k
Q2 2N2222
2N2222
Q1
C3 10-50pF
R4 470
R3 68
C1 0.002 µF
C2 0.001 µF
CRYSTAL: CTS-KNIGHTS H17T
6
9
14
1
8
MIC 932
7
OUTPUT

100-KHZ COLPITTS CRYSTAL—Operates from single 5-V supply. Consists of oscillator Q1, emitter-follower Q2, and DTL buffer gate. Output is square wave with rise and fall times under 50 ns. Will drive 25 DTL loads or 12 TTL loads. Stability is that of crystal. —D. Jonas, Stable Clock Oscillators are DTL/TTL Compatible, *EEE*, May 1968, p 123–124.

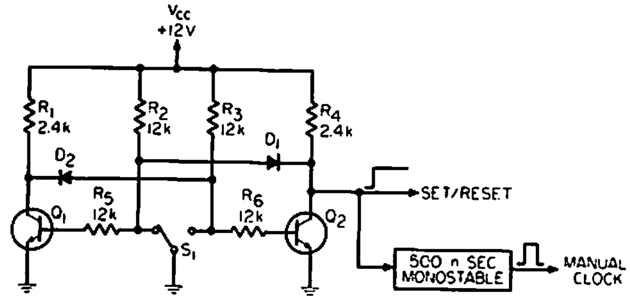

+12v
CONTROL VOLTAGE
470
+5v
470
Q1
Q2
C
470 pf
1
D1
2
D2
3
4
OUTPUT

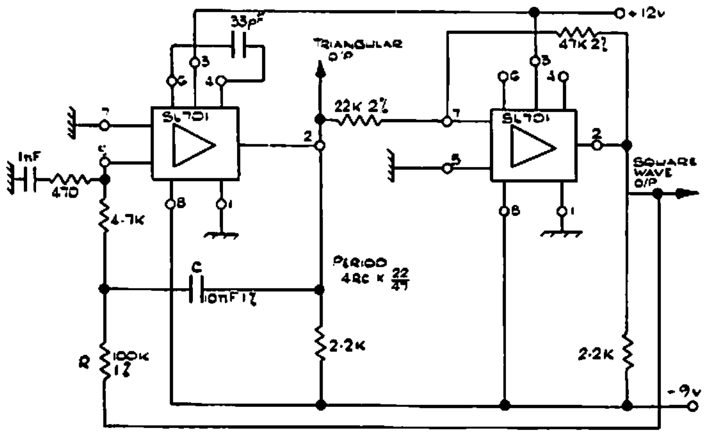
1—10 MHZ CONTINUOUSLY VARIABLE—Provides good timing for digital system, and can also be used as voltage-frequency converter. With SN7400 TTL quad gate, frequency range of square-wave output is 1 to 15 MHz depending on constant-current source Q1-Q2 and value of C.—P. Westphal, Digital Clock Operates in Low Megahertz Range, *Electronics*, Jan. 20, 1969, p 87.


A
B
C
RG3222
CLOCK
CP
+5v
10pf
5k
11
13
2
1
ONE SHOT
NOT-OR INPUTS
pL9601
$\overline{Q}$
Q
6
8
$\overline{OS}$
OS
A′
B′
$\overline{CP}$
C′
RG3222

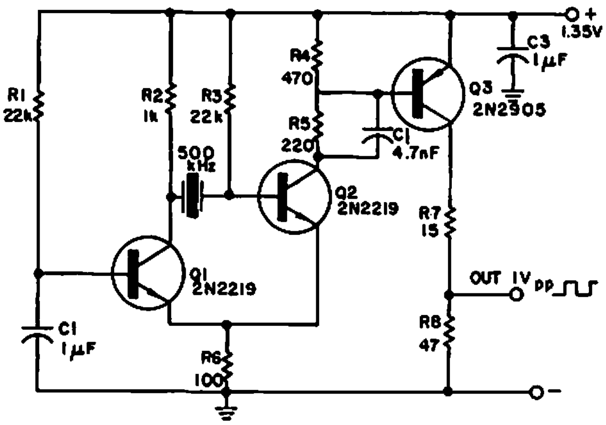
DOUBLE-TRIGGERED ONE-SHOT—With IC gates connected as flip-flops, taking feedback from one-shot back into triggering circuit, circuit produces trigger whenever input clock signal changes state, or on both edges of clock signal. Output is square wave at twice clock frequency.—P. B. Weil, Feedback Triggers One-Shot From Both Polarity Edges, *Electronics*, July 20, 1970, p 87.

MANUAL CLOCK PULSES—Useful for testing counters, adders, and other types of digital circuits. Eliminates effects of switch bounce that could cause false triggering. Provides complementary set-reset voltages at collectors of Q1 and Q2, and manual clock pulse each time mono is triggered by change in state of Q2 collector voltage from low to high. With 2N706 transistors, total latching time is less than 200 ns.—T. Carmody, Low-Cost Manual Pulser, *EEE*, Oct. 1967, p 143–144.

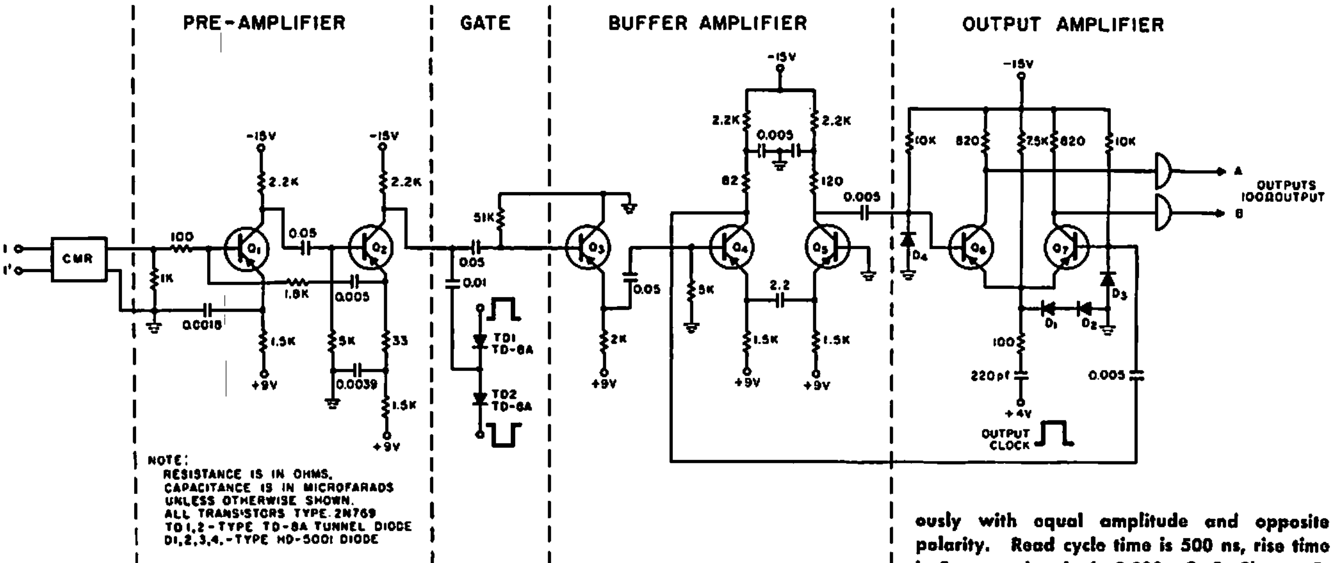

Vcc
+12V
R1 2.4k
R2 12k
R3 12k
R4 2.4k
D1
D2
R5 12k
R6 12k
Q1
Q2
S1
SET/RESET
500 n SEC MONOSTABLE
MANUAL CLOCK


33pF
+12v
TRIANGULAR O/P
SL701
SL701
22K 2%
47K 2%
1nF
470
4.7K
C 10nF 1%
R 100K 1%
PERIOD 4RC × 22/47
2.2K
2.2K
SQUARE WAVE O/P
-9v

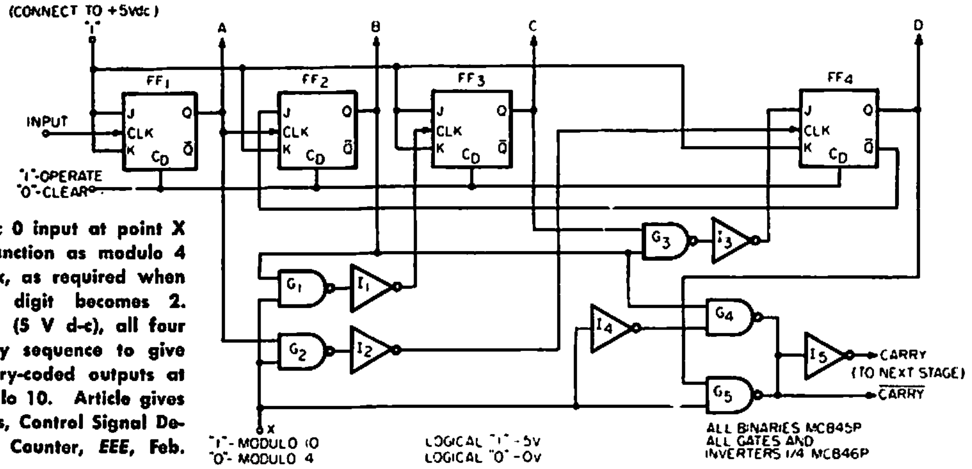
SQUARE-TRIANGULAR CLOCK—Uses Plessey high-gain d-c amplifiers as clock providing choice of two waveforms at frequency that is held constant within 2% over 50 deg C temperature range and 0.5-V change in supply voltages. Second amplifier uses positive feedback to achieve precision trigger circuit. —R. C. Foss and B. J. Green, The SL700 Series and Applications, Plessey, Swindon, England, No. 7.


+ 1.35V
C3 1μF
R1 22k
R2 1k
R3 22k
R4 470
R5 220
C1 4.7nF
Q3 2N2905
500 kHz
Q2 2N2219
Q1 2N2219
R7 15
OUT 1V pp
R8 47
C1 1μF
R6 100
−

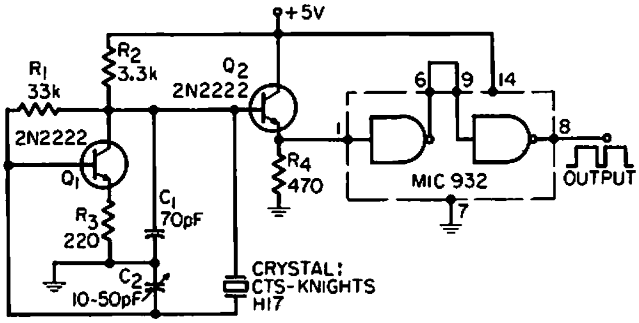
500-KHZ CRYSTAL—Operates from single 1.35-V mercury cell and delivers 1 V p-p square-wave output for clock generators, lab standards, or cro calibrators.—R. L. Billion, Crystal-Controlled Oscillator Operates From One Mercury Cell, *Electronic Design*, Nov. 8, 1969, p 109.


PRE-AMPLIFIER
GATE
BUFFER AMPLIFIER
OUTPUT AMPLIFIER
CMR
-15V
2.2K
100
1K
0.05
0.0018
1.8K
0.005
1.5K
5K
33
0.0039
1.5K
+9V
51K
0.05
0.01
TD1 TD-6A
TD2 TD-6A
0.05
2K
2.2K
0.005
82
120
0.005
2.2
1.5K
10K
820
7.5K
D4
D1
D2
D3
100
220pf
+4V
OUTPUT CLOCK
OUTPUTS 1000 OUTPUT
A
B
NOTE:
RESISTANCE IS IN OHMS.
CAPACITANCE IS IN MICROFARADS UNLESS OTHERWISE SHOWN.
ALL TRANSISTORS TYPE 2N769
TD1,2-TYPE TD-6A TUNNEL DIODE
D1,2,3,4,-TYPE HD-5001 DIODE

DOUBLE-CLOCK MEMORY READ AMPLIFIER—Proper timing of clocks gives maximum signal gain for reading thin-film memory, with transient noise completely rejected in output stage. Clock signals are applied to tunnel-diode gate connected as Goto pair, simultaneously with equal amplitude and opposite polarity. Read cycle time is 500 ns, rise time is 3 ns, and gain is 2,000.—C. F. Chong, G. H. Guttrogg, C. S. Ih and A. A. Wicks, High-Speed Read Amplifiers For Thin Films, *Electronic Design*, Aug. 3, 1964, p 38–40.

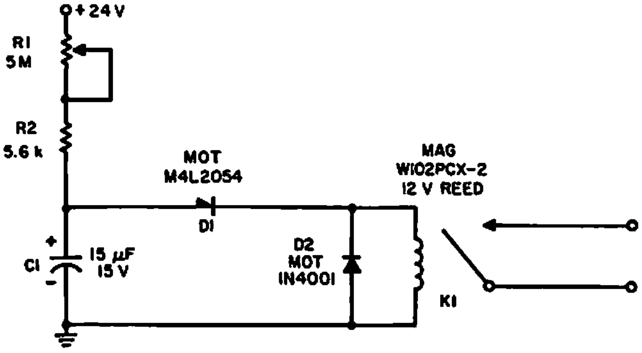

(CONNECT TO +5Vdc)
"1"
A
B
C
D
FF1
FF2
FF3
FF4
J
CLK
K
Q
Q̄
CD
INPUT
"1"-OPERATE
"0"-CLEAR
G1
G2
G3
G4
G5
I1
I2
I3
I4
I5
CARRY
(TO NEXT STAGE)
CARRY
X
"1"-MODULO 10
"0"-MODULO 4
LOGICAL "1"-5V
LOGICAL "0"-0V
ALL BINARIES MC845P
ALL GATES AND
INVERTERS 1/4 MC846P

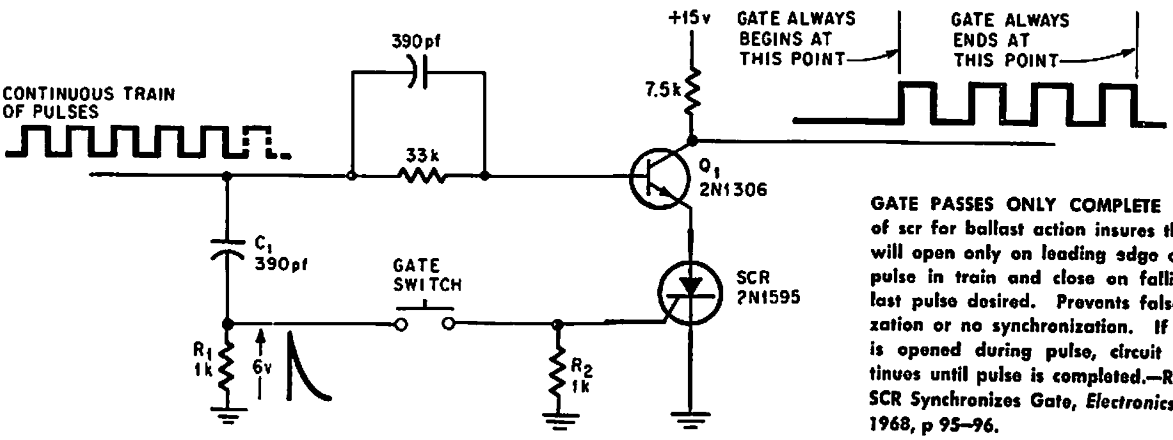
MODULO 10 OR 4—Logic 0 input at point X makes digital counter function as modulo 4 in electronic digital clock, as required when most significant hours digit becomes 2. When point X is logic 1 (5 V d-c), all four flip-flops count in binary sequence to give 1—2—4—8 weighted binary-coded outputs at A, B, C, and D for modulo 10. Article gives truth tables.—I. P. Breikss, Control Signal Determines Modulo of EC Counter, *EEE*, Feb. 1968, p 126 and 128.


+5V
R1
33k
R2
3.3k
Q2
2N2222
2N2222
Q1
R3
220
C1
70pF
C2
10-50pF
R4
470
CRYSTAL:
CTS-KNIGHTS
H17
1
6
9
14
8
7
MIC 932
OUTPUT

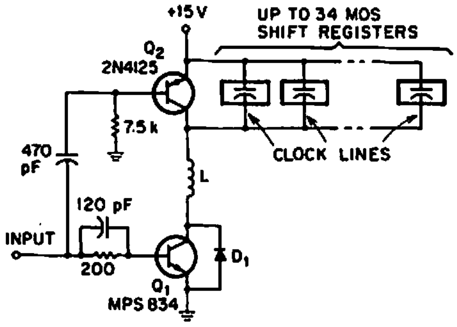
1-MHZ COLPITTS CRYSTAL—Operates from single 5-V supply and provides output levels completely compatible with digital IC's. Frequency stability approaches that of crystal alone, from 0 to 70 C.—D. Jones, Stable Clock Oscillators are DTL/TTL Compatible, *EEE*, May 1968, p 123–124.

PROCESS CONTROL PULSER—Simple clock, using four-layer diode as timing control, provides repetitive closures of relay at rates from 1 to 600 ppm. Closure time is about 10 ms at all rates. Applications include cycling of components on life test.—D. T. Krausman, Four-Layer Diode Clock Has Relay Closure Output, *Electronic Design*, May 10, 1967, p 92 and 94.

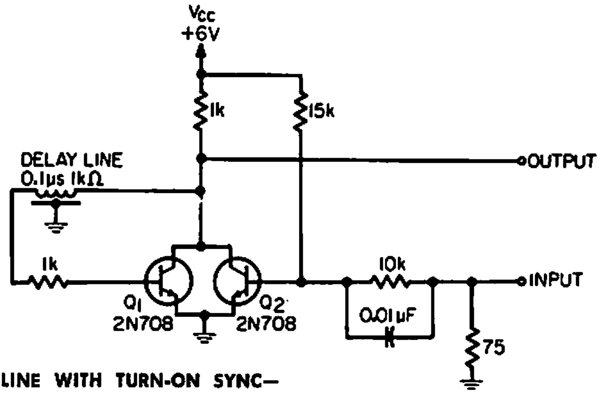

+24V
R1
5M
R2
5.6 k
MOT
M4L2054
D1
MAG
W102PCX-2
12 V REED
+
C1
-
15 µF
15 V
D2
MOT
1N4001
K1


CONTINUOUS TRAIN
OF PULSES
390pf
33k
C1
390pf
R1
1k
6v
GATE
SWITCH
R2
1k
+15v
7.5k
Q1
2N1306
SCR
2N1595
GATE ALWAYS
BEGINS AT
THIS POINT
GATE ALWAYS
ENDS AT
THIS POINT

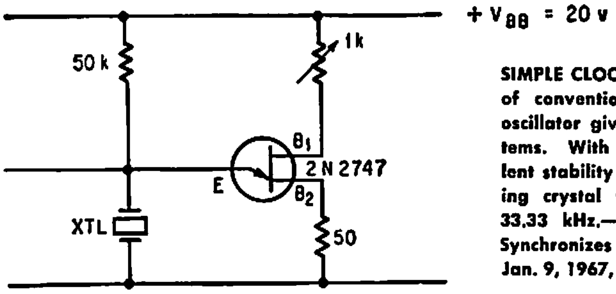
GATE PASSES ONLY COMPLETE PULSES—Use of scr for ballast action insures that gate Q1 will open only on leading edge of first clock pulse in train and close on falling edge of last pulse desired. Prevents false synchronization or no synchronization. If gate switch is opened during pulse, circuit action continues until pulse is completed.—R. A. Wilson, SCR Synchronizes Gate, *Electronics*, March 18, 1968, p 95–96.


+15 V
UP TO 34 MOS SHIFT REGISTERS
Q2
2N4125
7.5 k
CLOCK LINES
470 pF
L
120 pF
INPUT
200
D1
Q1
MPS 834

CLOCK-LINE DRIVER—Inductor L and transistor switch are connected in series with clock line to form series resonant tank circuit capable of handling 34 256-bit mos registers operating at clock frequency of 620 kHz. L is 6.8 μH.—R. O. Brink, Resonant Clock-Line Driver for MOS ICs, *EEE*, April 1969, p 118 and 120.

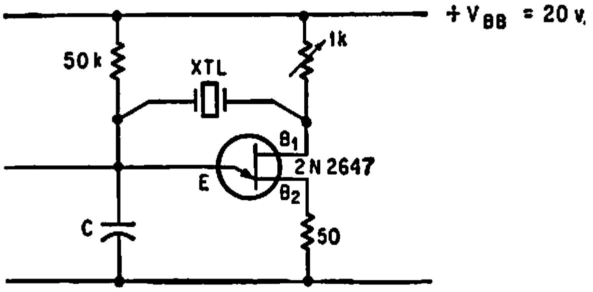

Vcc
+6V
1k
15k
DELAY LINE
0.1μs 1kΩ
OUTPUT
1k
10k
INPUT
Q1
2N708
Q2
2N708
0.01μF
75

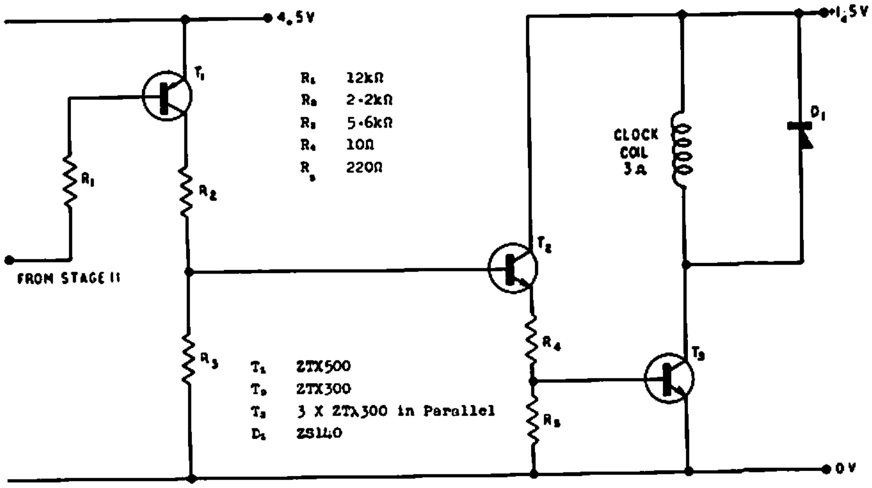
5-MHZ DELAY-LINE WITH TURN-ON SYNC—Clock pulses always start in phase with leading edge of input gate pulse, and always stop with trailing edge. Gives square-wave output. Delay line is PCA Electronics type DL-1000-0.1-2289 having 1K impedance and 100-ns delay. Circuit is designed for 5-V gate pulse. Eliminates possible range error of one count occurring with crystal-controlled clock oscillators.—P. E. Dingwell, Gated Delay-Line Oscillator Eliminates Range Error, *EEE*, Sept. 1968, p 108 and 110.


+V$_{BB}$ = 20 v
50 k
1 k
B1
2 N 2747
E
B2
XTL
50

SIMPLE CLOCK—Use of quartz crystal in place of conventional capacitor in ujt relaxation oscillator gives low-cost clock for digital systems. With 100-kHz crystal, clock has excellent stability at either 100 or 50 kHz. Shunting crystal with several hundred pF gives 33.33 kHz.—R. G. Damaye, Quartz Crystal Synchronizes Relaxation Oscillator, *Electronics*, Jan. 9, 1967, p 104.

CRYSTAL-UJT—With quartz crystal connected between emitter and base of relaxation oscillator, lock-in occurs at fundamental or submultiples of crystal frequency. External pulses are not required for synchronization. Serves as inexpensive 100, 50, or 33.33 Hz clock for digital systems, with high stability for both voltage and temperature variations.—R. G. Damaye, Quartz Crystal Synchronizes Relaxation Oscillator, *Electronics*, Jan. 9, 1967, p 104.

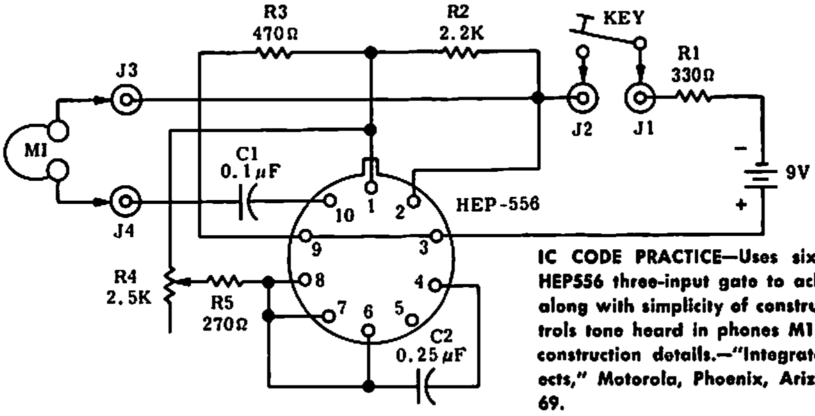

+V$_{BB}$ = 20 v.
50 k
XTL
1k
B1
2 N 2647
E
B2
C
50


4.5V
T1
R1 12kΩ
R2 2·2kΩ
R3 5·6kΩ
R4 10Ω
R5 220Ω
R1
R2
FROM STAGE 11
CLOCK COIL 3A
D1
1.5V
T2
R3
T1 ZTX500
T2 ZTX300
T3 3 X ZTX300 in Parallel
D1 ZS140
R4
T3
R5
0V

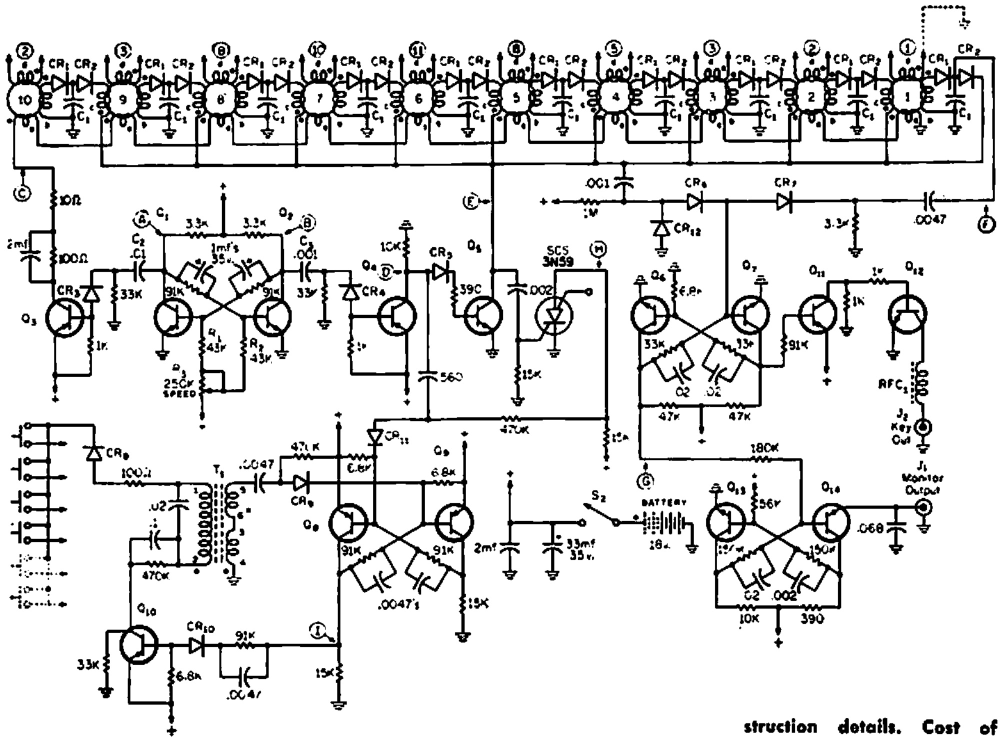
IMPULSE CLOCK DRIVE—Circuit receives narrow pulse every 30 s from frequency divider of battery-powered 100-kHz quartz crystal oscillator and delivers 300-mA current to coil of ratchet that advances clock hands half a minute. Output stage operates from separate 1.5-V cell so negative pulses on its supply line do not affect earlier stages. Impulse clock used is made by English Clock Systems, a branch of Smiths Clocks.—A Crystal Clock Using Plastic Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 34, 1968.

CHAPTER 14

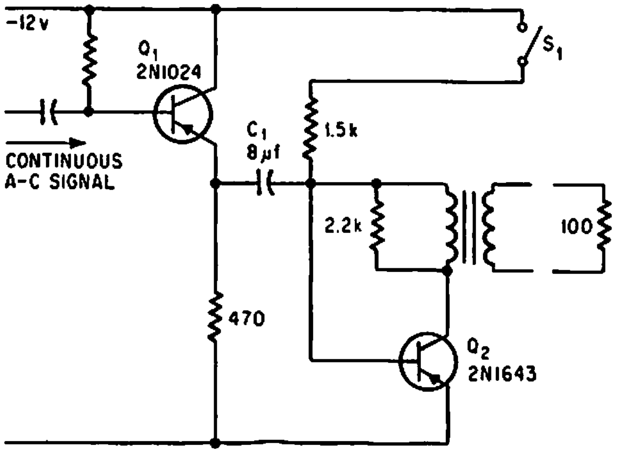
Code Circuits


R3
470Ω
R2
2.2K
KEY
R1
330Ω
J3
J2
J1
MI
C1
0.1μF
10
1
2
HEP-556
9V
9
3
J4
R4
2.5K
8
4
R5
270Ω
7
6
5
C2
0.25μF

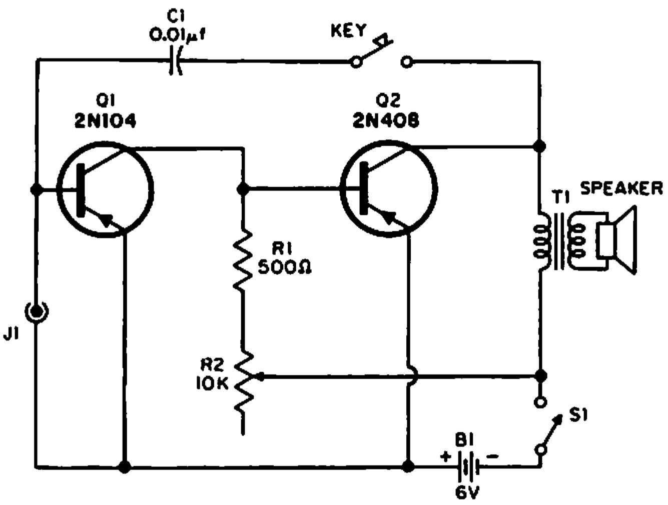
IC CODE PRACTICE—Uses six transistors in HEP556 three-input gate to achieve reliability along with simplicity of construction. R4 controls tone heard in phones M1. Article gives construction details.—"Integrated Circuit Projects," Motorola, Phoenix, Ariz., 1966, p 63–69.


CR₁
CR₂
C₁
10
9
8
7
6
5
4
3
2
1
10Ω
100Ω
2mf
CR₃
33K
Q₃
1K
33K
3.3K
1mf's
35v
91K
R₁
43K
R₂
43K
R₃
250K
SPEED
.001
CR₄
10K
CR₅
Q₅
39C
SCS
3N59
.002
560
15K
.001
1M
CR₆
CR₇
CR₁₂
3.3K
.0047
Q₆
6.8K
Q₇
Q₁₁
Q₁₂
1K
91K
47K
RFC₁
J₂
Key Out
J₁
Monitor Output
CR₈
100Ω
T₁
.0047
.02
470K
CR₉
CR₁₁
6.8K
Q₈
Q₉
91K
.0047's
15K
2mf
33mf
35v
S₂
BATTERY
18v
180K
Q₁₃
56K
Q₁₄
150K
.068
.02
.002
10K
390
Q₁₀
CR₁₀
91K
33K
6.8K
.0047
15K

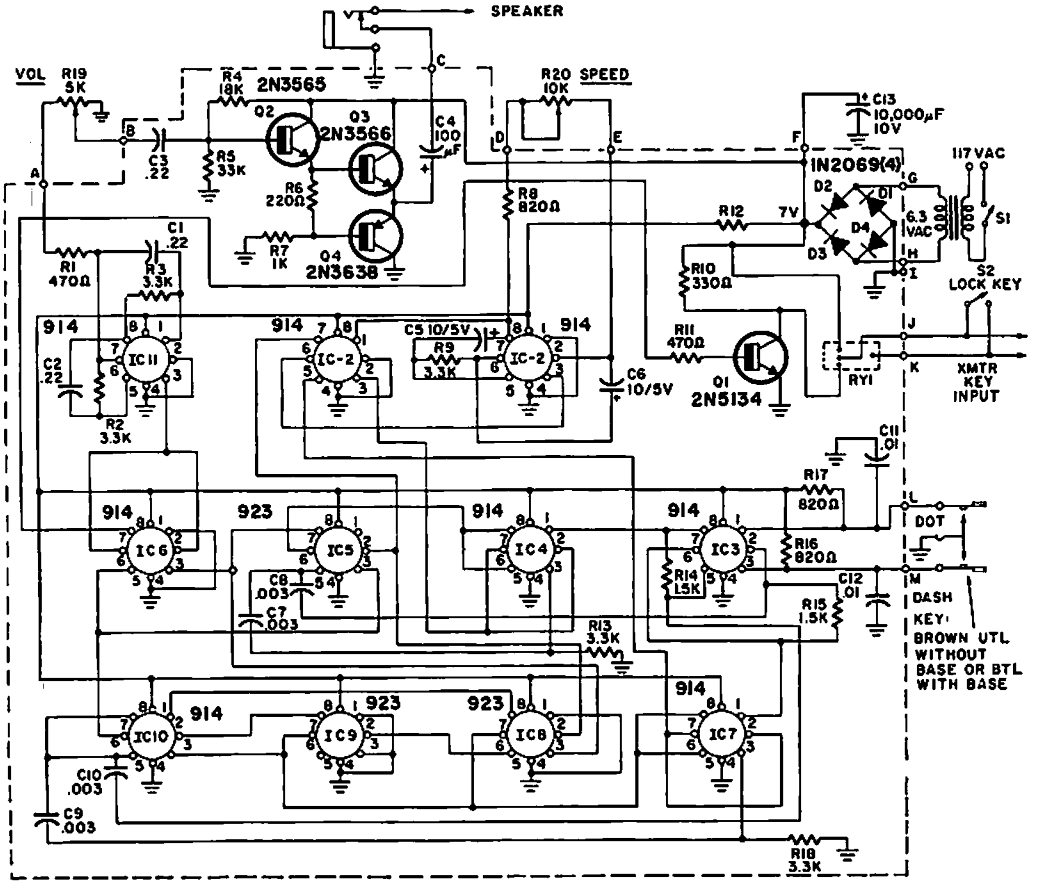
CODE-GENERATING C-W KEYBOARD—Generates corresponding Morse code automatically when key for letter or numeral is pressed. Microswitches under keys control magnetic-core shift register in which astable mvbr Q1-Q2 runs continuously to provide shift and switching pulses. Article gives interconnection diagram for shift register set windings that generate required combination of dots and dashes for each character, and gives construction details. Cost of components is about $130. C1 is 0.1 μF; CR1-CR11 1N645; CR12 1N191; Q1-Q2, Q5-Q7, Q13-Q14 2N1252; Q3-Q4 2N1131; Q8-Q11 2N404; Q12 2N657.—H. Granberg, A Push-Button Keyer, CQ, Sept. 1964, p 28–31 and 92.


-12v
Q1
2N1024
CONTINUOUS
A-C SIGNAL
C1
8μf
1.5k
S1
2.2k
100
470
Q2
2N1643

SWITCHING AUDIO TONES NOISELESSLY—Two-transistor circuit with 1:1 transformer makes key clicks negligible at switching speeds up to 50 bauds. Signal suppression during off periods is 70 dB. Operates well with up to 0.2 μF across switch contacts, permitting remote control of keying with long cable.—J. M. Little, Transistor Switch For Clickless Keying, *Electronics*, Oct. 31, 1966, p 68.

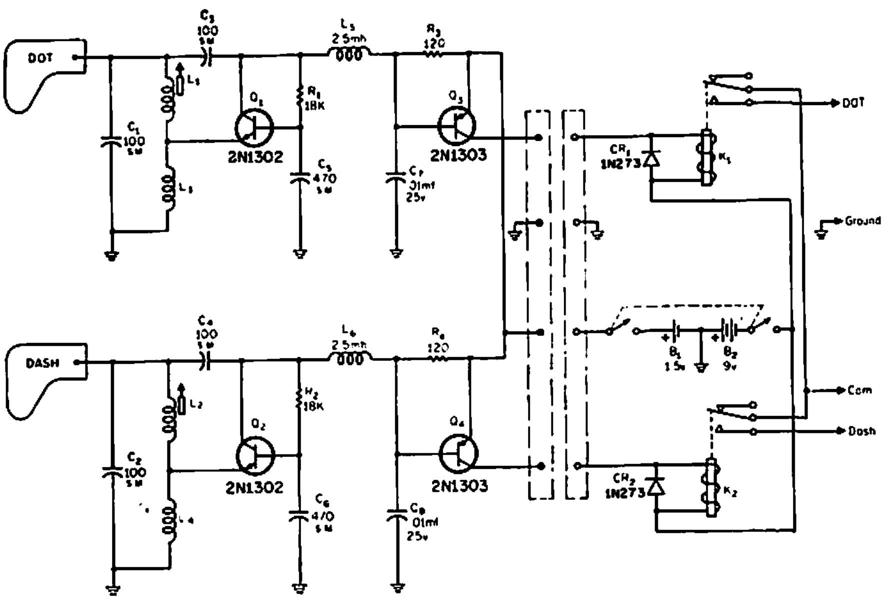

C1
0.01μf
KEY
Q1
2N104
Q2
2N408
T1
SPEAKER
R1
500Ω
J1
R2
10K
S1
B1
6V

CODE PRACTICE SET—R2 controls tone. Earphone can be plugged into phono jack J1. T1 is output transformer having 500-ohm primary and 3.2-ohm secondary, for driving 3.2-ohm 6-inch p-m speaker.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 10.

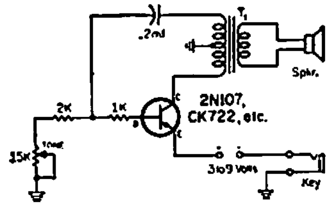

SPEAKER
VOL R19 5K
R4 18K
2N3565
C
R20 SPEED 10K
B
C3 .22
Q2
Q3
2N3566
C4 100μF
D
E
F
C13 10,000μF 10V
117VAC
R5 33K
A
R6 220Ω
R8 820Ω
1N2069(4)
D2
D1
D4
D3
G
6.3 VAC
S1
R12
7V
H
I
R1 470Ω
C1 .22
R7 1K
Q4
2N3638
R3 3.3K
R10 330Ω
S2 LOCK KEY
914
IC11
C2 .22
R2 3.3K
914
IC-2
C5 10/5V
R9 3.3K
914
IC-2
C6 10/5V
R11 470Ω
Q1
2N5134
J
RY1
K
XMTR KEY INPUT
C11 .01
R17 820Ω
L
DOT
914
IC6
923
IC5
C8 .003
C7 .003
914
IC4
914
IC3
R16 820Ω
R14 1.5K
C12 .01
M
R15 1.5K
DASH
KEY: BROWN UTL WITHOUT BASE OR BTL WITH BASE
R13 3.3K
914
IC10
923
IC9
923
IC8
914
IC7
C10 .003
C9 .003
R18 3.3K

(BOTTOM VIEW OF IC'S)

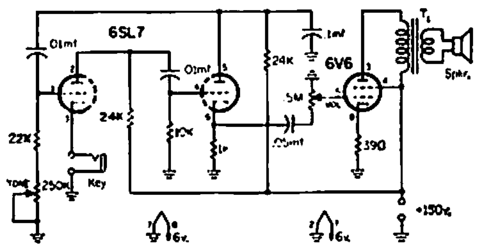
ELECTRONIC KEYER—Generates perfect Morse-code dots and dashes, with dashes always three times longer than dots and with each dot or dash self-completing even though key is released. Circuit uses Fairchild or ITT type 923 JK IC flip-flops in combination with type 914 dual RTL IC gates and three transistors. Keying-relay output may be connected to any transmitter keying circuit. Operating speed is set by R20. Article gives construction details. R12 is about 21 ohms.—W. O. Hamlin, Build Perfect Electronic Keyer, *Radio-Electronics*, Nov. 1969, p 69–72.


DOT
DASH
C3 100 SM
C4 100 SM
L5 2.5mh
L6 2.5mh
R3 120
R4 120
L1
L2
C1 100 SM
C2 100 SM
Q1
Q2
Q3
Q4
2N1302
2N1303
R1 18K
R2 18K
C5 470 SM
C6 470 SM
C7 .01mf 25v
C8 .01mf 25v
CR1 1N273
CR2 1N273
K1
K2
B1 1.5v
B2 9v
DOT
Ground
Com
Dash

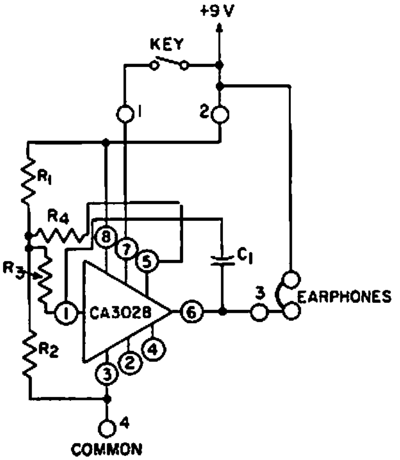
MOTIONLESS KEY—Resembles and is operated like conventional paddle key but responds to slightest touch of either stationary paddle for triggering capacitance-sensing dot or dash generator of electronic keyer. Both paddles are grounded for d-c. Action is fast and reliable with normally moist skin. For dry skin, glycerine rubbed between thumb and fingers will increase conductivity enough for reliable triggering. Article gives construction details. A-c power supply and long-dash circuit (described in CQ, Feb. 1965, p 59 and 104–105) are desirable options.—A. H. Jackson, The Touch-Key, CQ, Nov. 1964, p 28–31 and 137.


.2mf
T1
Spkr.
2K
1K
35K
TONE
2N107, CK722, etc.
3 to 9 volts
Key

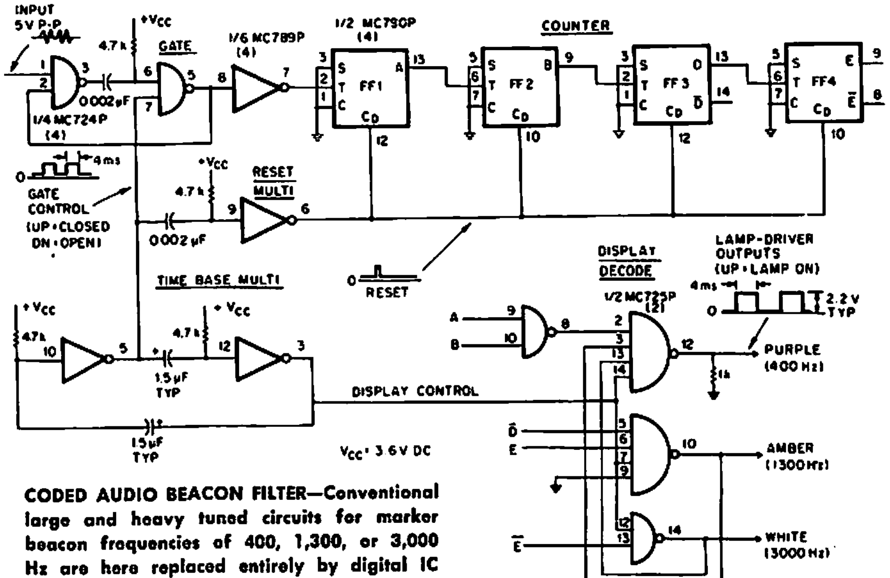
PRACTICE SET WITH SPEAKER—Any expensive pnp transistor may be used. T1 is Lafayette TR-109 transistor output transformer or equivalent.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 84.


.01mf
6SL7
.01mf
24K
24K
22K
TONE
250K
Key
1mf
6V6
.5M
.05mf
390
T1
Spkr.
+150v
6v
6v

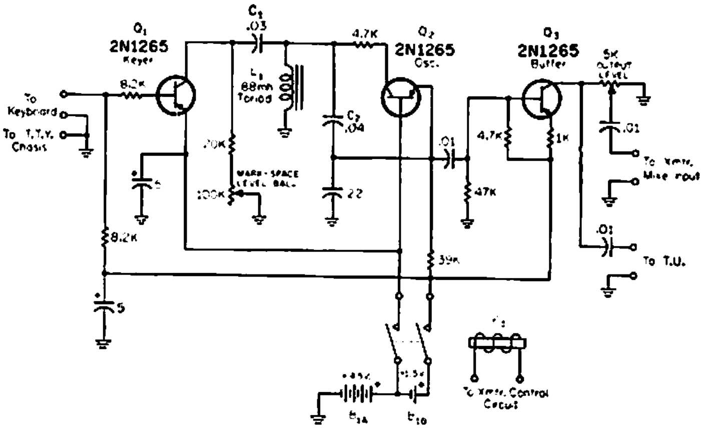
THREE-TUBE PRACTICE SET—Provides sufficient loudspeaker volume for classroom use. Almost any other dual-triode and pentode may be used by changing pin connections and filament voltage. T1 is any 50L6-type output transformer.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 85.


+9 V
KEY
1
2
R1
R4
R3
R2
C1
CA3028
8
7
5
1
6
3
2
4
3
EARPHONES
4
COMMON

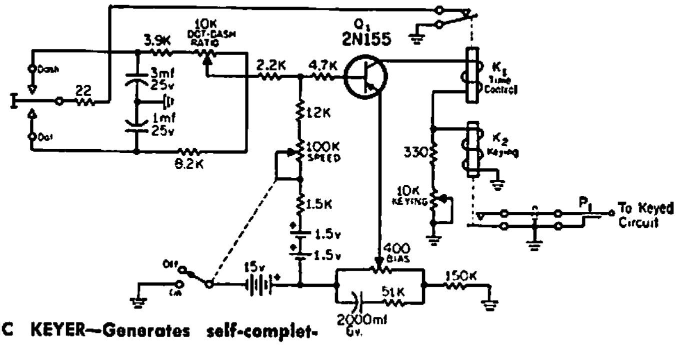
IC CODE PRACTICE OSCILLATOR—Current drain with key down is only 5.5 mA from 9-V transistor radio battery. Values are: C1 0.47 μf; R1, R3, R4 1K; R2 2K; phones 2K magnetic.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 59.


INPUT 5V P-P
+Vcc
4.7k
GATE
1/6 MC789P (4)
1/2 MC790P (4)
COUNTER
FF1
FF2
FF3
FF4
1/4 MC724P (4)
.0002μF
GATE CONTROL (UP=CLOSED DN=OPEN)
4ms
RESET MULTI
.0002μF
RESET
TIME BASE MULTI
1.5μF TYP
15μF TYP
DISPLAY CONTROL
Vcc = 3.6V DC
DISPLAY DECODE
1/2 MC725P (2)
LAMP-DRIVER OUTPUTS (UP=LAMP ON)
2.2 V TYP
PURPLE (400 Hz)
AMBER (1300 Hz)
WHITE (3000 Hz)

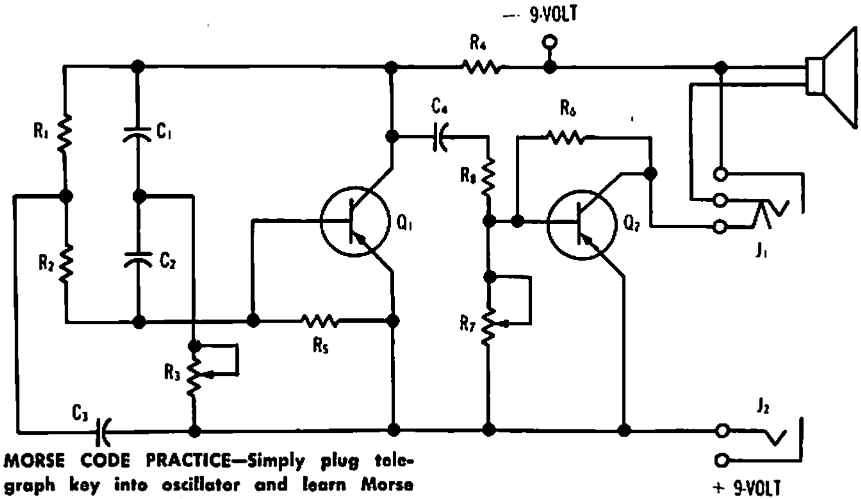
CODED AUDIO BEACON FILTER—Conventional large and heavy tuned circuits for marker beacon frequencies of 400, 1,300, or 3,000 Hz are here replaced entirely by digital IC frequency counter. Counting and display periods are about 4 ms each. When gate control line is positive, gate is closed, and previous count activates lamp corresponding to frequency. In typical 4-ms count, input of 250 to 1,000 Hz gives count of 1 to 3 and purple light, 1,000 to 2,000 Hz gives 4–7 and amber light, and 2,000 to 4,000 gives 8–15 and white light. Lamps are disabled during counting period to prevent flicker.—R. J. Battes, Digital ICs Serve as Audio Filters, *EEE*, Sept. 1969, p 131.


Q1
2N1265
Keyer
C1
.03
Q2
2N1265
Osc.
Q3
2N1265
Buffer
4.7K
8.2K
To Keyboard
To T.T.Y. Chassis
L1
88mh
Toroid
C2
.04
.01
4.7K
1K
5K
Output Level
.01
To Xmtr. Mike Input
.01
To T.U.
47K
22
Mark-Space Level Bal.
100K
8.2K
39K
5
To Xmtr. Control Circuit

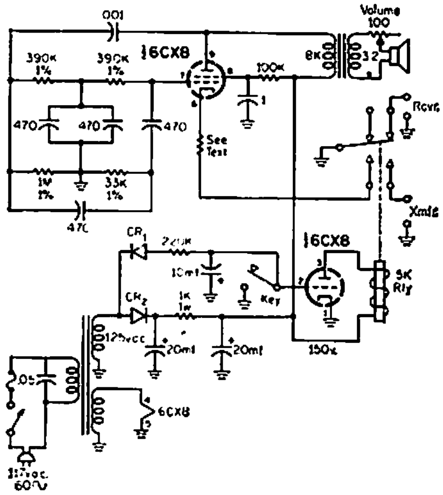
AUDIO FSK—Developed for radioteletype work on vhf bands, in which transmitter must be modulated at 2,975 Hz for space signal and at 2,125 Hz for mark signal. Frequency shift keyer circuit shown uses inexpensive components, is free from capacitive loading effects of keying circuit, has provisions for balancing mark and space output levels, and has good frequency stability. Space signal is transmitted when keyboard contacts are open. Article gives construction procedure. —R. P. Brickey, A Transistorized A. F. Shift Keyer, CQ, Nov. 1964, p 90–91, 124, and 126.


3.9K
10K
Dot-Dash Ratio
Q1
2N155
Dash
22
3mf
25v
1mf
25v
Dot
8.2K
2.2K
4.7K
K1
Time Control
12K
100K
Speed
330
K2
Keying
10K
Keying
P1
To Keyed Circuit
1.5K
1.5v
1.5v
400
Bias
15v
Off
On
51K
150K
2000mf
6v.

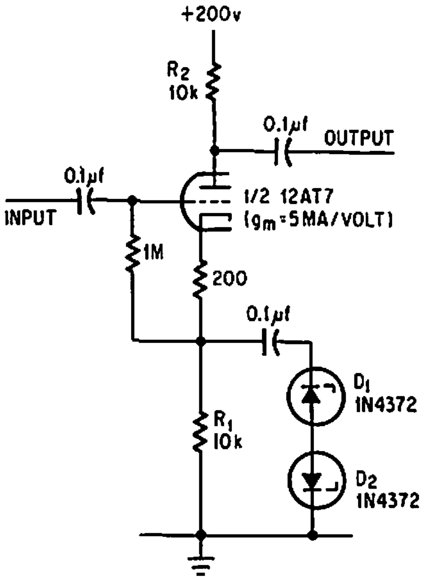
ELECTRONIC KEYER—Generates self-completing dash when paddle is pushed to left and released. Speed control determines length of dash. If dot is sent before dash is completed, keyer automatically completes dash and following space before producing dot and its space.—H. J. Sartori, An Electronic Keyer for Every C. W. Operator, CQ, April 1964, p 37–39 and 102.


— 9-VOLT
R4
R1
C1
C4
R6
R8
Q1
Q2
R2
C2
R7
R5
R3
J1
C3
J2
+ 9-VOLT
B +

MORSE CODE PRACTICE—Simply plug telegraph key into oscillator and learn Morse code, either privately using headphones or in groups using speaker. Article gives construction details. Parts values are: R1-R2 62K; R3 5K; R4 5.6K; R5 6.8K; R6 100K; R7 50K; R8 15K; C1-C2 0.005 μF; C3 0.01 μF; C4 0.1 μF; Q1 HEP254; Q2 HEP253; speaker 100 ohms.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 21–26.


.001
Volume
100
390K
1%
390K
1%
16CX8
100K
8K
3.2
Rcvr.
470
470
470
See Text
1M
1%
33K
1%
470
Xmtr.
CR1
22K
16CX8
10mf
CR2
1K
1w
Key
5K
Rly
125vcc
20mf
20mf
150K
.05
6CX8
117vac.
60~

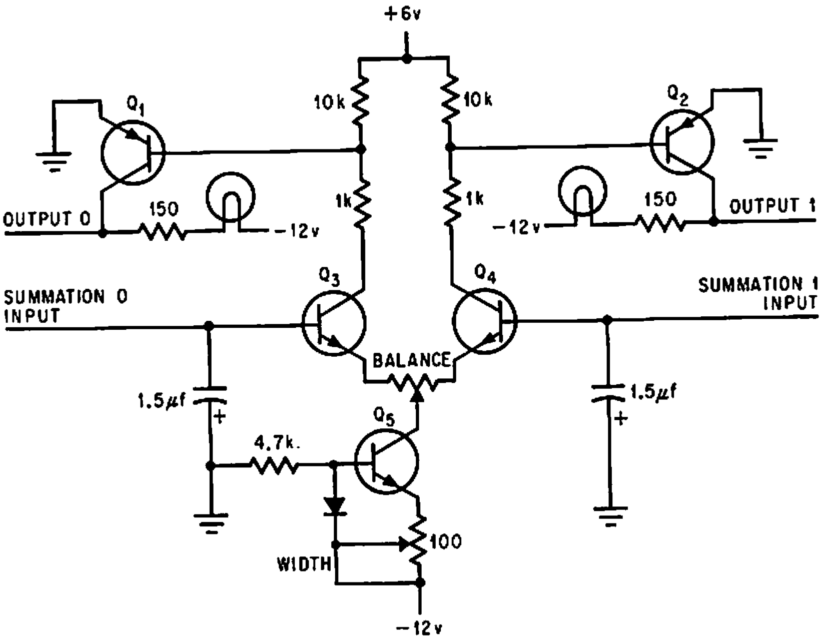
KEYING RELAY—With key and keying relay open, receiver contacts are closed and receiver is operating, while grid of keyer tube is blocked by negative voltage. With key closed, monitor and transmitter are operational. Use 500-ohm pot for cathode resistor of tetrode and adjust until oscillator functions. Diodes should be rated 300 piv.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 84.


+200v
R2
10k
0.1μf
OUTPUT
0.1μf
INPUT
1/2 12AT7
(gm=5MA/VOLT)
1M
200
0.1μf
D1
1N4372
R1
10k
D2
1N4372

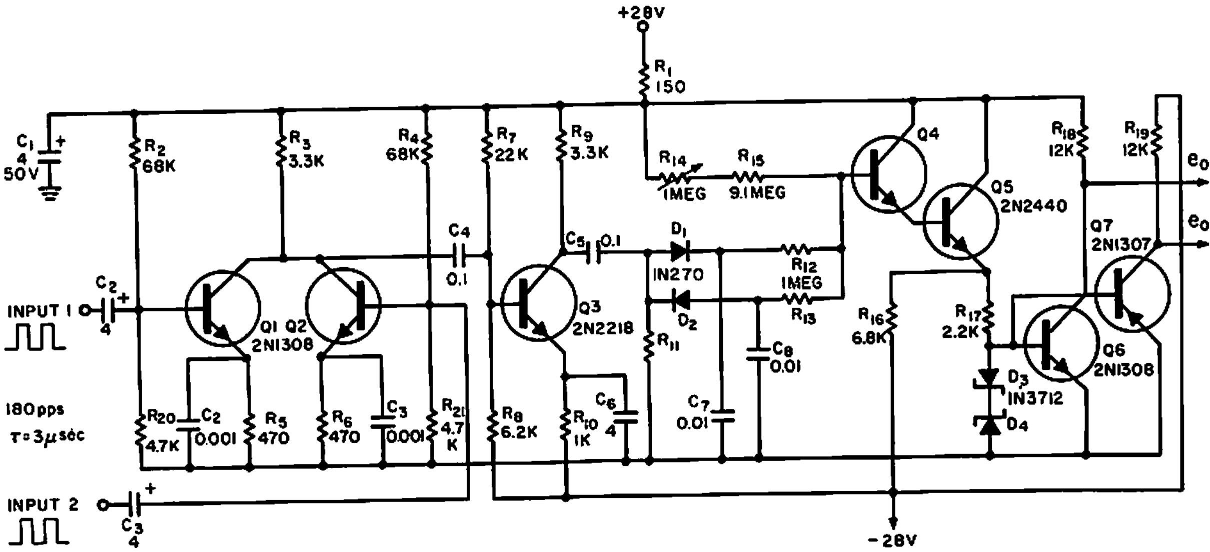
BOOSTING S/N RATIO—Input signals above predetermined threshold level make amplifier gain increase suddenly, to give effect of stretching signal amplitude. Used to improve signal-to-noise ratio of keyed c-w signal. Maximum gain is 25 and minimum less than 1. Rise in gain results from sudden decrease in reverse resistance of zener diode when voltage across it passes critical level.—J. Holland, Zener Diodes Control Amplitude Stretching, *Electronics*, July 10, 1967, p 83.

CHAPTER 15

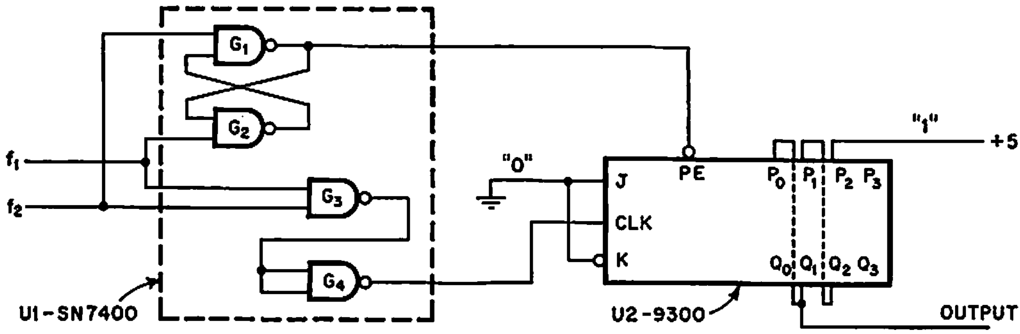
Comparator Circuits


+6v
Q1
10k
10k
Q2
1k
1k
OUTPUT 0
150
-12v
-12v
150
OUTPUT 1
Q3
Q4
SUMMATION 0 INPUT
SUMMATION 1 INPUT
BALANCE
1.5μf
1.5μf
Q5
4.7k.
100
WIDTH
-12v

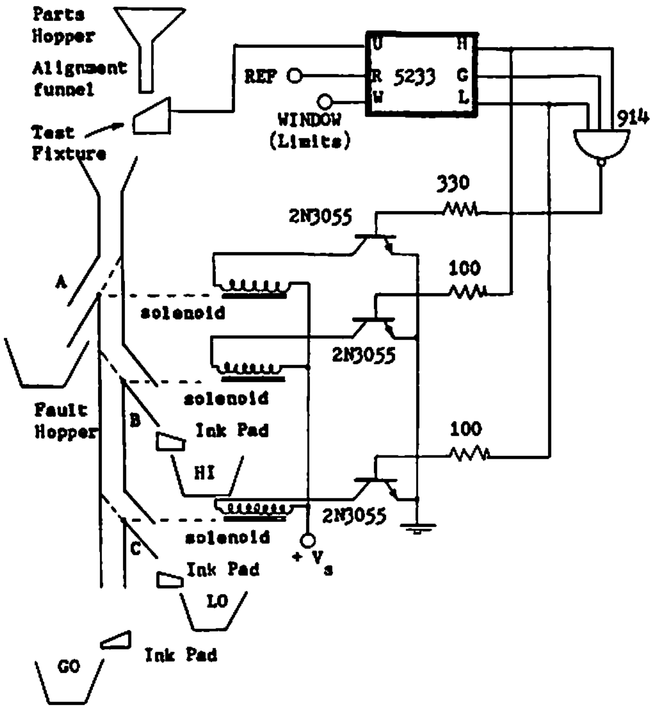
TERNARY DECISION UNIT—Compares voltage levels on the two input lines and gives 0 or 1 output depending on which input has more positive voltage. Input difference as small as 0.05 V will generate solid 0 or 1 output. Used in pattern recognizer developed by IBM for spoken words or graphic inputs. Transistor and diode types are not critical.—G. L. Clapper, Machine Looks, Listens, Learns, *Electronics*, Oct. 30, 1967, p 91–102.


+28V
R1 150
C1 4 50V
R2 68K
R3 3.3K
R4 68K
R7 22K
R9 3.3K
R14 1MEG
R15 9.1MEG
Q4
Q5 2N2440
R18 12K
R19 12K
e02
e01
Q7 2N1307
C4 0.1
C5 0.1
D1 1N270
D2
R12 1MEG
R13
R11
C8 0.01
INPUT 1
C2 4
Q1 Q2 2N1308
Q3 2N2218
R16 6.8K
R17 2.2K
D3 1N3712
D4
Q6 2N1308
180pps
τ=3μsec
R20 4.7K
C2 0.001
R5 470
R6 470
C3 0.001
R21 4.7K
R8 6.2K
R10 1K
C6 4
C7 0.01
INPUT 2
C3 4
-28V

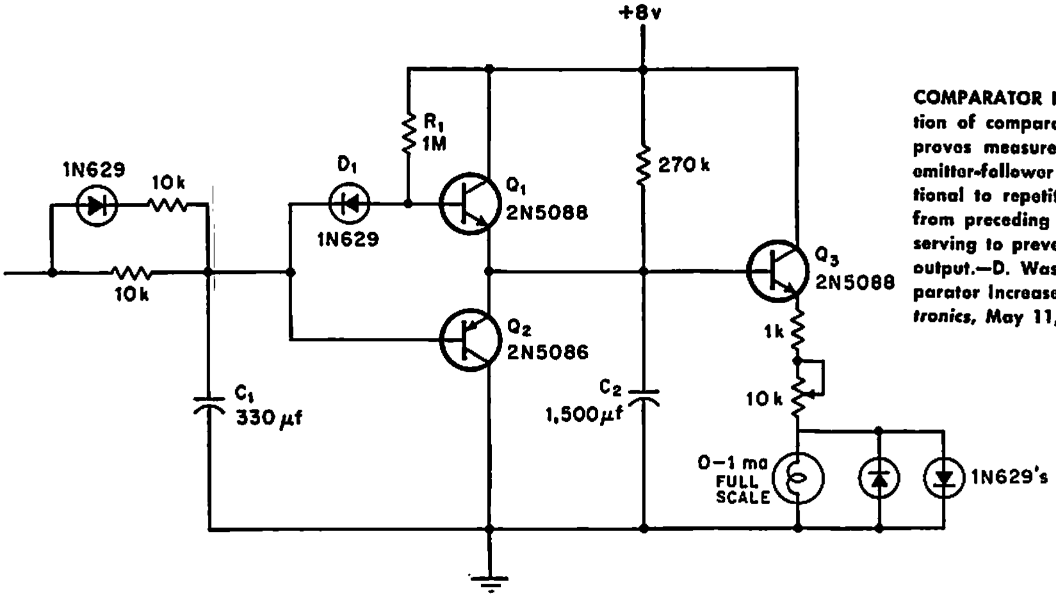
ALGEBRAIC COMPARATOR—Input stage Q1-Q2 adds pulses at inputs 1 and 2 algebraically, and feeds inverse of algebraic sum to amplifier Q3. Time constants of positive-negative rectifier circuit D1-D2-R11-R12-R13 can be adjusted to accommodate various input pulse frequencies and widths. Voltage at emitter of Q5 in Darlington pair is adjusted to zero (without input) by R14 to compensate for drift, leakage, or transistor changes. D3-D4 are Goto pair. Last stage has two outputs, one for positive algebraic sum and other for negative.—A. J. Burdi, Pulse Comparator Combines Versatility, Low Cost, *Electronic Design*, March 2, 1964, p 60 and 62.


G1
G2
G3
G4
f1
f2
U1-SN7400
"0"
"1"
+5v
J
PE
CLK
K
P0 P1 P2 P3
Q0 Q1 Q2 Q3
U2-9300
OUTPUT

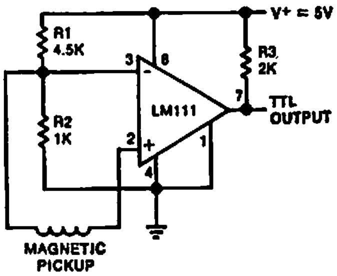
VARIABLE-FREQUENCY PHASE COMPARATOR—Produces output pulse pattern with duty cycle proportional to relative phase of two trains of input pulses having same frequency, but no outputs if other frequency ratios are present. Logic state of output Q1 is 0 as long as pulses arrive at f1 input or majority of pulses are f1. When f2 pulses predominate, output becomes constant logic 1.—I. Breikss, Shift Register Simplifies Design of Phase Comparator, *Electronics*, Jan. 19, 1970, p 93.


Parts Hopper
Alignment funnel
Test Fixture
REF
WINDOW (Limits)
U
R
W
5233
H
G
L
914
330
2N3055
100
A
solenoid
2N3055
Fault Hopper
solenoid
B
Ink Pad
100
HI
2N3055
solenoid
C
+Vs
Ink Pad
LO
GO
Ink Pad

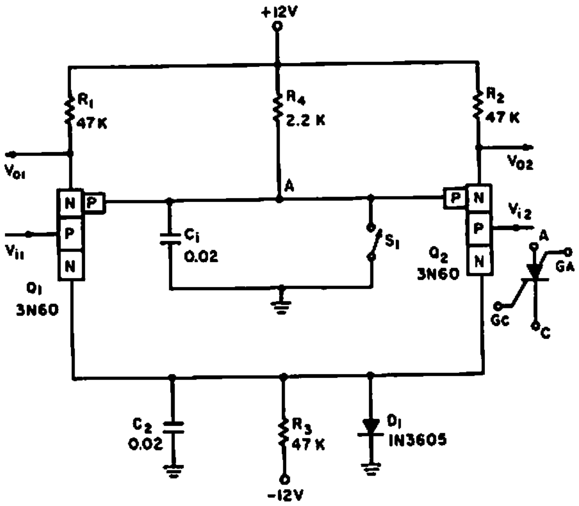
GO-NO-GO IC TESTER WITH HOPPER SORT—OEI Model 5233 IC comparator provides three outputs, depending on whether electrical characteristics of product under test are above, below, or within preset limits. Parts drop one by one into test fixture designed for automatic contact and measurement, with IC actuating solenoid of flapper that guides part into correct hopper after test. If part is within tolerance limits, it drops straight through into GO hopper. Ink pad at each hopper provides automatic color coding. If part fails all three tests, it is guided into fault or junk hopper. Test fixture may provide reset command signal for dropping next part after receiving signal indicating that part has fallen into appropriate hopper.—Using a Comparator for Production Selecting, Optical Electronics, Tucson, Ariz., No. 10102.


+8v
R1 1M
D1
1N629
10k
1N629
10k
Q1 2N5088
Q2 2N5086
270k
Q3 2N5088
1k
10k
C1 330µf
C2 1,500µf
0-1 ma FULL SCALE
1N629's

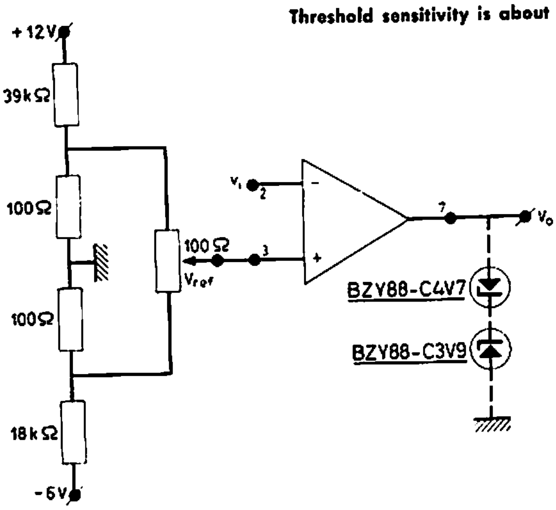
COMPARATOR IMPROVES RATE METER—Addition of comparator Q1-Q2 to rate meter improves measurement response time. Output emitter-follower Q3 delivers voltage proportional to repetition rate of input pulse train from preceding mono mvbr, with comparator serving to prevent input ripple from affecting output.—D. Wasserman and G. Parker, Comparator Increases Rate Meter's Response, *Electronics*, May 11, 1970, p 100.


V+ = 5V
R1
4.5K
R2
1K
R3
2K
LM111
TTL
OUTPUT
MAGNETIC
PICKUP
3
8
7
2
1
4

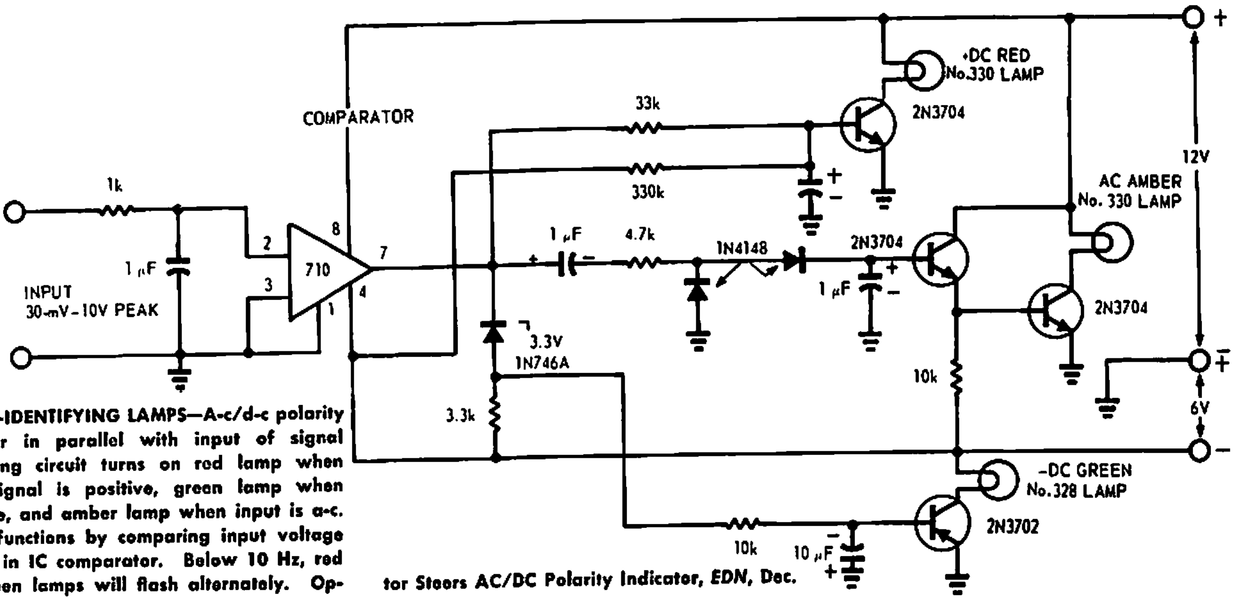
IC FOR MAGNETIC PICKUP—Universal IC voltage comparator will drive logic circuits, lamps, or relays up to 50 V at 50 mA, under control of pulses from magnetic pickup or other pulse source.—Detector for Magnetic Transducer (National Semiconductor ad), *Electronic News*, June 8, 1970, p 11.


+12V
R₁
47K
R₄
2.2 K
R₂
47 K
V₀₁
V₀₂
A
V_i1
V_i2
C₁
0.02
S₁
Q₁
3N60
Q₂
3N60
A
GA
GC
C
N
P
N
P
P
N
P
N
C₂
0.02
R₃
47 K
D₁
IN3605
-12V

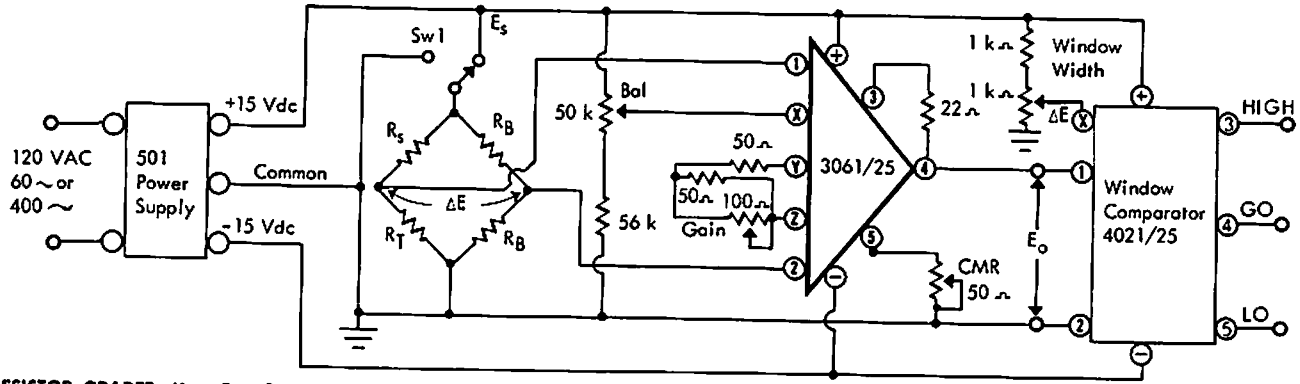
SCS STORES HIGHER OF TWO VOLTAGES—Silicon controlled switches (scs) Q1 and Q2, connected as differential amplifier and regenerative switch, sense channel having higher instantaneous voltage and store result. Threshold sensitivity is about 5 mV. Common-mode voltages can be up to 1 V in either polarity. Article describes operation in detail and suggests modifications for other applications.—T. P. Sylvan, SCS Linear Amplifier Gives Threshold Switching, *Electronic Design*, Jan. 20, 1964, p 78–79.


+12V
39kΩ
100Ω
100Ω
18kΩ
-6V
100Ω
V_ref
V_i
2
3
7
V₀
BZY88-C4V7
BZY88-C3V9

ZERO DETECTOR—Uses Philips TAA241 difference amplifier as comparator or zero detector. If input voltage Vi is greater than reference voltage, output is about −5 V; if input is below reference, output is +10 V. If zero reference is required, ground input terminal temporarily and adjust pot to compensate for offset voltage. If optional zeners are connected as shown, output voltages will be symmetrical at +5 V and −5 V.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.

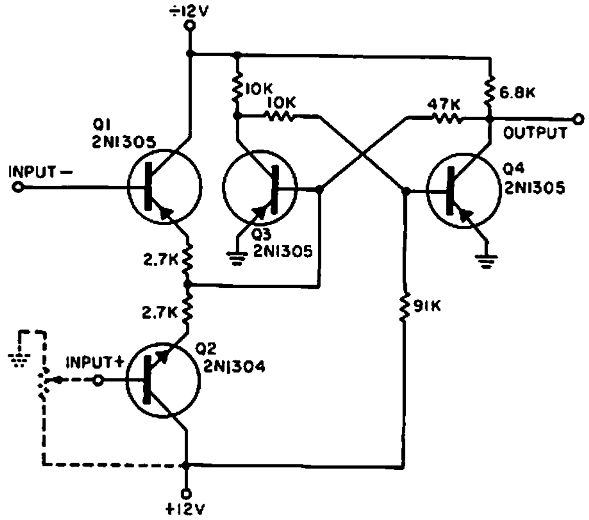

+
+DC RED
No.330 LAMP
COMPARATOR
33k
2N3704
330k
12V
AC AMBER
No. 330 LAMP
1k
1 µF
4.7k
1N4148
2N3704
1 µF
2N3704
INPUT
30-mV-10V PEAK
1 µF
710
2
3
8
7
1
4
3.3V
1N746A
3.3k
10k
6V
−
−DC GREEN
No.328 LAMP
2N3702
10k
10 µF

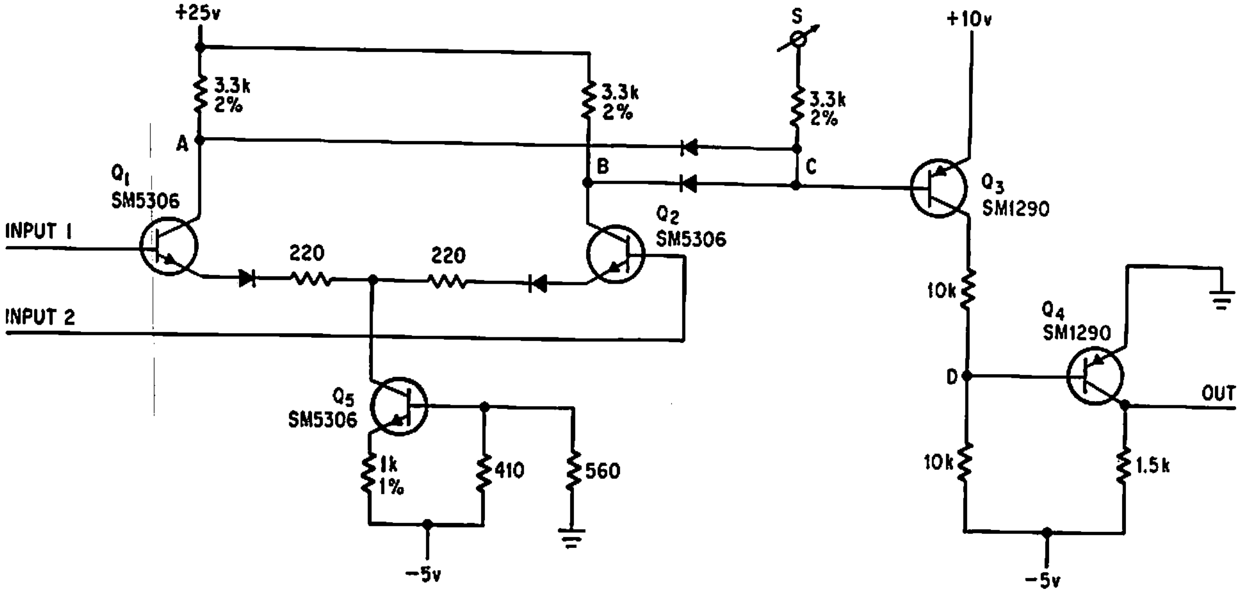
SIGNAL-IDENTIFYING LAMPS—A-c/d-c polarity indicator in parallel with input of signal processing circuit turns on red lamp when input signal is positive, green lamp when negative, and amber lamp when input is a-c. Circuit functions by comparing input voltage to zero in IC comparator. Below 10 Hz, red and green lamps will flash alternately. Operates up to 1 MHz.—R. C. Gerdes, Comparator Steers AC/DC Polarity Indicator, *EDN*, Dec. 1, 1969, p 64.


120 VAC
60 ~ or
400 ~
501
Power
Supply
+15 Vdc
Common
-15 Vdc
Sw1
E_s
R_s
R_B
R_T
R_B
ΔE
50 k
Bal
56 k
50 Ω
50 Ω
100 Ω
Gain
3061/25
22 Ω
CMR
50 Ω
1 kΩ
Window
Width
1 kΩ
ΔE
E_o
Window
Comparator
4021/25
HIGH
GO
LO

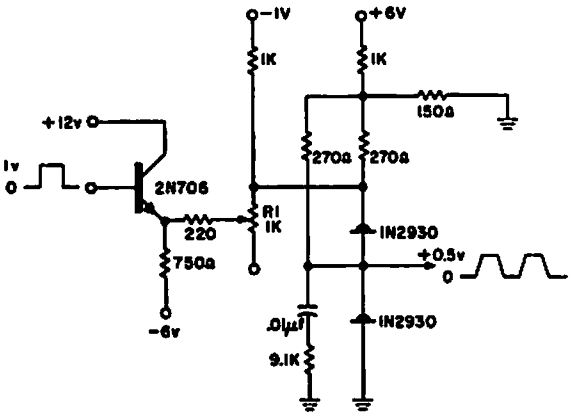
RESISTOR GRADER—Uses Burr-Brown 4021/25 window comparator fed by 3061/25 differential-input instrumentation amplifier and Wheatstone bridge containing unknown resistor. Pulse outputs of comparator provide convenient way of obtaining low, in-tolerance, or high indications for resistor under test. Used for matching pairs of resistors to within 1% accuracy. Article discusses operating procedures for matching to within 0.01%.—"Instrument Amplifiers," Burr-Brown Research, Tucson, Ariz., PDS-207C, 1969, p 24.

TRIGGER CHOOSES HIGHER OF TWO VOLTAGES—When used as comparator, circuit can decide which of two voltages in range from 0 to 12 V has the greater numerical value when one is positive and the other negative. When positive voltage is greater, Q3 is cut off and Q4 is saturated. When negative is greater, trigger Q3-Q4 flips over so Q4 is cut off and Q3 is saturated. Differing output voltages will then indicate which input is greater. By adding potentiometer to positive input terminal, as shown by dashed lines, circuit will act as Schmitt trigger in which trip point is equal to voltage-level setting of pot. —S. Stuhr, Wide-Range Trigger Compares Absolute Values, *Electronic Design*, Jan. 6, 1964, p 85–86.

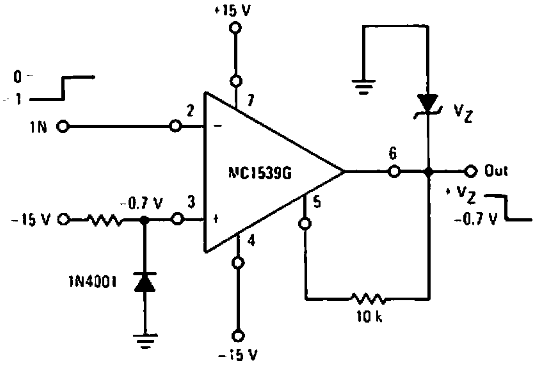

-12V
10K
10K
47K
6.8K
OUTPUT
Q1
2N1305
INPUT−
Q3
2N1305
Q4
2N1305
2.7K
2.7K
91K
INPUT+
Q2
2N1304
+12V


+25v
3.3k
2%
3.3k
2%
S
3.3k
2%
+10v
A
B
C
Q_1
SM5306
INPUT 1
220
220
Q_2
SM5306
INPUT 2
Q_3
SM1290
10k
Q_4
SM1290
D
OUT
10k
1.5k
Q_5
SM5306
1k
1%
410
560
−5v
−5v

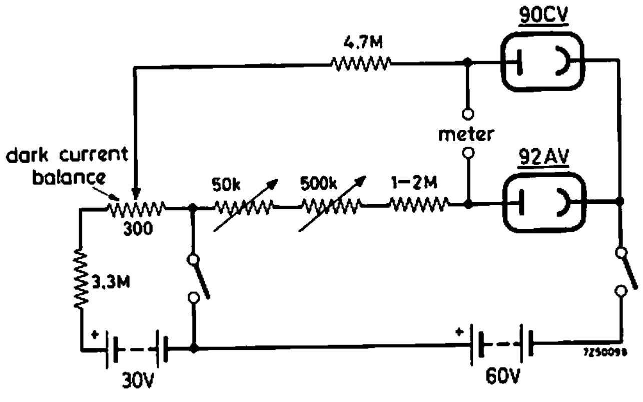
ADJUSTABLE-SENSITIVITY ANALOG COMPARATOR—Adjusting voltage S gives sensitivity range of 0.2 to 2 V. Binary 1 output occurs when the two inputs are equal within sensitivity margin. Used in Paramatrix system for preprocessing analog information, chiefly photos and graphs, while converting to digital signals under computer control.—W. J. Poppelbaum, M. Faiman, and E. Carr, Paramatrix Puts Digital Computer in Analog Picture, and Vice Versa, *Electronics*, Sept. 4, 1967, p 99–108.


-1V
+6V
1K
1K
150Ω
+12v
1v
0
2N706
270Ω
270Ω
R1
1K
220
750Ω
IN2930
+0.5v
0
-6v
.01µf
9.1K
IN2930

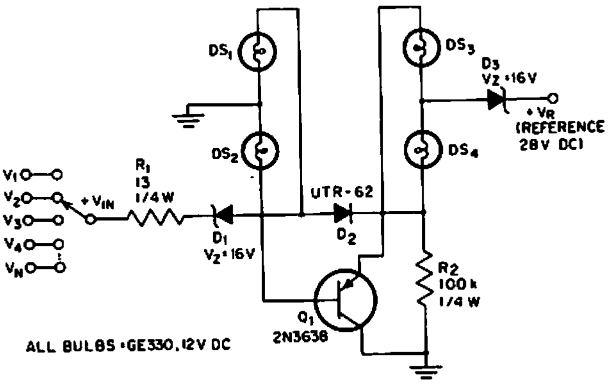
VOLTAGE COMPARATOR FOR 2 MHZ—Highly sensitive tunnel-diode comparator detects 5-mV change from on to off state. Tunnel diodes are biased as flip-flop, with bias chosen so 0.8 mA is required to make them switch. If output is required when input is above 1 V, R1 is adjusted to make diodes switch at this point.—N. Marchese, Voltage Comparator Uses Tunnel Diode Flip-Flop, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y, 1964, p 163.


+15 V
0
-1
IN
2
7
MC1539G
6
Out
V_Z
-0.7 V
3
-15 V
5
4
+V_Z
-0.7 V
1N4001
10 k
-15 V

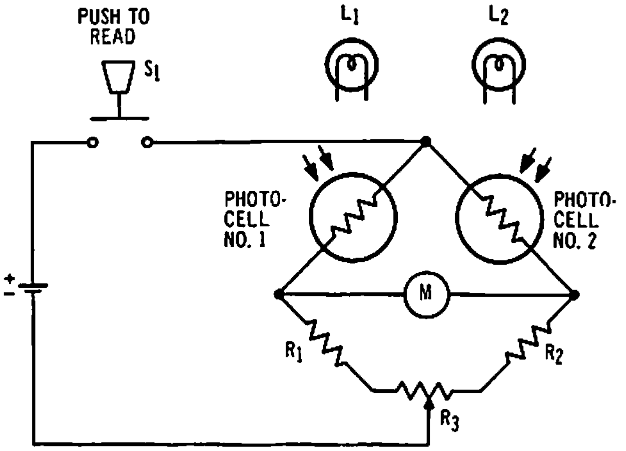
SINGLE-OPAMP VOLTAGE COMPARATOR—By interchanging inputs, can be made inverting or noninverting. Open-loop operation assures fast response. Tying zener between output and ground limits output level to that acceptable to saturated logic families.—K. Huehne, The Continuing Dominance of the Operational Amplifier, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 5–13.


90CV
4.7M
meter
92AV
dark current balance
300
50k
500k
1-2M
3.3M
30V
60V

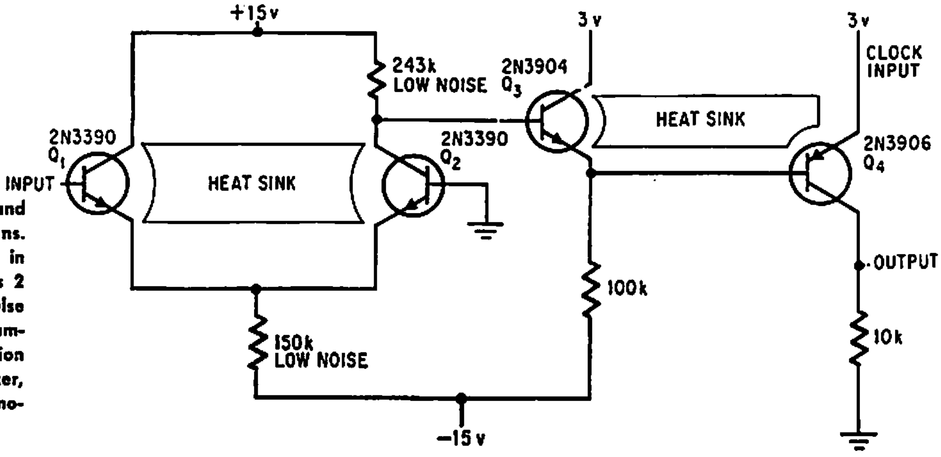
LAMP CALIBRATOR—Two photocells, 90CV red-sensitive and 92AV blue-sensitive, form part of bridge circuit in which electronic voltmeter serves as null detector. Used to compare color temperature of service lamp against that of standard calibration lamp mounted side by side in image-converter-tube tester. Report gives calibration and measurement procedures.—G. P. Brouwer and A. G. Geurts, An Instrument for Measuring the Sensitivity of Photocathodes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 323, 1966.


DS1
DS2
DS3
DS4
D3
VZ=16V
+VR
(REFERENCE 28V DC)
V1
V2
V3
V4
VN
R1
13
1/4W
+VIN
D1
VZ=16V
UTR-62
D2
R2
100k
1/4 W
Q1
2N3638
ALL BULBS =GE330, 12V DC

GO-NO-GO WITH READOUT—Compares monitored voltages with reference voltage and energizes lamps DS1-DS2 to indicate continuity. For open circuit, DS3-DS4 are on. Lamps are paired for redundancy, so circuit gives unambiguous indication even if one lamp fails.—W. A. Magee, Voltage Comparator with Visual Readout, *EEE*, May 1969, p 118 and 120.

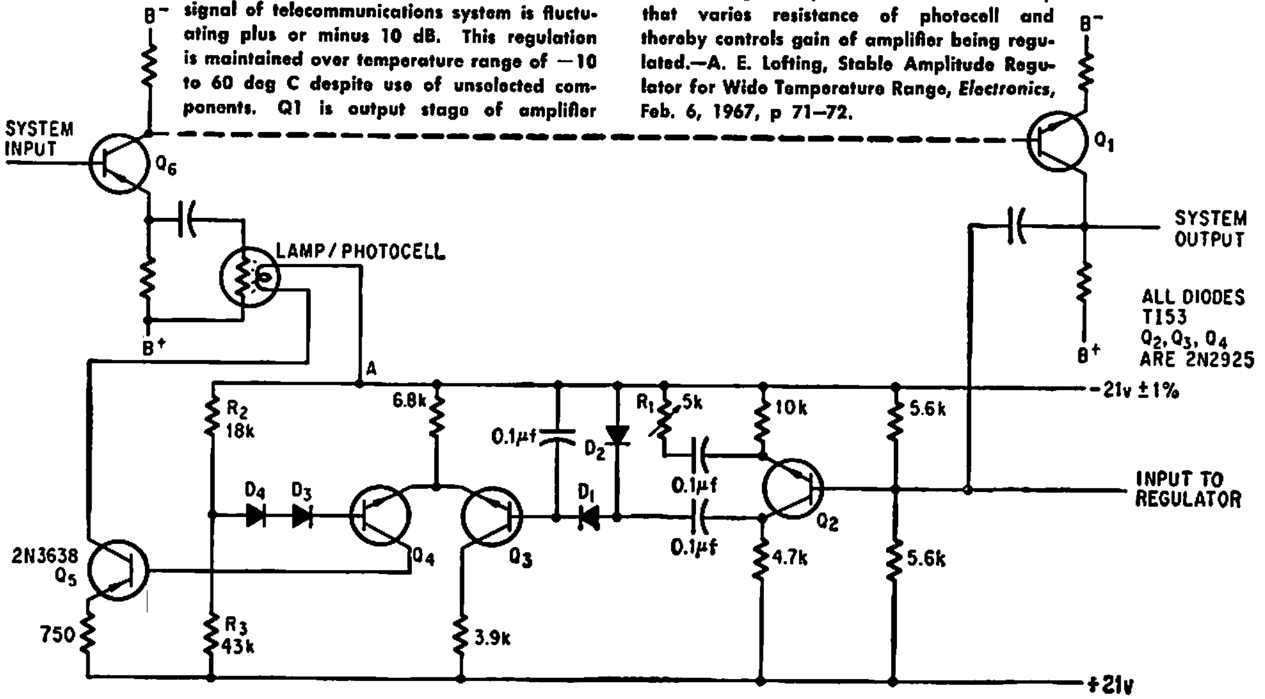

PUSH TO READ
S1
L1
L2
PHOTO-CELL NO. 1
PHOTO-CELL NO. 2
M
R1
R2
R3

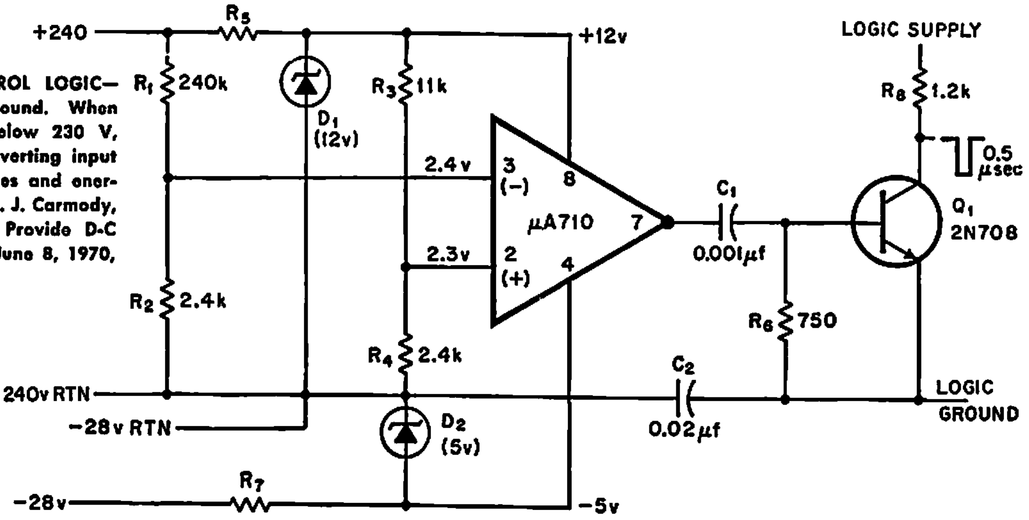
LIGHT COMPARATOR—Permits matching of two unknown light sources or one unknown with standard. Circuit is initially nulled with R3. Photocells are SQ2508; R1-R2 15K; R3 25K; meter 50–0–50 µA 2K; battery 1.4 V.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 24.


+15v
243k LOW NOISE
2N3904 Q3
3v
3v
CLOCK INPUT
HEAT SINK
2N3390 Q1
INPUT
HEAT SINK
2N3390 Q2
2N3906 Q4
OUTPUT
100k
10k
150k LOW NOISE
−15v

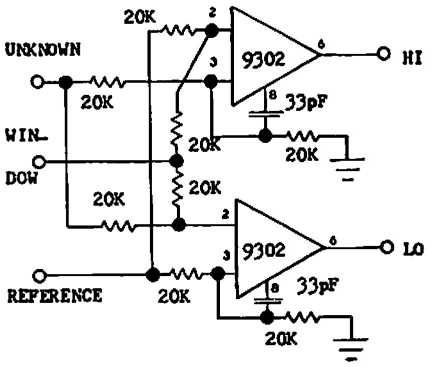
DIFFERENTIAL AMPLIFIER—Can detect and react to input changes in as little as 100 ns. Output can be switched from logic 0 to 1 in less than 63 nA. Temperature stability is 2 nA per deg C. Can be driven by clock pulse for synchronous comparison. Differential amplifier Q1-Q2 provides comparator function and Q3 is buffer for driver Q4.—R. Becker, Inexpensive Comparator Reacts in 100 Nanoseconds, *Electronics*, Sept. 2, 1968, p 70.

SIGNAL AMPLITUDE REGULATOR—Holds signal amplitude constant within 0.1 dB when input signal of telecommunications system is fluctuating plus or minus 10 dB. This regulation is maintained over temperature range of −10 to 60 deg C despite use of unselected components. Q1 is output stage of amplifier being regulated and Q6 is its input. Q3-Q4 form voltage comparator. Q5 drives lamp that varies resistance of photocell and thereby controls gain of amplifier being regulated.—A. E. Lofting, Stable Amplitude Regulator for Wide Temperature Range, *Electronics*, Feb. 6, 1967, p 71–72.

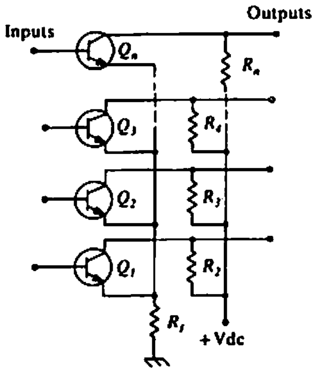

B−
SYSTEM INPUT
Q6
LAMP/PHOTOCELL
B+
A
R2 18k
6.8k
0.1µf
D2
R1 5k
10k
5.6k
−21v ±1%
B−
Q1
SYSTEM OUTPUT
ALL DIODES T153
Q2, Q3, Q4 ARE 2N2925
B+
D4
D3
D1
0.1µf
0.1µf
Q2
INPUT TO REGULATOR
2N3638 Q5
Q4
Q3
4.7k
5.6k
750
R3 43k
3.9k
+21v


+240
R5
+12v
LOGIC SUPPLY
R1 240k
D1 (12v)
R3 11k
R8 1.2k
0.5 µsec
2.4v
3 (−)
8
µA710
7
C1
0.001µf
Q1 2N708
2.3v
2 (+)
4
R2 2.4k
R6 750
R4 2.4k
C2
240v RTN
LOGIC GROUND
−28v RTN
D2 (5v)
0.02µf
R7
−28v
−5v

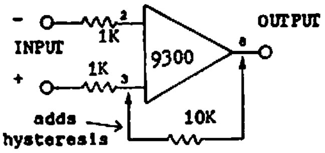
D-C TRANSFORMER FOR CONTROL LOGIC—Operates without common ground. When 240-V supply voltage drops below 230 V, less than 2.3 V is applied to inverting input of IC comparator, and it switches and energizes output logic through Q1.—T. J. Carmody, Comparator and A-C Coupling Provide D-C Transformer Action, *Electronics*, June 8, 1970, p 98.


UNKNOWN
WIN-
DOW
REFERENCE
20K
9302
2
3
6
8
33pF
HI
LO

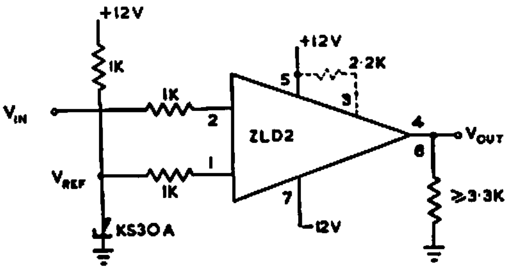
FULL COMPARATOR—Combination of two 9302 OEI opamps indicates whether unknown input is more positive than reference by giving HI output, less positive by giving LO output, or equal by giving LO output from both opamps. HI is +10 V and LO is −10 V. Window input accepts positive voltages and generates tolerance equal to window input. If unknown is within window voltage of reference, both outputs are −10 V corresponding to equal condition.—Applying the Model 9302 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10135.


Inputs
Outputs
Q_n
Q_3
Q_2
Q_1
R_n
R_4
R_3
R_2
R_1
+Vdc

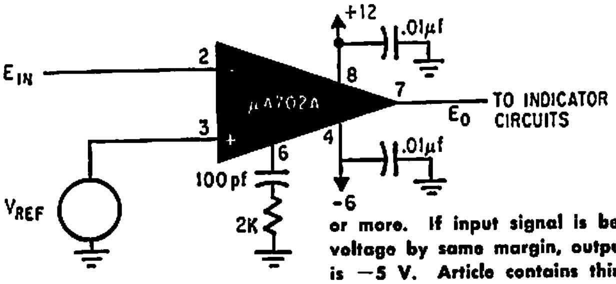
VOLTAGE COMPARATOR—Can be directly coupled to binary encoder for detection of highest input voltage. Has advantages over diode comparator gates. Operates from 20 V d-c supply, for inputs of zero to 10 V d-c and outputs of 20 or 10 V d-c. All transistors are 2N780, R1 is 100 ohms, and all other resistors 100K.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 80.


-
INPUT
+
1K
1K
2
3
9300
8
OUTPUT
10K
adds
hysteresis

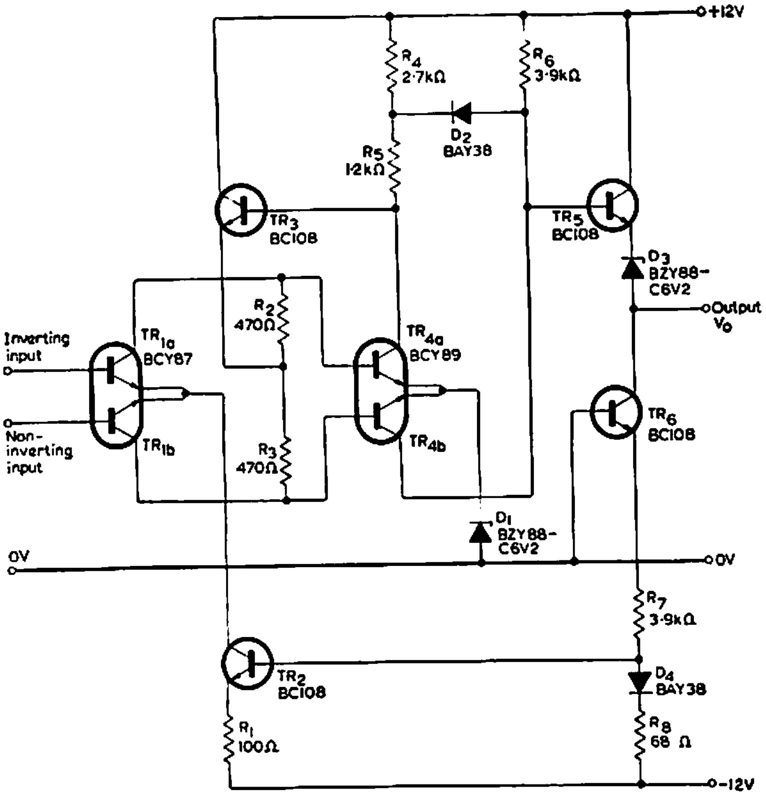
SIMPLE COMPARATOR—With only three external resistors, OEI 9300 opamp serves as voltage comparator with full performance to 2 MHz and reduced comparison accuracy at higher frequencies. Output level is compatible with DTL and RTL logic.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tuscon, Ariz., No. 10134.


+12V
1K
V_{IN}
1K
V_{REF}
1K
KS30A
+12V
2·2K
5
3
2
1
ZLD2
4
8
7
V_{OUT}
-12V
≥3·3K

D-C VOLTAGE COMPARATOR—Signal voltage applied to terminal 2 of Ferranti ZLD2 IC differential-input d-c amplifier is compared with voltage of reference diode at other input. Output voltage will be either maximum negative or maximum positive, depending on whether signal voltage is greater or less than reference voltage.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 12.

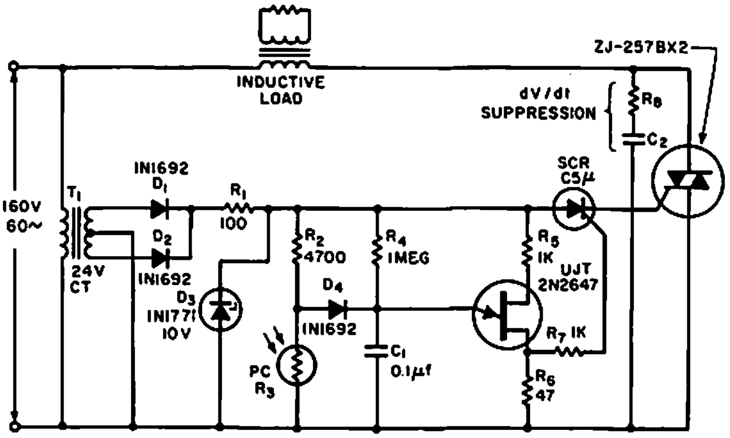

E_{IN}
2
3
μA702A
+12
.01μf
8
7
4
-6
.01μf
E_0
TO INDICATOR CIRCUITS
6
100pf
2K
V_{REF}

2-MV SENSITIVITY—Fairchild μA702A IC opamp amplifies difference between unknown signal and reference voltage, and delivers 5 V output if signal exceeds reference by 2 mV or more. If input signal is below reference voltage by same margin, output to indicator is −5 V. Article contains thirteen other IC opamp application circuits.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.

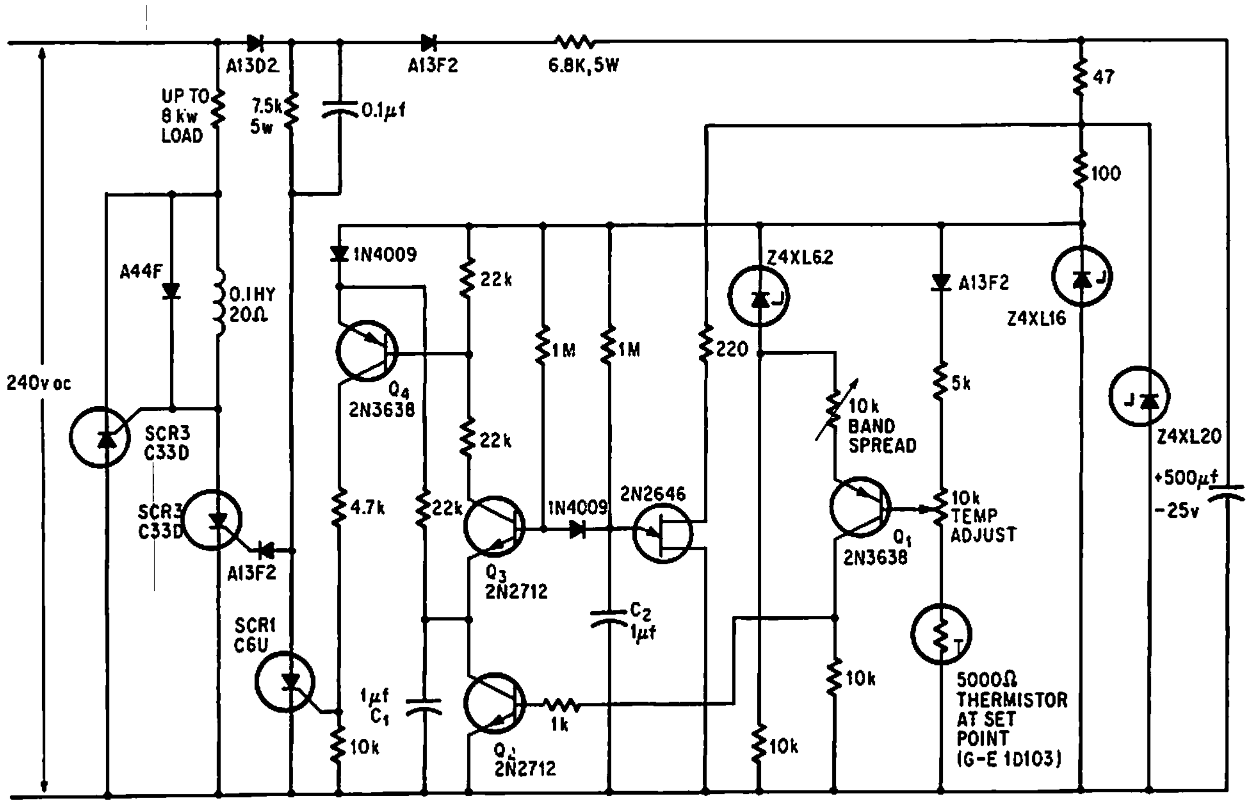

+12V
R_4 2·7kΩ
R_6 3·9kΩ
D_2 BAY38
R_5 12kΩ
TR_3 BC108
TR_5 BC108
D_3 BZY88-C6V2
Output V_0
R_2 470Ω
R_3 470Ω
Inverting input
Non-inverting input
TR_{1a} BCY87
TR_{1b}
TR_{4a} BCY89
TR_{4b}
TR_6 BC108
D_1 BZY88-C6V2
0V
0V
R_7 3·9kΩ
TR_2 BC108
D_4 BAY38
R_1 100Ω
R_8 68 Ω
-12V

STABLE VOLTAGE COMPARATOR—Uses transistor pairs in differential stages, with constant-current transistor source for holding input stage emitter currents constant. Output voltage is limited to 0.7 V and 3 V, for driving wide variety of logic circuits.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 26.

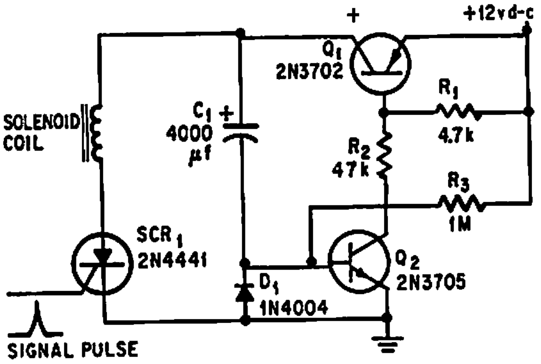
CHAPTER 16
Control Circuits


INDUCTIVE LOAD
ZJ-257BX2
dV/dt SUPPRESSION
R8
C2
SCR C5μ
160V 60~
T1
24V CT
1N1692 D1
D2
1N1692
D3 1N1771 10V
R1 100
R2 4700
D4
1N1692
R4 1MEG
C1 0.1μf
PC R3
R5 1K
UJT 2N2647
R7 1K
R6 47

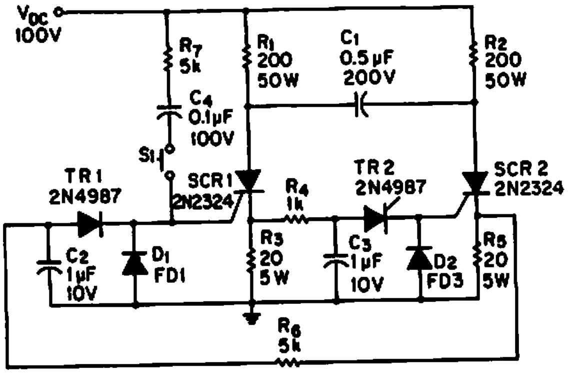
UJT PHASE-CONTROL FOR INDUCTIVE LOADS—Phase reference for ujt is derived from supply voltage instead of from bilateral scr. Gate drive for scr continues from point of triggering to end of half-cycle. Circuit provides symmetrical waveforms and positive triggering even when load current rises slowly.—E. K. Howell, Bilateral SCR Lets Designers Economize on Circuitry, *Electronic Design*, Jan. 20, 1964, p 74–77.


A13D2
A13F2
6.8K,5W
47
UP TO 8 kW LOAD
7.5k 5w
0.1μf
100
240v ac
A44F
0.1HY 20Ω
1N4009
22k
Q4 2N3638
22k
1M
1M
220
Z4XL62
A13F2
Z4XL16
5k
10k BAND SPREAD
Z4XL20
+500μf -25v
SCR3 C33D
SCR3 C33D
A13F2
4.7k
22k
Q3 2N2712
1N4009
2N2646
C2 1μf
Q1 2N3638
10k TEMP ADJUST
SCR1 C6U
1μf C1
10k
Q2 2N2712
1k
10k
10k
5000Ω THERMISTOR AT SET POINT (G-E 1D103)

POWER CONTROL WITH DISCRETE COMPONENTS—Will control up to 8 kW through resistive load, though requiring over 40 components as compared to half a dozen if one is General Electric's PA424 IC described in same article.—F. W. Gutzwiller and J. H. Galloway, Power Grab by Linear IC's, *Electronics*, Aug. 21, 1967, p 81–86.

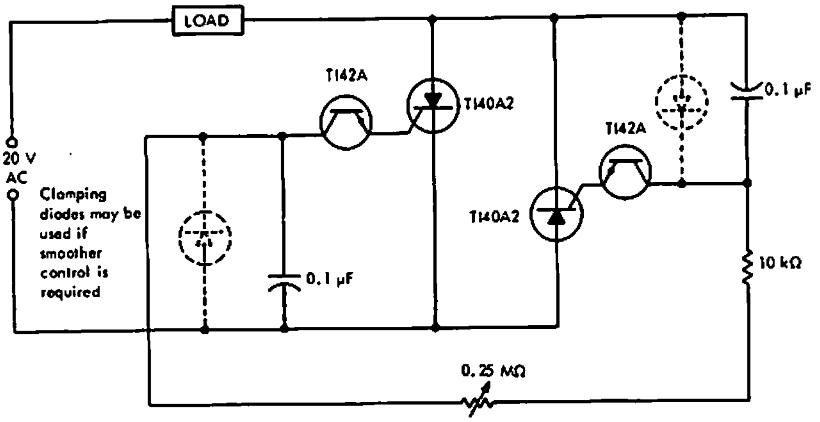

+
+12vd-c
Q1
2N3702
R1
4.7k
SOLENOID
COIL
C1
4000
μf
R2
47k
R3
1M
SCR1
2N4441
Q2
2N3705
D1
1N4004
SIGNAL PULSE

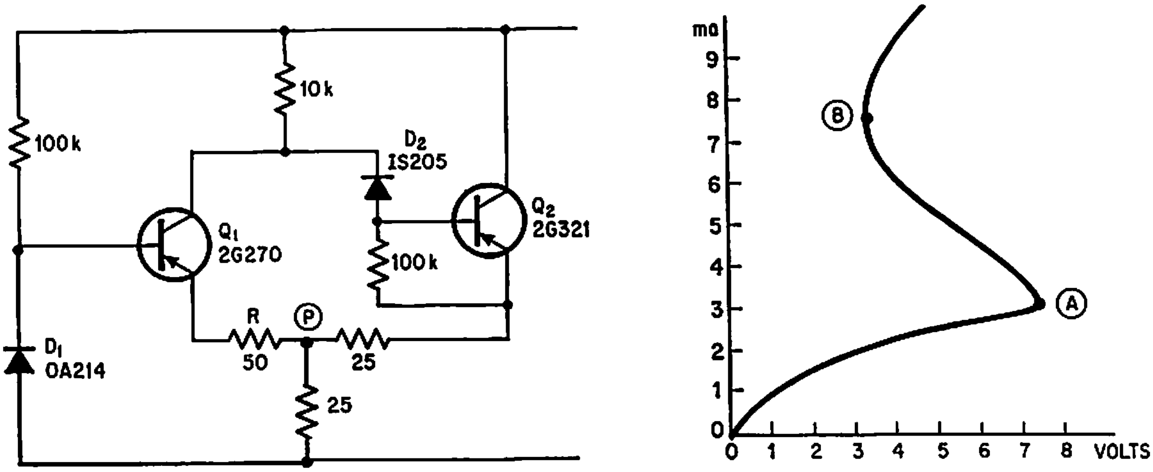
RAISING SATELLITE ANTENNA—Signal pulse from earth triggers SCR1, so C1 discharges through solenoid to provide powerful stroke for pushing out antenna or providing other required mechanical motion. Q1 then pulls capacitor-recharging current to low level to allow scr to turn off and thereby reduce recycling time of solenoid. When C1 is charged to 12 V, Q2 turns off and stops Q1. —J. J. Klinikowski, Transistor Speeds Up Charging Circuit, *Electronics*, Aug. 5, 1968, p 105.


V_{DC}
100V
R_7
5k
R_1
200
50W
C_1
0.5 μF
200V
R_2
200
50W
C_4
0.1μF
100V
S1
TR1
2N4987
SCR1
2N2324
R_4
1k
TR2
2N4987
SCR 2
2N2324
C_2
1μF
10V
D_1
FD1
R_3
20
5W
C_3
1μF
10V
D_2
FD3
R_5
20
5W
R_6
5k

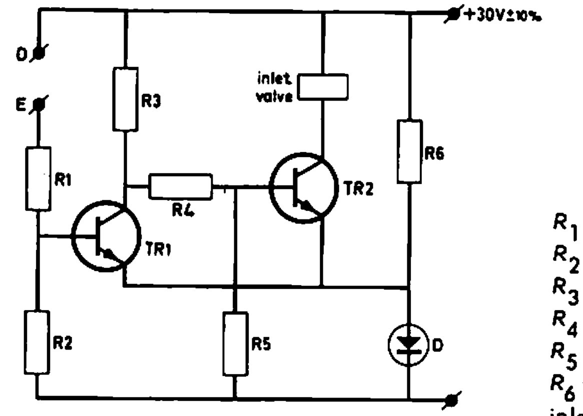
SEQUENTIAL CONTROL—Momentary closing of S1 initiates switching sequence, with each scr stage having independently adjustable operating time. Conduction of SCR1 is determined by R4, C3, drop across R3, and operating voltage of trigger diode TR1. Values shown are for 0.5-A load current. Additional controlled stages may be added.—E. Kiburis, Sequential Control with Silicon Controlled Rectifiers, *EEE*, March 1970, p 100–103.

FULL-WAVE CONTROL—Uses T142A breakdown diodes for triggering scr's. For handling loads up to power rating of scr's.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, CC101, 1968, p 24107.


LOAD
T142A
T140A2
0.1 μF
T142A
120 V
AC
Clamping diodes may be used if smoother control is required
T140A2
0.1 μF
10 kΩ
0.25 MΩ


10k
100k
D2
1S205
Q2
2G321
Q1
2G270
100k
R
P
50
25
25
D1
0A214
ma
9
8
7
6
5
4
3
2
1
0
B
A
0
1
2
3
4
5
6
7
8
VOLTS

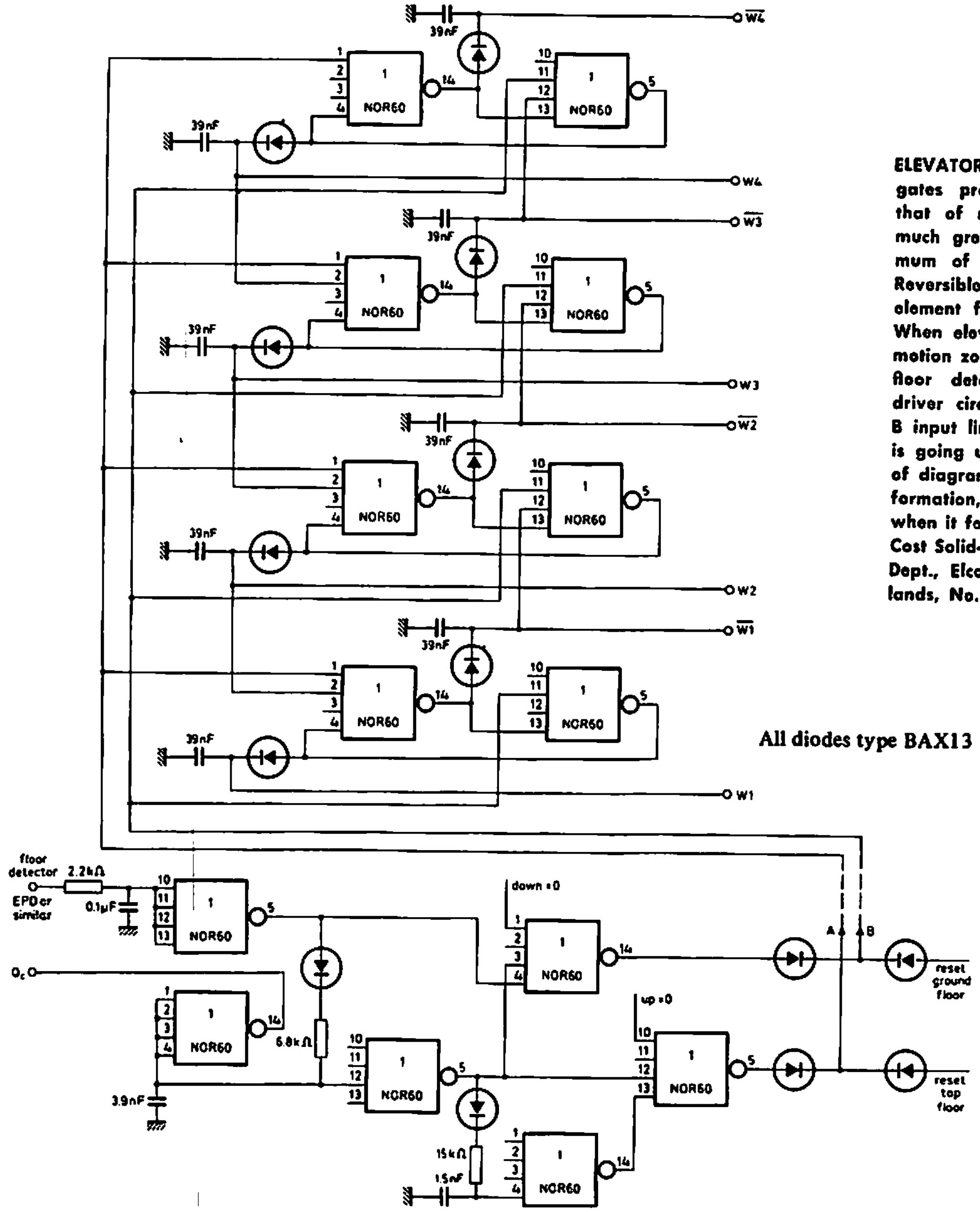
CURRENT-CONTROLLED NEGATIVE RESISTANCE—For currents up to 3 mA between circuit terminals, voltage drop across circuit increases almost linearly because only Q1 is conducting. For higher currents, up to about 7.5 mA, both transistors conduct and voltage decreases (negative slope, corresponding to negative resistance). Above 7.5 mA, only Q2 conducts and voltage again increases with current. Can be used as flip-flop.—F. Brochtoniolo, A Negative-Resistance Circuit Doubles for V or I Control, *Electronics*, April 28, 1969, p 78–79.


+30V±10%
D
E
R1
R2
R3
R4
R5
R6
inlet valve
TR1
TR2
D

WASHING-MACHINE WATER-LEVEL CONTROL—Simple electrodes D and E sealed in wall of open vertical tube sense change in resistance when water level reaches both electrodes, then energize inlet valve through transistors to shut off water. Operates from same 30-V d-c supply used for other sensors in washing machine.—Transistorized Level Sensor, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968.

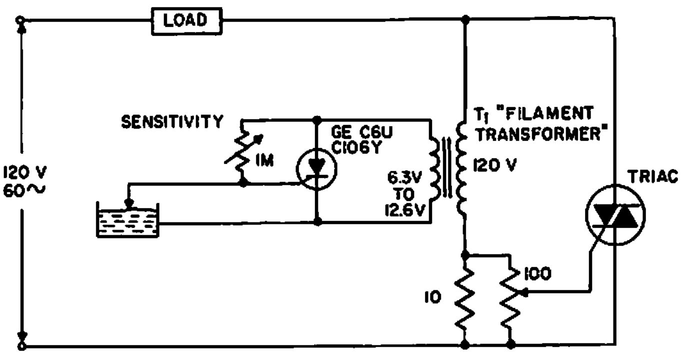
R_1 = 12 kΩ
R_2 = 3 kΩ
R_3 = 2.2 kΩ
R_4 = 560 Ω
R_5 = 820 Ω
R_6 = 1.5 kΩ
inlet valve: 28 V; 280 mA

TR_1 = BC147
TR_2 = BFY55
D = BA148

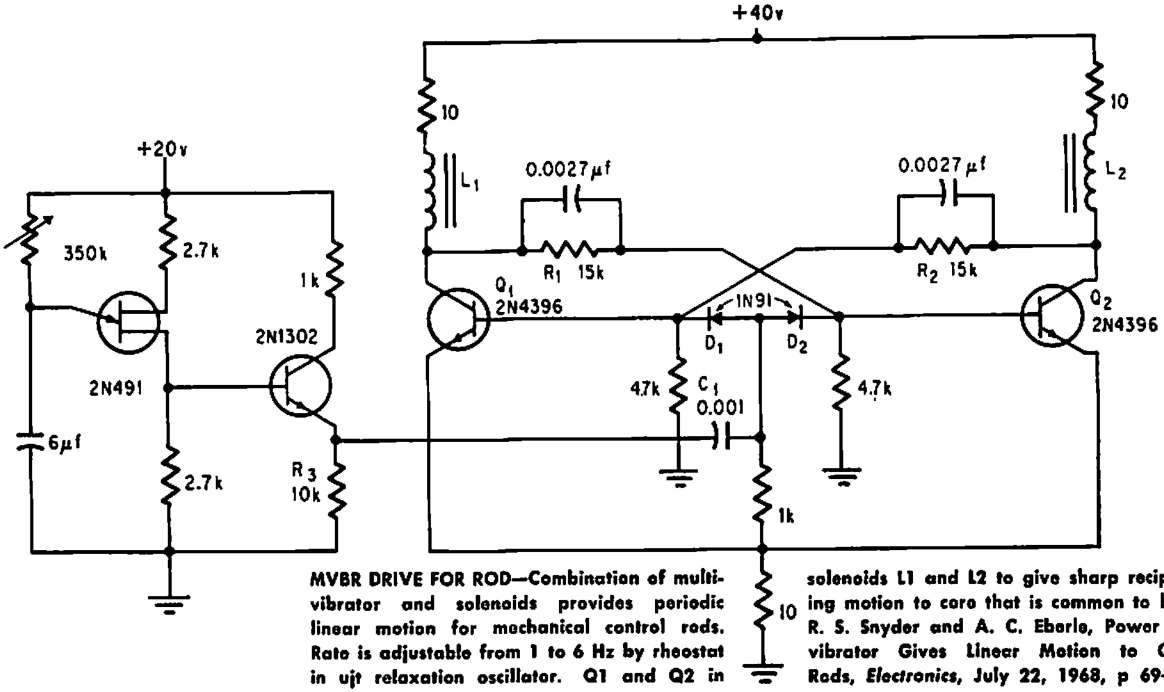

$\overline{W4}$
W4
$\overline{W3}$
W3
$\overline{W2}$
W2
$\overline{W1}$
W1
39nF
NOR60
floor detector EPD or similar
2.2kΩ
0.1µF
O_c
6.8kΩ
3.9nF
15kΩ
1.5nF
down = 0
up = 0
A
B
reset ground floor
reset top floor

All diodes type BAX13

ELEVATOR POSITION REGISTER—Philips IC gates provide performance comparable to that of relay system, with same cost but much greater reliability. Can handle maximum of six floors in apartment building. Reversible column-type counter has memory element for all but top and bottom floors. When elevator passes lowest point of slow-motion zone at each floor, signal is fed from floor detector through pulse stretcher in driver circuit (bottom of diagram) to A or B input line, depending on whether elevator is going up or down. Pulse register at top of diagram stores and delivers positional information, except for top or bottom floor when it feeds reset signal.—J. P. Exalto, Low-Cost Solid-State Elevator Control, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 69.

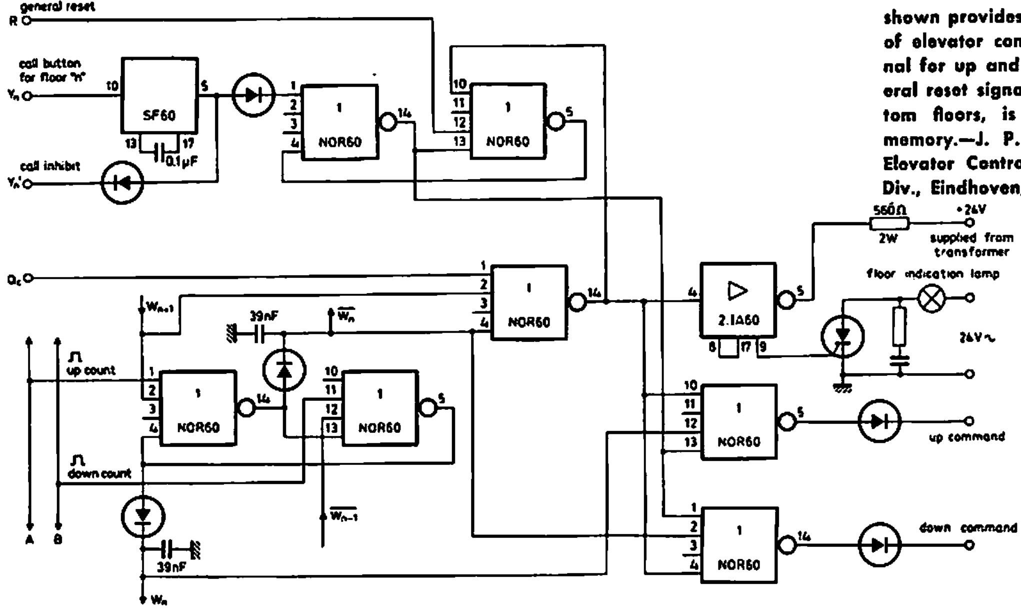

LOAD
SENSITIVITY
1M
GE C6U
C106Y
T_1 "FILAMENT
TRANSFORMER"
6.3V
TO
12.6V
120 V
120 V
60~
TRIAC
100
10

SENSING WATER LEVEL—Applies power to load through appropriately rated triac until water level touches probe and bypasses gate current from low-current C6U scr. This gives isolated low-voltage probe for meeting safety requirements.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 14.

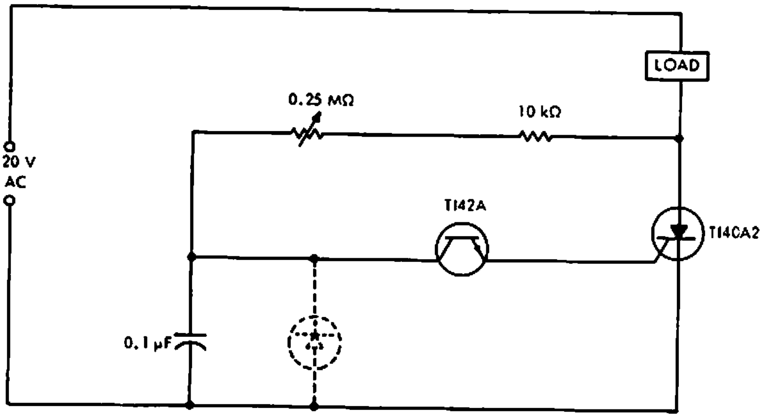

+40v
10
L_1
0.0027μf
R_1 15k
0.0027μf
R_2 15k
10
L_2
+20v
350k
2.7k
1k
2N1302
2N491
6μf
2.7k
R_3
10k
Q_1
2N4396
1N91
D_1
D_2
4.7k
C_1
0.001
4.7k
Q_2
2N4396
1k
10

MVBR DRIVE FOR ROD—Combination of multivibrator and solenoids provides periodic linear motion for mechanical control rods. Rate is adjustable from 1 to 6 Hz by rheostat in ujt relaxation oscillator. Q1 and Q2 in mvbr alternately energize and de-energize solenoids L1 and L2 to give sharp reciprocating motion to core that is common to both.—R. S. Snyder and A. C. Eberle, Power Multivibrator Gives Linear Motion to Control Rods, *Electronics*, July 22, 1968, p 69–70.

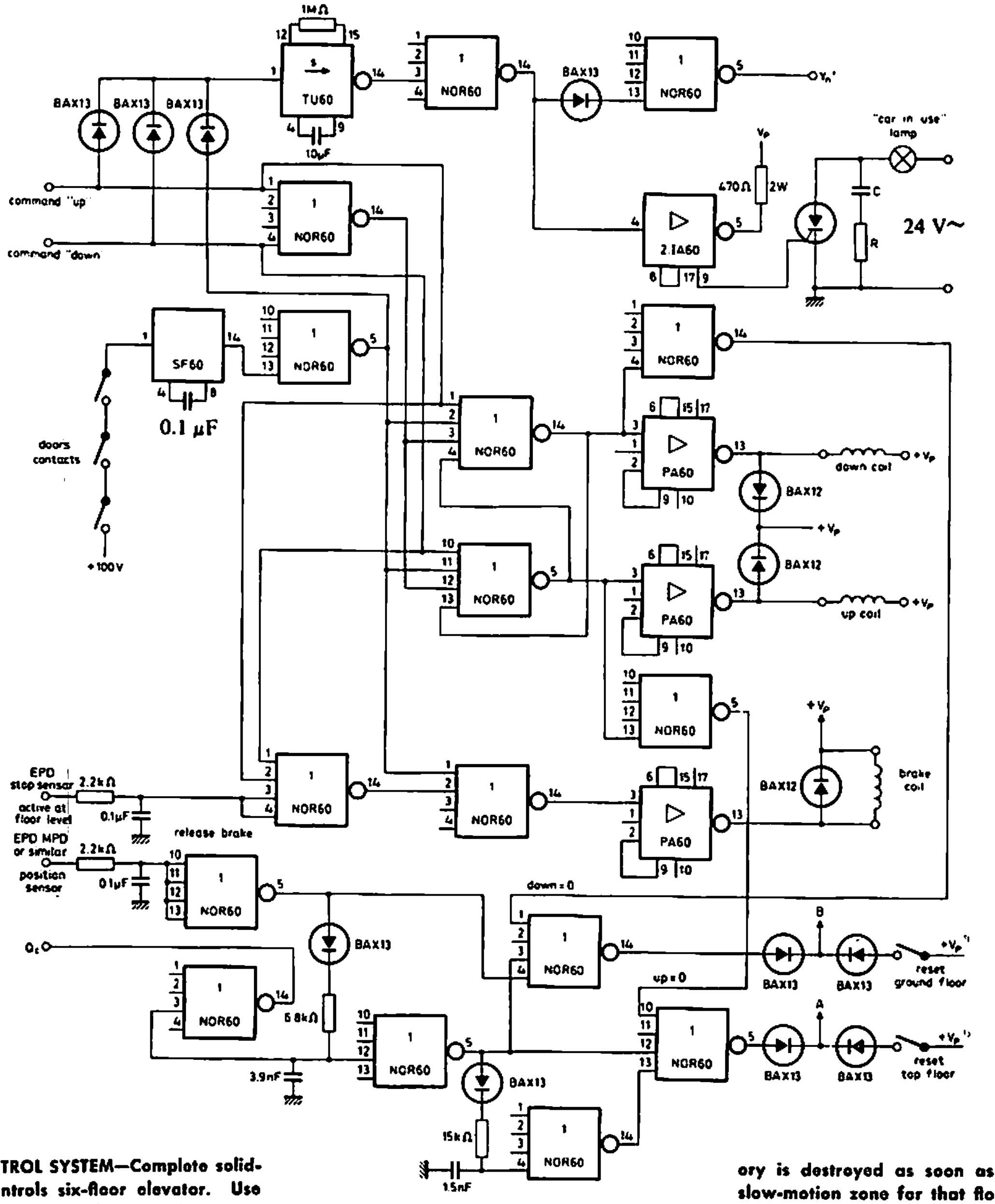
ELEVATOR FLOOR CONTROL—Arrangement shown provides signal to floor indicator lamp of elevator control system and enabling signal for up and down command gates. General reset signal R, produced at top and bottom floors, is applied to upper left-hand memory.—J. P. Exalto, Low-Cost Solid-State Elevator Control, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 69.


general reset
R
call button
for floor "n"
Y_n
SF60
0.1μF
call inhibit
Y_n'
NOR60
NOR60
Q_c
W_{n+1}
39nF
$\overline{W_n}$
NOR60
up count
NOR60
NOR60
down count
$\overline{W_{n-1}}$
A
B
39nF
W_n
560Ω
2W
+24V
supplied from
transformer
floor indication lamp
2.1A60
24V~
NOR60
up command
NOR60
down command

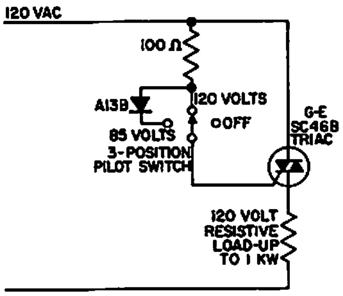
All diodes type BAX13


120 V AC
LOAD
0.25 MΩ
10 kΩ
TI42A
TI4CA2
0.1 μF

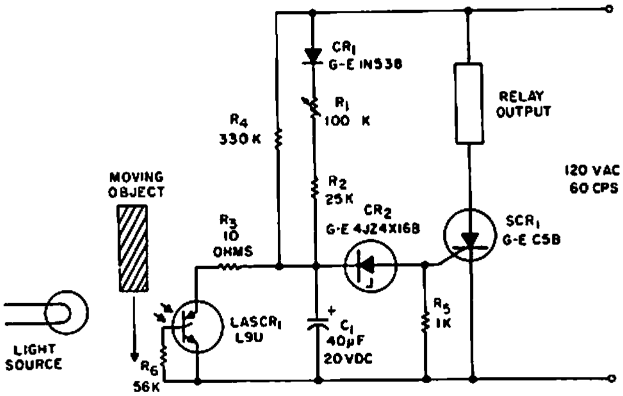
HALF-WAVE CONTROL—Uses TI42A breakdown diode for triggering scr at point in half-cycle determined by setting of rheostat. Load capacity depends on rating of scr.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, CC101, 1968, p 24107.


1MΩ
TU60
10μF
BAX13
NOR60
"car in use" lamp
470Ω 2W
24 V~
2.1A60
command "up"
command "down"
SF60
0.1 μF
doors contacts
+100V
PA60
down coil
up coil
BAX12
brake coil
EPD stop sensor
active at floor level
EPD MPD or similar
position sensor
2.2kΩ
0.1μF
release brake
down = 0
up = 0
6.8kΩ
3.9nF
15kΩ
1.5nF
reset ground floor
reset top floor

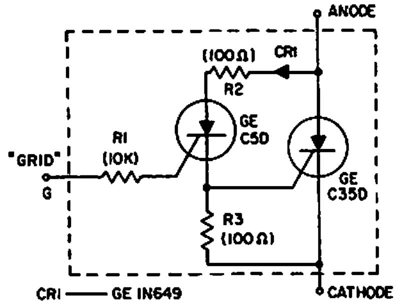
ELEVATOR CONTROL SYSTEM—Complete solid-state system controls six-floor elevator. Use of Philips IC building blocks makes, costs comparable to that of relay system while giving much greater reliability. Elevator cannot move until doors are properly closed. If child opens doors while in transit, brakes are applied. Call information stored in floor memory is destroyed as soon as elevator enters slow-motion zone for that floor.—J. J. Exalto, Low-Cost Solid-State Elevator Control, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 69.


120 VAC
100 Ω
A13B
120 VOLTS
OOFF
85 VOLTS
3-POSITION PILOT SWITCH
G-E SC46B TRIAC
120 VOLT RESISTIVE LOAD-UP TO 1 KW

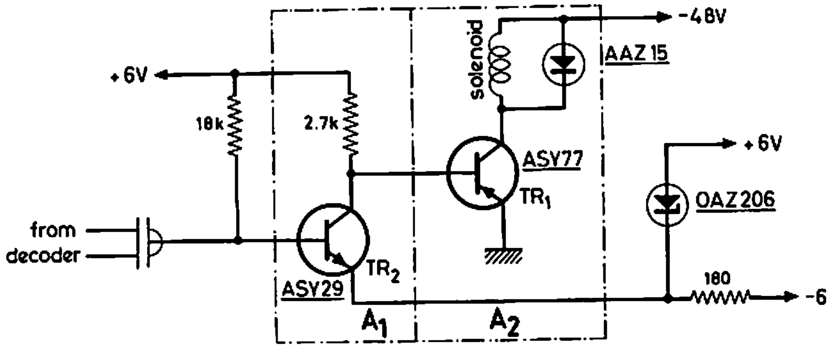
TRIAC POWER CONTROL—Three-position switch gives full or reduced power for load. At reduced power, rectifier changes triggering point of triac. Switch can be low-current type. Good for applications requiring cyclic switching without noise of circuit breakers, and for remote control.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 7.


CR1 G-E 1N538
R1 100 K
R4 330 K
RELAY OUTPUT
120 VAC 60 CPS
MOVING OBJECT
R2 25K
CR2 G-E 4JZ4X16B
SCR1 G-E C5B
R3 10 OHMS
R5 1K
LIGHT SOURCE
LASCR1 L9U
C1 40μF 20VDC
R6 56K

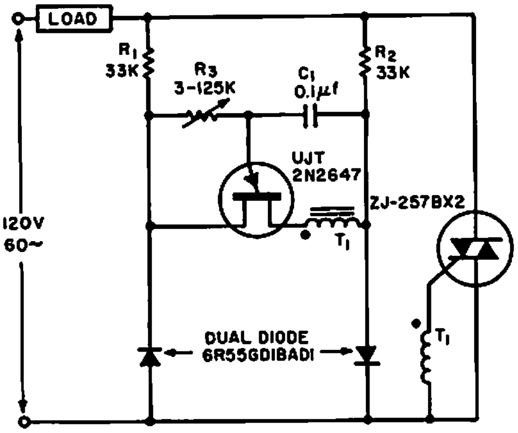
CONVEYOR-JAM MONITOR—Lascr and light source on opposite sides of conveyor or chute act with delay and scr to overlook or pass small self-clearing pile-ups but shut down line quickly for impending catastrophic jam. With light on, lascr conducts and prevents voltage buildup across C1. Each interruption of beam turns off lascr and starts charging of C1. Interruptions of only a few ms do not charge C1 enough to fire zener and scr. R1 adjusts delay before scr fires, up to several seconds.—E. K. Howell, The Light Activated SCR, General Electric, Syracuse, N.Y., No. 200.34, 1965.


ANODE
(100Ω)
CR1
R2
GE C50
R1 (10K)
"GRID"
G
GE C350
R3 (100Ω)
CR1 —— GE 1N649
CATHODE

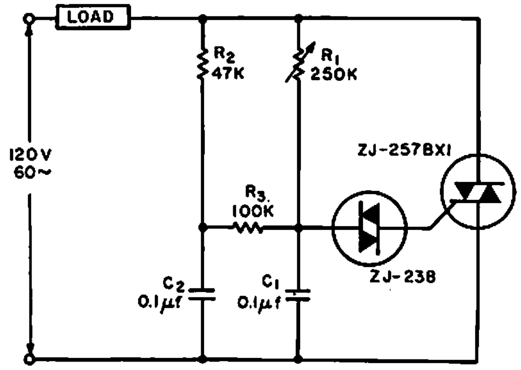
THYRATRON SUBSTITUTE—Combination of small scr as trigger and large scr for power-handling gives performance characteristics of thyratron gas tube, including very high signal input impedance. Maximum forward blocking voltage with single C5 trigger is 400 V. Maximum load current of circuit is 25 A rms. —"SCR Manual," 4th Edition, General Electric, 1967, p 169–170.


-48V
solenoid
AAZ 15
+6V
18k
2.7k
ASY77
TR1
+6V
OAZ206
from decoder
TR2
ASY29
180
-6V
A1
A2

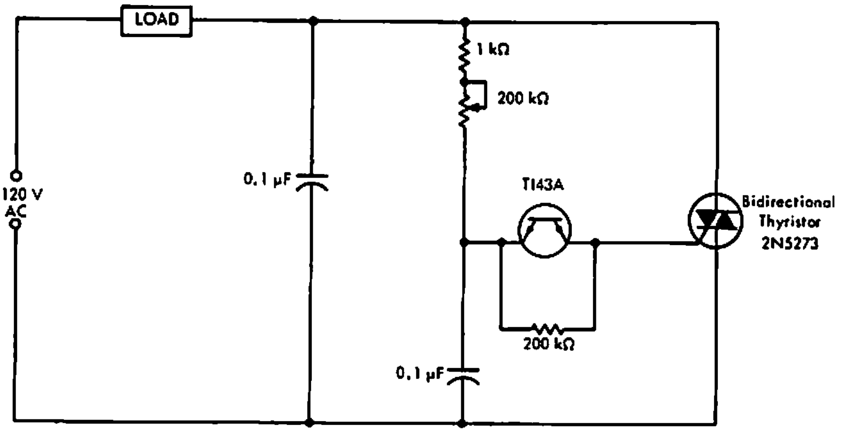
TYPEWRITER SOLENOID DRIVERS—Used to actuate printing keys of electric typewriter under control of electrical signals from computer or calculator. Each key has armature that is pulled down magnetically by solenoid. Since only one character can be printed at given moment, only one output transistor TR1 must conduct at given moment, with all other output transistors (for other keys) cut off.—Output Unit for an Electric Typewriter, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 832, 1966.


LOAD
R1 33K
R3 3-125K
C1 0.1μf
R2 33K
UJT 2N2647
ZJ-257BX2
120V 60~
T1
DUAL DIODE 6R55GD1BAD1
T1

UJT PHASE CONTROL WITHOUT HYSTERESIS—Operation is independent of variations in supply voltage. Easily adapted for automatic feedback control systems by introducing transducer in one leg of bridge.—E. K. Howell, Bilateral SCR Lets Designers Economize on Circuitry, *Electronic Design*, Jan. 20, 1964, p 74–77.

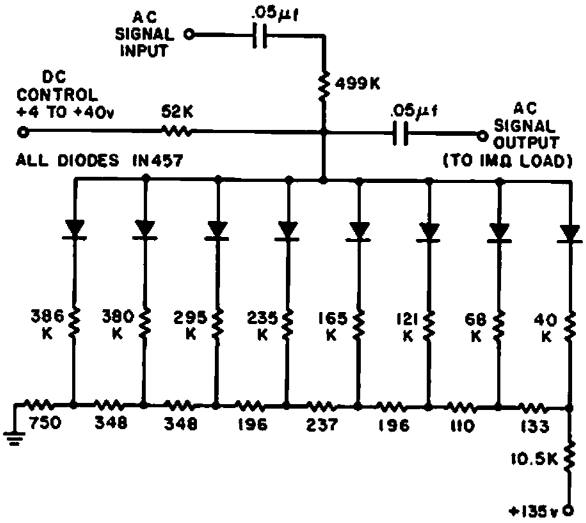

LOAD
R2 47K
R1 250K
120V 60~
ZJ-257BX1
R3 100K
C2 0.1μf
C1 0.1μf
ZJ-238

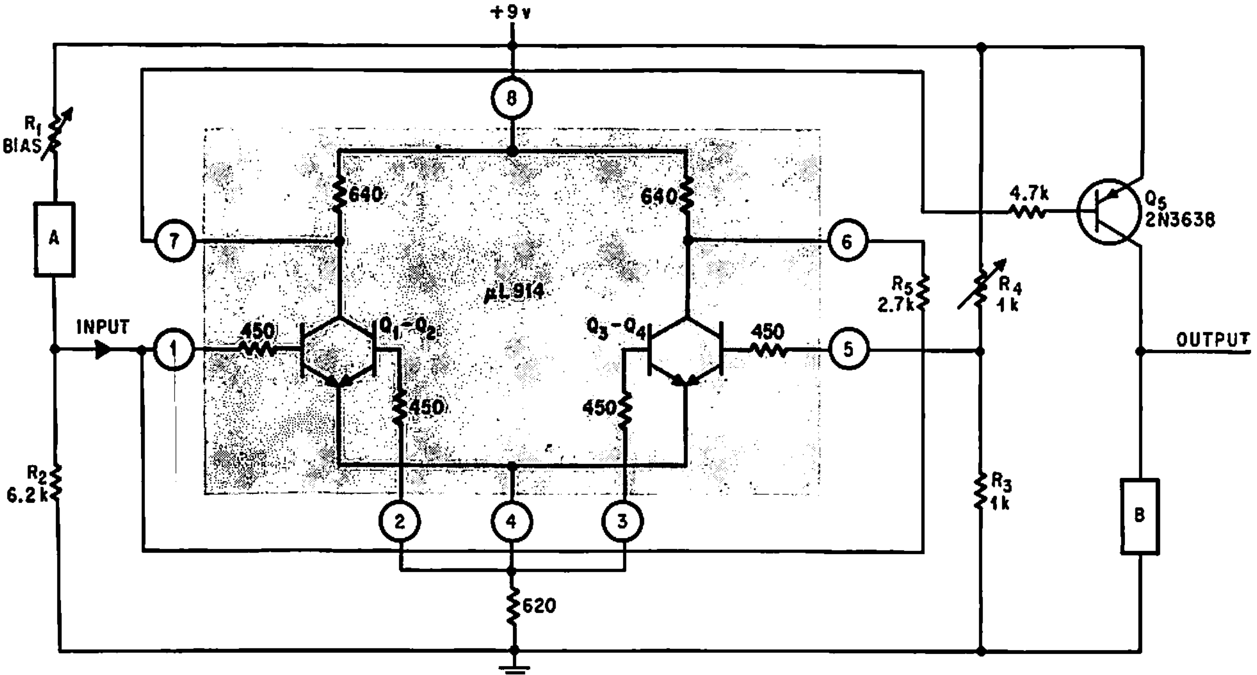
DUAL-RC BILATERAL SCR—Additional phase-shift network provides control over range of 5% to 95% load and reduces hysteresis. Suitable for lamps, heaters, and fan speed controls.—E. K. Howell, Bilateral SCR Lets Designers Economize on Circuitry, *Electronic Design*, Jan. 20, 1964, p 74–77.


LOAD
120 V
AC
0.1 μF
1 kΩ
200 kΩ
T143A
200 kΩ
0.1 μF
Bidirectional
Thyristor
2N5273

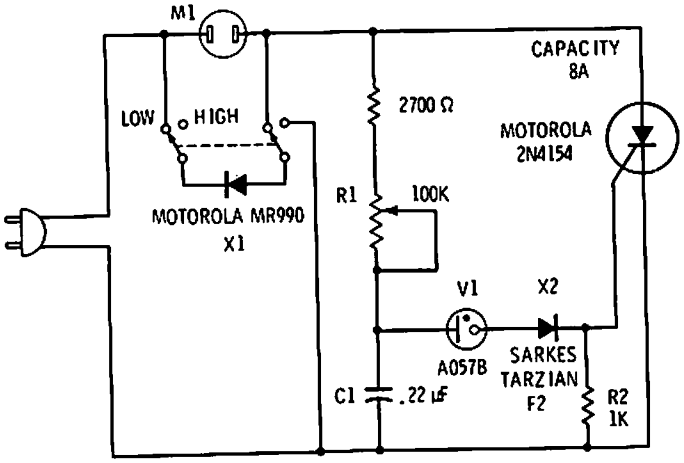
FULL-WAVE WITH THYRISTOR—Breakdown diode provides triggering of bidirectional thyristor on both half-cycles, at point in cycle determined by setting of pot. Load capacity depends on rating of thyristor.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, CC101, 1968, p 24108.

VOLTAGE-CONTROLLED GAIN CHANGER—Provides 4:1 gain change of 400-Hz square-wave carrier signal that is up to 25 V p-p at input. Diodes are used to switch additional parallel paths sequentially in simple voltage-divider circuit. Increasing d-c control voltage makes diodes conduct in sequence because of increasing back-bias applied to successive paths. Gain is maximum at lowest control voltage, when no diodes are conducting.—R. B. Mossman, Diode Divider Circuit Provides A-C Gain Control, *Electronic Design*, April 26, 1965, p 46–48.

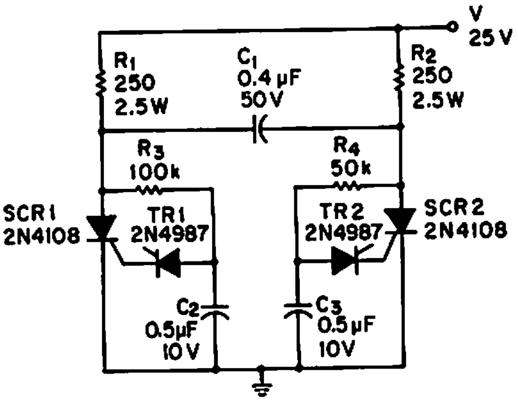

AC
SIGNAL
INPUT
.05μf
499K
DC
CONTROL
+4 TO +40v
52K
.05μf
AC
SIGNAL
OUTPUT
(TO 1MΩ LOAD)
ALL DIODES IN457
386 K
380 K
295 K
235 K
165 K
121 K
68 K
40 K
750
348
348
196
237
196
110
133
10.5K
+135v


+9v
8
R1
BIAS
A
640
640
7
6
4.7k
Q5
2N3638
μL914
R5
2.7k
R4
1k
INPUT
1
450
Q1-Q2
Q3-Q4
450
5
OUTPUT
450
450
R2
6.2k
R3
1k
B
2
4
3
620

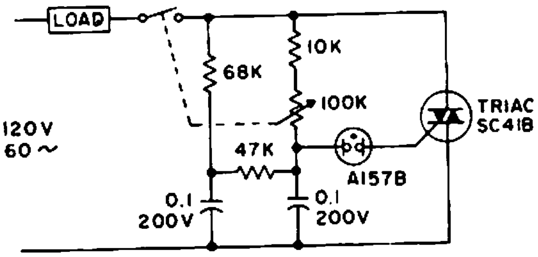
DIGITAL IC AS CONTROL SWITCH—Q5 serves as output stage for Fairchild dual-gate IC to give versatile circuit at total cost under $2. With resistors at A and B and R5 open, linear amplifier is obtained. Snap-action temperature control switch is obtained with R5 in, 1,000-ohm thermistor at A, and 6-V 100-mA relay at B. With FPM100 phototransistor at A and 330-ohm load resistor at B, circuit becomes light-sensing preamp with digital readout.—R. Ricks, Low-Cost Digital IC Performs Linear Functions, *Electronics*, July 24, 1967, p 86–87.


M1
LOW
HIGH
MOTOROLA MR990
X1
2700 Ω
R1
100K
V1
X2
A057B
SARKES TARZIAN F2
C1
.22 µF
R2
1K
CAPACITY 8A
MOTOROLA 2N4154

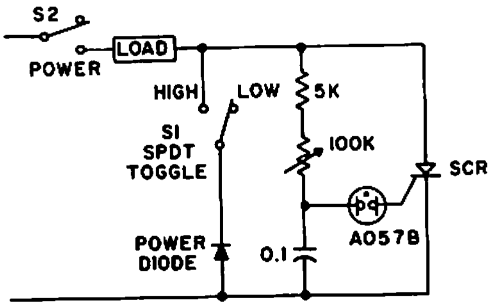
330-DEG SCR CONTROL—Turn-on pulse for scr X3 is generated when neon fires. Point at which it fires in positive half of a-c line cycle is determined by R1, to give 330-deg range for load control in each cycle.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 62.


V
25V
R1
250
2.5W
C1
0.4 µF
50V
R2
250
2.5W
R3
100k
R4
50k
SCR1
2N4108
TR1
2N4987
TR2
2N4987
SCR2
2N4108
C2
0.5µF
10V
C3
0.5µF
10V

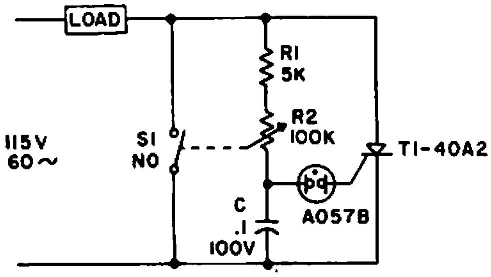
TWO-STATE SEQUENTIAL—Sequential control for only two loads gives high overall efficiency and is self-starting. Operating time of each 100-mA load is independently adjustable.—E. Kiburis, Sequential Control with Silicon Controlled Rectifiers, *EEE*, March 1970, p 100–103.


LOAD
120V
60 ~
68K
10K
100K
47K
A157B
TRIAC
SC41B
0.1
200V
0.1
200V

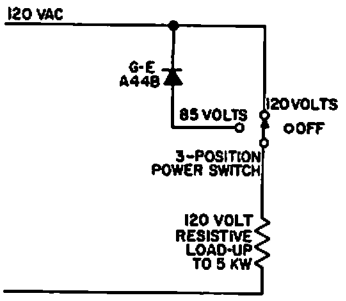
600-W TRIAC—Provides full-wave proportional control, using triac triggered by neon lamp whose breakdown voltage is same in both directions.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 125.


S2
POWER
LOAD
HIGH
LOW
S1
SPDT
TOGGLE
5K
100K
SCR
A057B
POWER DIODE
0.1

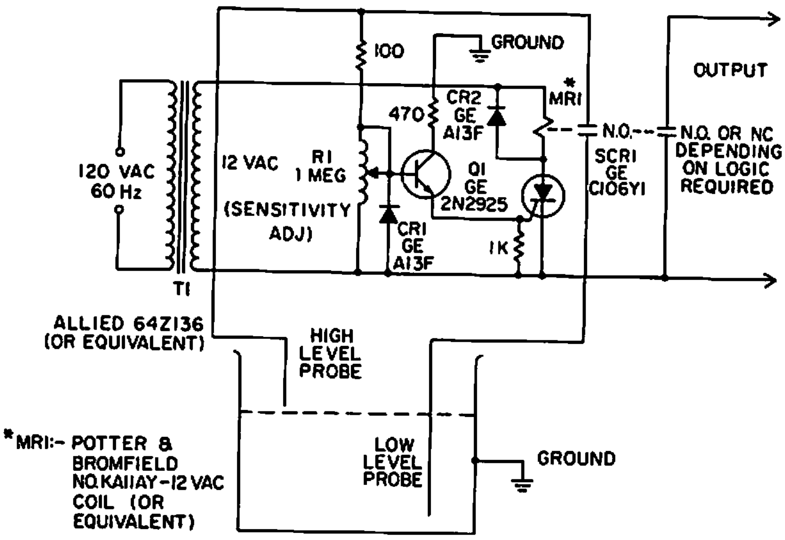
360-DEG PHASE SHIFTER—Neon-triggered scr regulates power delivered to load on both half-cycles. Full power is delivered when S1 is in HIGH position. Scr is TI-40A2.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 121.


LOAD
R1
5K
R2
100K
115V
60 ~
S1
NO
TI-40A2
A057B
C
.1
100V

110-DEG PHASE SHIFTER—During each positive half-cycle of sine-wave voltage, 24% to 95% of available power (depending on setting of R2) is supplied to load via scr triggered by neon lamp. Full clockwise rotation of R2 applies full power to load through S1 ganged to R2.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 120.

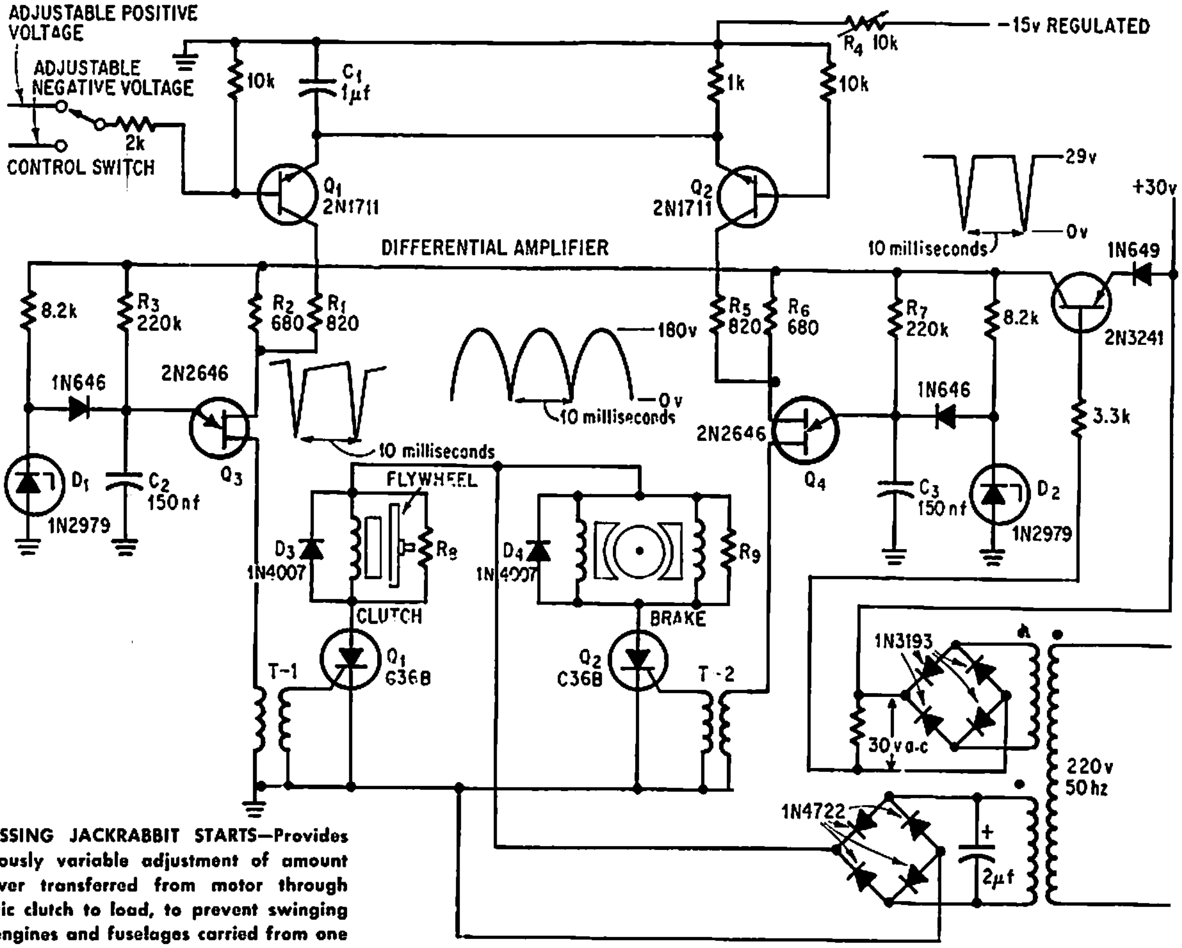

120 VAC
G-E
A44B
85 VOLTS
120 VOLTS
O OFF
3-POSITION
POWER SWITCH
120 VOLT
RESISTIVE
LOAD-UP
TO 5 KW

3-POSITION POWER CONTROL—Rectifier reduces load power by cutting line voltage to 85 V rms.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 7.

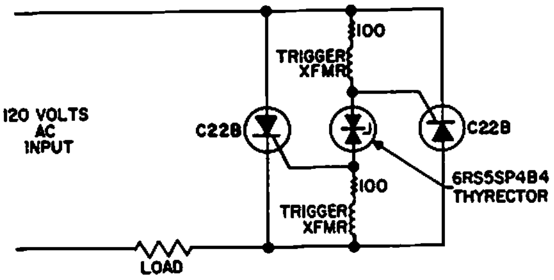

120 VAC
60 Hz
T1
ALLIED 64Z136
(OR EQUIVALENT)
12 VAC
R1
1 MEG
(SENSITIVITY
ADJ)
100
470
GROUND
CR2
GE
A13F
Q1
GE
2N2925
CR1
GE
A13F
1K
MR1
SCR1
GE
C106Y1
N.O.
N.O. OR NC
DEPENDING
ON LOGIC
REQUIRED
OUTPUT
HIGH
LEVEL
PROBE
LOW
LEVEL
PROBE
GROUND

*MRI:- POTTER & BROMFIELD NO.KA11AY-12 VAC COIL (OR EQUIVALENT)

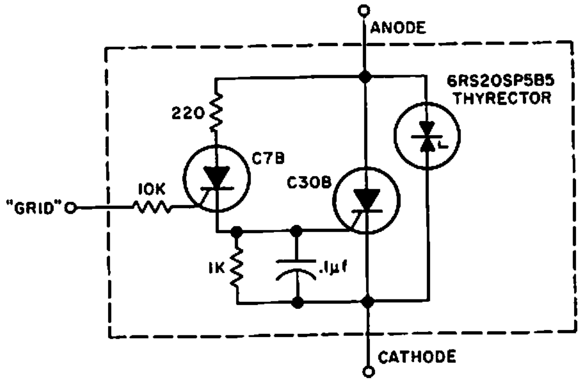
LIQUID-LEVEL CONTROL—Maintains liquid level between two previously established limits, determined by positioning two metal probes, in any reasonably well grounded container. Energization of probes with a-c eliminates electrolytic corrosion. Output can be pump, solenoid valve, or other device for changing liquid level. Operation from 12-V secondary of filament transformer contributes to safety.—D. R. Grafham, Automatic Liquid Level Control, General Electric, Syracuse, N.Y., No. 201.14, 1966.


ADJUSTABLE POSITIVE
VOLTAGE
ADJUSTABLE
NEGATIVE VOLTAGE
2k
CONTROL SWITCH
10k
C1
1μf
Q1
2N1711
Q2
2N1711
1k
10k
R4 10k
−15v REGULATED
DIFFERENTIAL AMPLIFIER
−29v
−0v
10 milliseconds
+30v
1N649
2N3241
8.2k
R3
220k
R2
680
R1
820
180v
0v
10 milliseconds
R5
820
R6
680
R7
220k
8.2k
3.3k
1N646
2N2646
Q3
10 milliseconds
2N2646
Q4
1N646
D1
1N2979
C2
150nf
C3
150nf
D2
1N2979
FLYWHEEL
D3
1N4007
R8
D4
1N4007
R9
CLUTCH
BRAKE
Q1
C36B
Q2
C36B
T-1
T-2
1N3193
30 v a-c
220v
50hz
1N4722
2μf

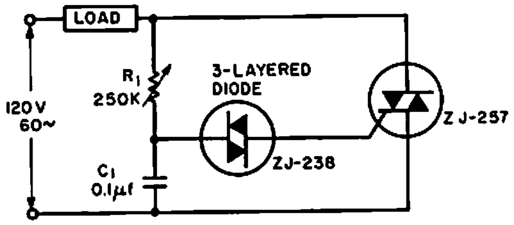
SUPPRESSING JACKRABBIT STARTS—Provides continuously variable adjustment of amount of power transferred from motor through magnetic clutch to load, to prevent swinging of jet engines and fuselages carried from one work station to next by overhead trolley. Same circuit acts on magnetic brakes to prevent jerky stops. Uses differential amplifier added to conventional ujt's Q3 and Q4 in brake and clutch control circuits. Control R4 serves both for startup and braking, since these can never occur simultaneously.—P. J. Kaskinen, Differential Amplifier Governs Magnetic Brakes And Clutches, *Electronics*, May 13, 1968, p 75–76.


120 VOLTS
AC
INPUT
C22B
TRIGGER
XFMR
100
C22B
100
TRIGGER
XFMR
6RS5SP4B4
THYRECTOR
LOAD

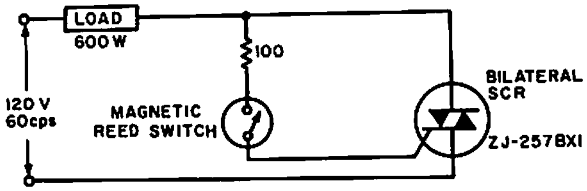
TRANSIENT SUPPRESSION WITH THYRECTOR—With thyrector connected in gate circuits of scr's, portion of transient energy triggers forward-biased scr into conduction, thereby protecting reverse-biased scr from damage. Arrangement permits use of smaller and lower-cost thyrector for given degree of protective effectiveness in an scr control circuit.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 18.


ANODE
6RS20SP5B5
THYRECTOR
220
C7B
C30B
10K
"GRID"
1K
.1μf
CATHODE

SCR REPLACEMENT FOR THYRATRON—Circuit shown is suitable for direct replacement of C3J thyratron in many 120-V a-c applications. Thyrector provides transient voltage protection for C30B scr.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 35.

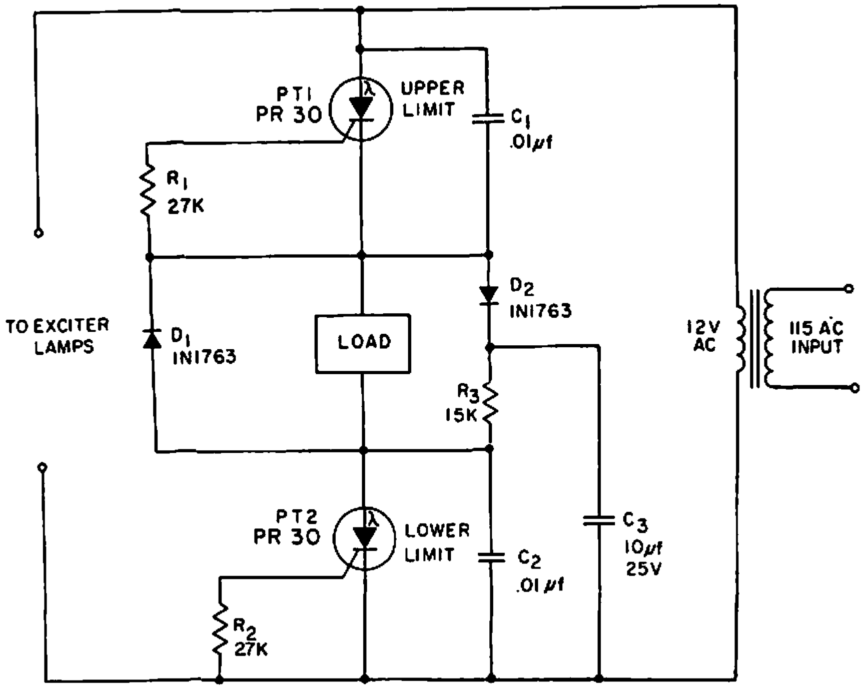

LOAD
R_1
250K
3-LAYERED
DIODE
120V
60~
ZJ-238
Z J-257
C_1
0.1μf

PHASE-CONTROLLED BILATERAL SCR—Requires only four components, though has limited control range and large hysteresis at low output. When voltage across triggering diode reaches 35 V, C1 discharges through diode into gate of bilateral scr.—E. K. Howell, Bilateral SCR Lets Designers Economize on Circuitry, *Electronic Design*, Jan. 20, 1964, p 74–77.

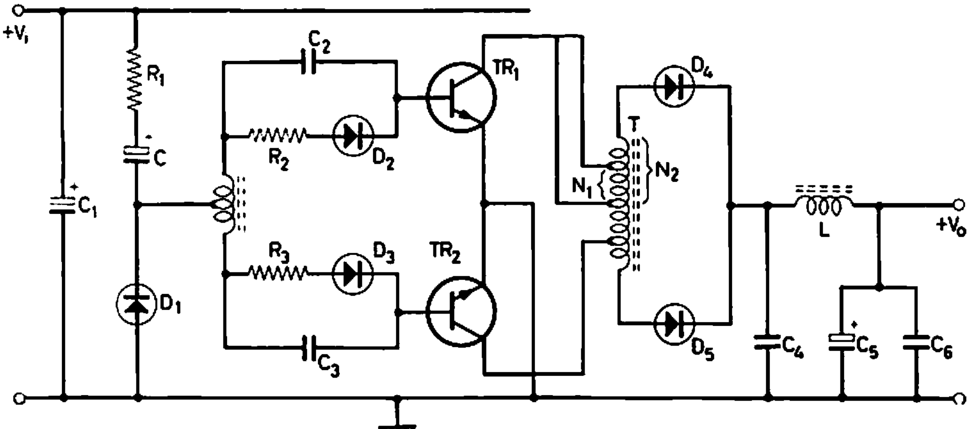

LOAD
600W
100
120V
60cps
MAGNETIC
REED SWITCH
BILATERAL
SCR
ZJ-257BX1

MECHANICALLY ACTUATED SCR—Only three components are needed with bilateral scr for full-wave control of a-c load, as compared to nine components and two conventional scr's in conventional circuit. Any other type of switch may be used.—E. K. Howell, Bilateral SCR Lets Designers Economize on Circuitry, *Electronic Design*, Jan. 20, 1964, p 74–77.

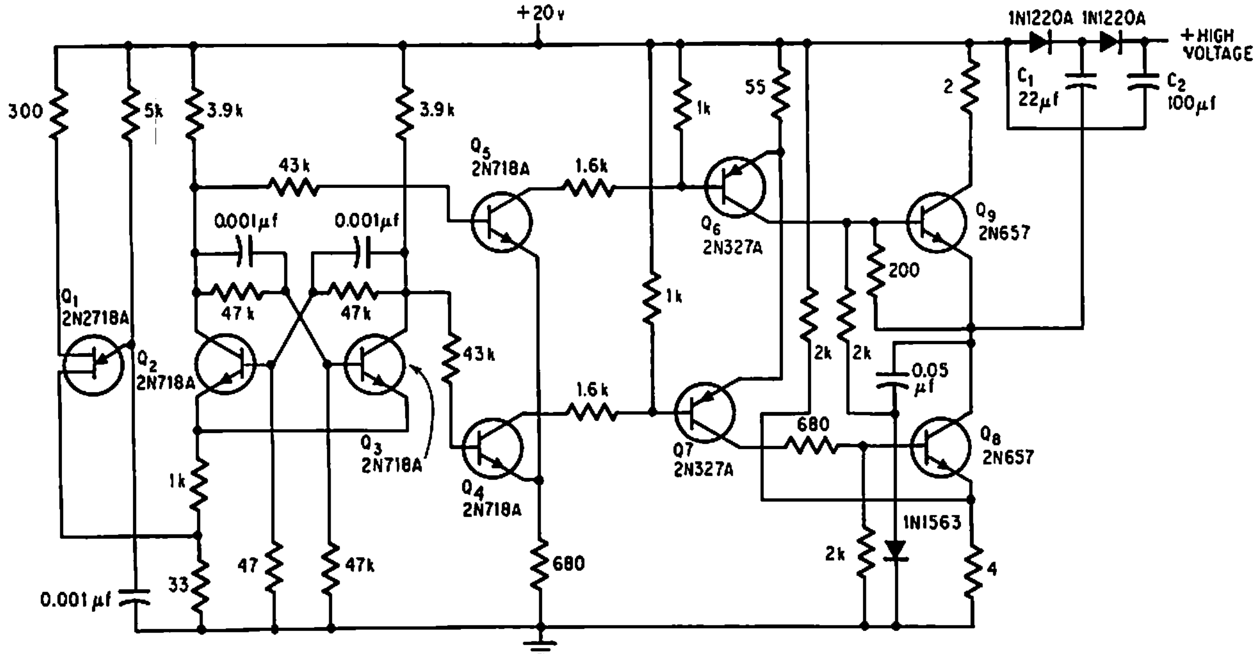
BIN LEVEL CONTROL—Uses two SSPI PR30 light-sensitive scr's with light sources, mounted at upper and lower control limits of material in bin. With level above upper limit, both photoscr's are dark and off. When level falls below upper limit, PT1 switches on and C3 charges to peak positive a-c supply voltage. When level falls below lower limit, PT2 is triggered on, making half-wave rectified a-c energize load and refill bin. When level rises above lower control limit, C3 voltage holds PT2 on. When level reaches upper limit, PT1 turns off and load is deenergized, stopping charging of C3 so PT2 also turns off.—Automatic Bin Feed Control, Solid State Products, Salem, Mass., No. 12.


PT1
PR 30
UPPER
LIMIT
C_1
.01μf
R_1
27K
D_2
IN1763
TO EXCITER
LAMPS
D_1
IN1763
LOAD
12V
AC
115 AC
INPUT
R_3
15K
PT2
PR 30
LOWER
LIMIT
C_2
.01μf
C_3
10μf
25V
R_2
27K

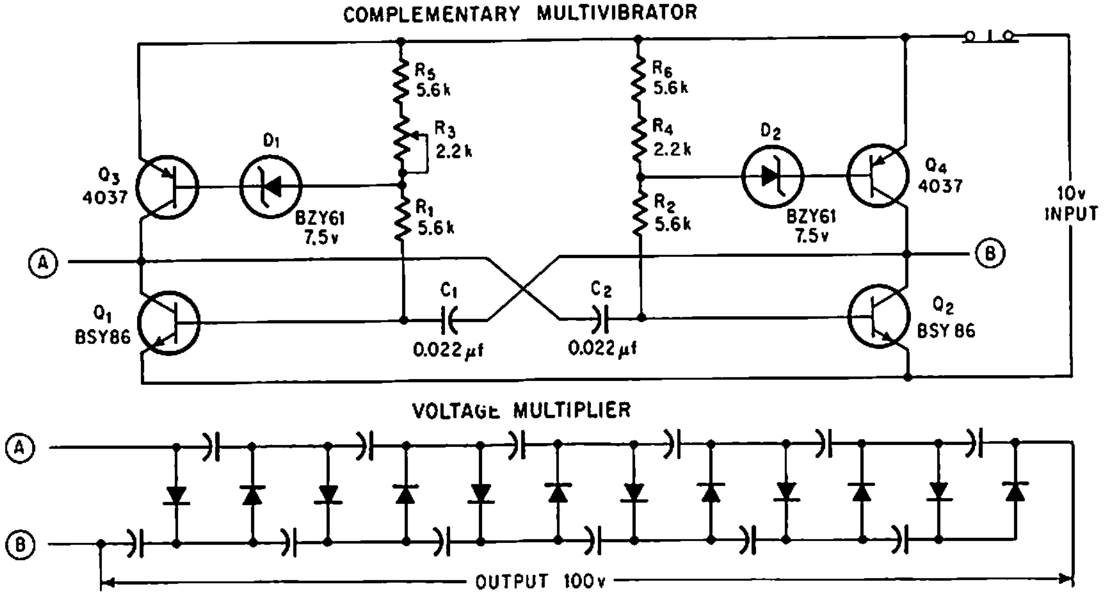
CHAPTER 17
Converter Circuits—D-C to D-C


$+V_i$
R_1
C
C_1
D_1
C_2
R_2
D_2
R_3
D_3
C_3
TR_1
TR_2
T
N_1
N_2
D_4
D_5
L
$+V_o$
C_4
C_5
C_6

20-KHZ 30-W D-C CONVERTER—Uses BDY10 transistors in autotransformer connection that permits adding 13.8-V d-c input voltage to 26-V rectified output of converter to give required 40-V d-c output for mobile transmitter applications. Report gives all winding data. D1 is BYZ13, D2 and D3 are BYX10, and D4 and D5 are BY118. R1 is 68, and R2 and R3 are 10. C and C1 are 100 μF, C2 and C3 are 680 nF, C4 and C6 are 1 μF, and C5 is 8 μF.—A. H. Hilbers, D. C. Converters Operating at 20 KHZ, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 436, 1966.

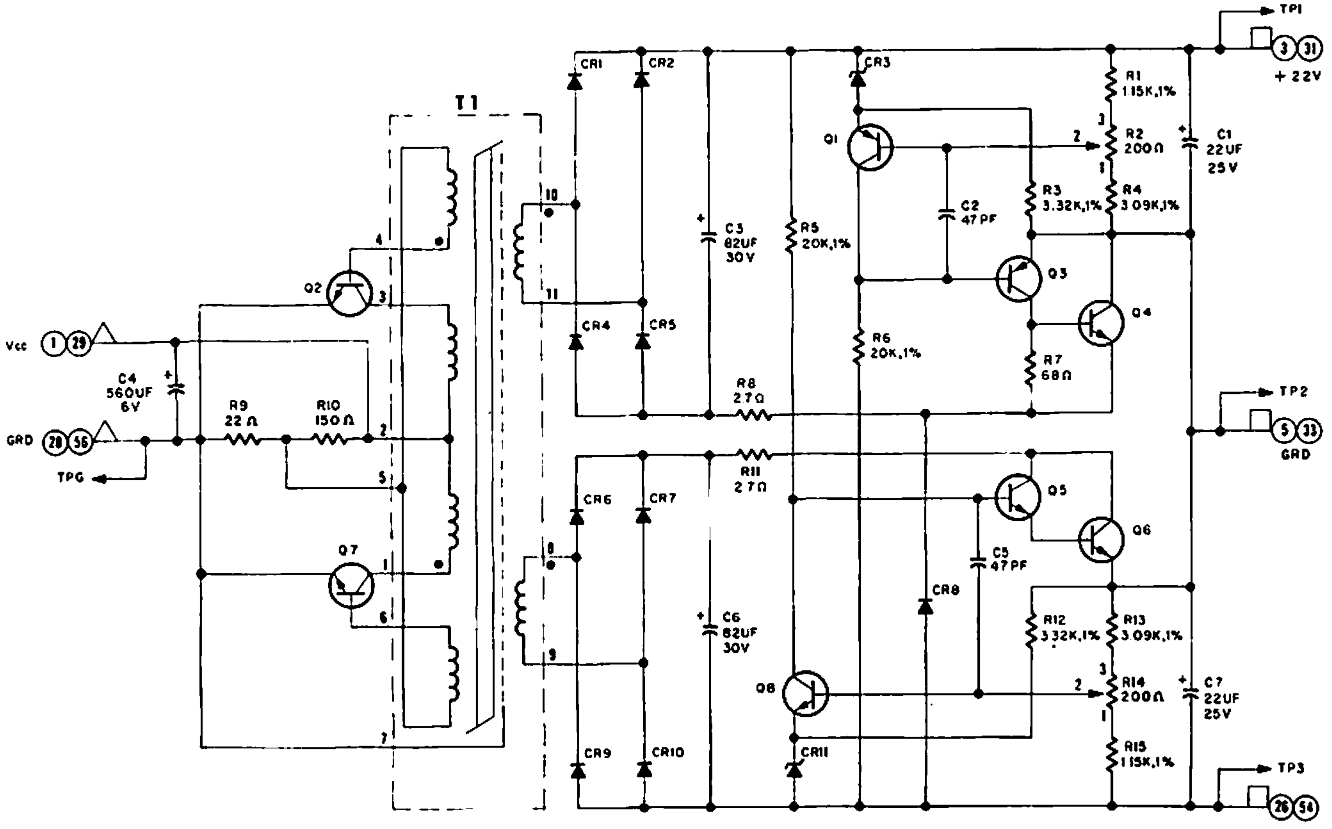

+20 v
1N1220A
1N1220A
+HIGH VOLTAGE
C_1 22μf
C_2 100μf
300
5k
3.9k
3.9k
43k
0.001μf
0.001μf
47k
47k
Q_1 2N2718A
Q_2 2N718A
Q_3 2N718A
43k
Q_4 2N718A
Q_5 2N718A
1.6k
1.6k
1k
1k
55
Q_6 2N327A
Q7 2N327A
2
Q_9 2N657
200
2k
2k
0.05 μf
680
Q_8 2N657
1N1563
2k
4
680
1k
33
47
47k
0.001 μf

D-C STEPUP AUTOTRANSFORMER—Steps up supply voltage for solid-state circuit by using transistors Q8 and Q9 to charge C1 and then discharge it into C2 repeatedly. With 20-V input, output of circuit is 35.5 V at 80 mA, with efficiency of 60%. Ujt relaxation oscillator Q1 controls switching action through flip-flop Q2-Q3.—C. D. Brock and L. E. Johnston, Push-pull Capacitors Multiply Input Voltage, *Electronics*, Nov. 13, 1967, p 101–102.


COMPLEMENTARY MULTIVIBRATOR
R5 5.6k
R3 2.2k
R1 5.6k
R6 5.6k
R4 2.2k
R2 5.6k
D1
BZY61 7.5v
D2
BZY61 7.5v
Q3 4037
Q4 4037
Q1 BSY86
Q2 BSY 86
C1 0.022µf
C2 0.022µf
A
B
10v INPUT
VOLTAGE MULTIPLIER
A
B
OUTPUT 100v

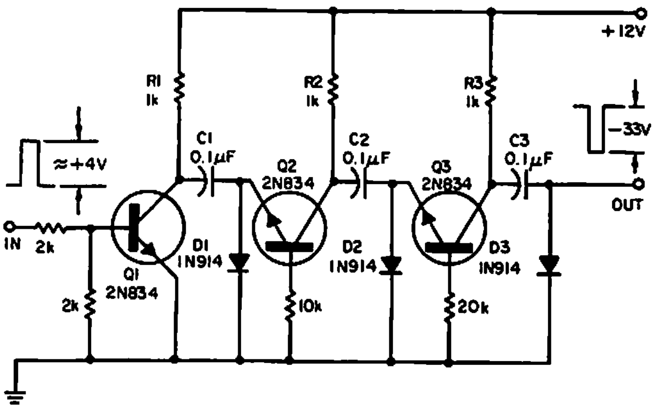
ALL DIODES BAY 38 ALL CAPACITORS 10µf, 25VOLTS

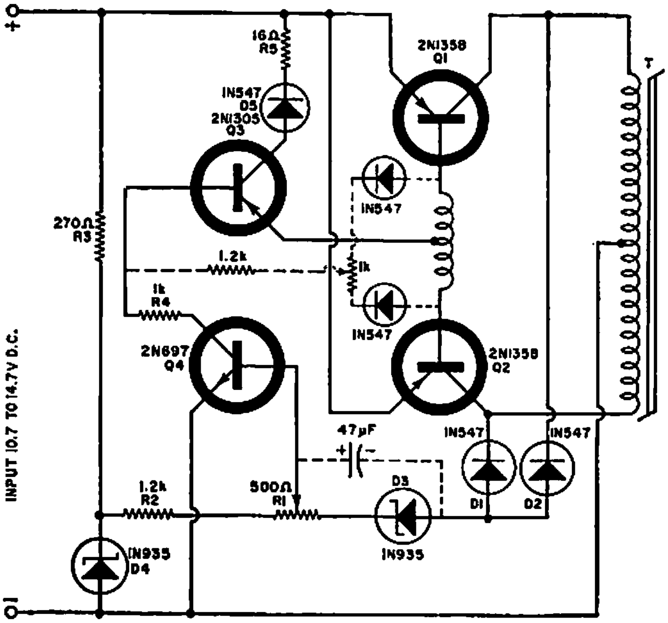
D-C VOLTAGE CONVERTER—Uses 10-kHz complementary mvbr to change 10-V input to 100-V output with 280 mW power. Efficiency is 70%. Square-wave output of mvbr is fed into diode-capacitor network below, for rectification and multiplying of amplitude according to number of multiplier stages. Reversing connections of diodes and capacitors changes output polarity. Mvbr does not restart itself, so starting switch is placed in d-c input line.—K. Van der Geer, Transformerless D-c Voltage Converter is 70% Efficient, *Electronics*, April 14, 1969, p 95.


T1
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
CR9
CR10
CR11
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
R1 115K,1%
R2 200Ω
R3 3.32K,1%
R4 3.09K,1%
R5 20K,1%
R6 20K,1%
R7 68Ω
R8 27Ω
R9 22Ω
R10 150Ω
R11 27Ω
R12 3.32K,1%
R13 3.09K,1%
R14 200Ω
R15 115K,1%
C1 22UF 25V
C2 47PF
C3 82UF 30V
C4 560UF 6V
C5 47PF
C6 82UF 30V
C7 22UF 25V
Vcc 1 29
GRD 28 56
TPG
TP1
3 31
+22V
TP2
5 33
GRD
TP3
26 54
-22V
1
2
3
4
5
6
7
8
9
10
11

22 V BIPOLAR FROM 5 V D-C—Provides supply voltages required by analog cards, with load and line regulation better than 0.15% at 360 mA output current. Input is from standard 5-V d-c digital power source. Consists of d-c to a-c converter, rectifier, filter assembly, and regulator. Q1 & Q3 are 2N3906; Q4 & Q6 are 2N1485; Q2 & Q7 are 2N5190; Q5 & Q8 are 2N3904. CR3 & CR11 are IN5232B 5.6-V zener; all other diodes are MR310. T1 is Topa PNA8144. Available commercially as D-4085 plug-in module. Circled numbers are etched board connector pins.—Integrated Circuit Logic Cards, Electronic Engineering Co., Santa Ana, Cal., 1969, p DS77.

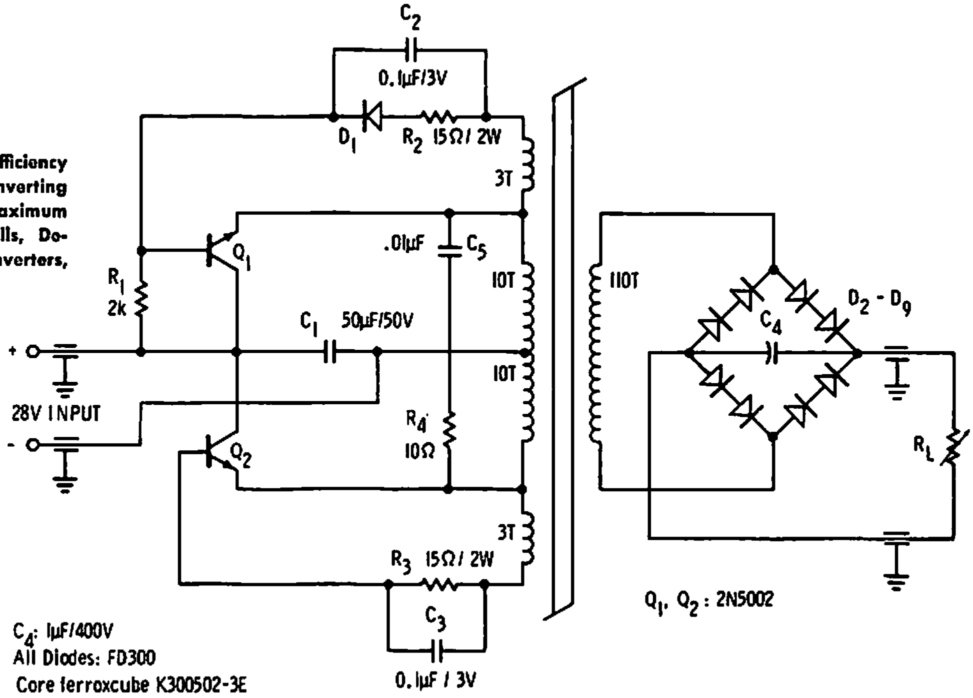
33 V FROM 12 V—Transistors act as switches for charging capacitors in parallel and discharging in series to obtain inexpensive transformerless voltage multiplication of square-wave pulses when required pulse amplitude is greater than available supply voltage. To obtain positive output pulses, use negative supply, reverse diodes, and change to pnp transistors. Values shown handle repetition rates up to 6 kHz into 2K load.—P. Yanczer, Eliminate Pulse Transformer with a Voltage Multiplier, *Electronic Design*, Aug. 15, 1968, p 234.


+12V
R1 1k
R2 1k
R3 1k
C1 0.1μF
C2 0.1μF
C3 0.1μF
≈+4V
IN 2k
2k
Q1 2N834
Q2 2N834
Q3 2N834
D1 1N914
D2 1N914
D3 1N914
10k
20k
−33V
OUT


+
−
INPUT 10.7 TO 14.7V D.C.
16Ω R5
1N547 D5
2N1305 Q3
270Ω R3
1.2k
1k
1k R4
2N697 Q4
2N1358 Q1
2N1358 Q2
1N547
1N547
T
47μF
1N547
1N547
D1
D2
1.2k R2
500Ω R1
D3
1N935
1N935 D4

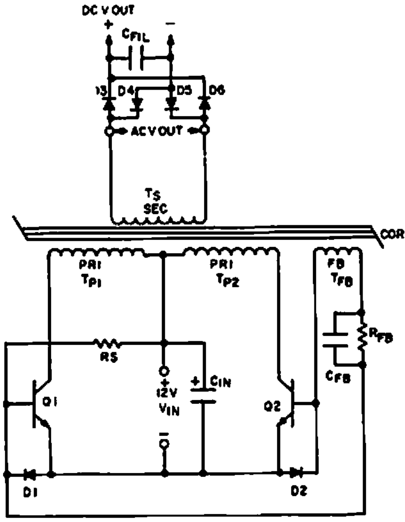
REGVERTER—Uses solid-state d-c converter as series regulator to obtain high efficiency as mobile supply operating from 12-V battery and delivering 25 W at 115 V and 400 Hz. Operated over 3 years in space orbit application. Output transformer (secondary not shown) uses Magnetics Inc. core 50425-4A with 556-turn secondary. Article gives transformer design data.—S. Levy and W. L. Blair, High-Efficiency D.C.-D.C. Converter, *Electronics World*, Feb. 1969, p 35–37 and 59.

100 W IN 12 OUNCES—Gives 85% efficiency at 50 kHz operating frequency, in converting 28 V d-c to 250 V d-c at 400 mA. Maximum ripple in output is 0.5%.—T. B. Mills, Designing Smaller, Lighter Dc-to-Dc Converters, *EEE*, March 1969, p 76–80.


C_2
0.1μF/3V
D_1
R_2 15Ω / 2W
3T
Q_1
.01μF
C_5
10T
R_1 2k
C_1 50μF/50V
+
28V INPUT
−
10T
R_4 10Ω
Q_2
3T
R_3 15Ω / 2W
C_3
0.1μF / 3V
110T
C_4
$D_2 - D_9$
R_L

C_4: 1μF/400V
All Diodes: FD300
Core ferroxcube K300502-3E

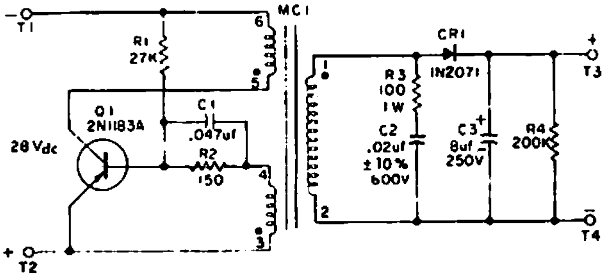
Q_1, Q_2 : 2N5002


DC VOUT
+
−
C_{FIL}
D3
D4
D5
D6
ACVOUT
T_S SEC
CORE
PRI T_{P1}
PRI T_{P2}
FB T_{FB}
R_{FB}
C_{FB}
RS
+ 12V V_{IN}
−
+ C_{IN}
Q1
Q2
D1
D2

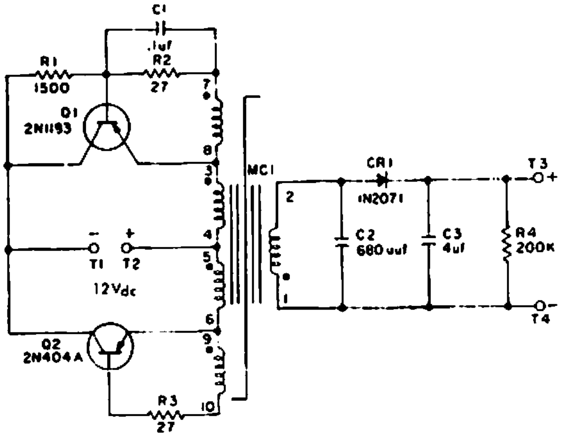
Q1, Q2	D27C3 HEATSINK
D1, D2	A14F
R_S	4.7 KΩ
R_{FB}	100Ω, 10W
C_{FB}	.0068 50V
C_{IN}	100 µf
C_{FIL}	1 µf 400V
D3,4,5,6	1N5056

CORE: FERROXCUBE
#2616P-3E POT CORE
T_{P1}, T_{P2} 7T #25 WIRE
T_{FB} 10T # 25 WIRE
T_S 160T # 32 WIRE

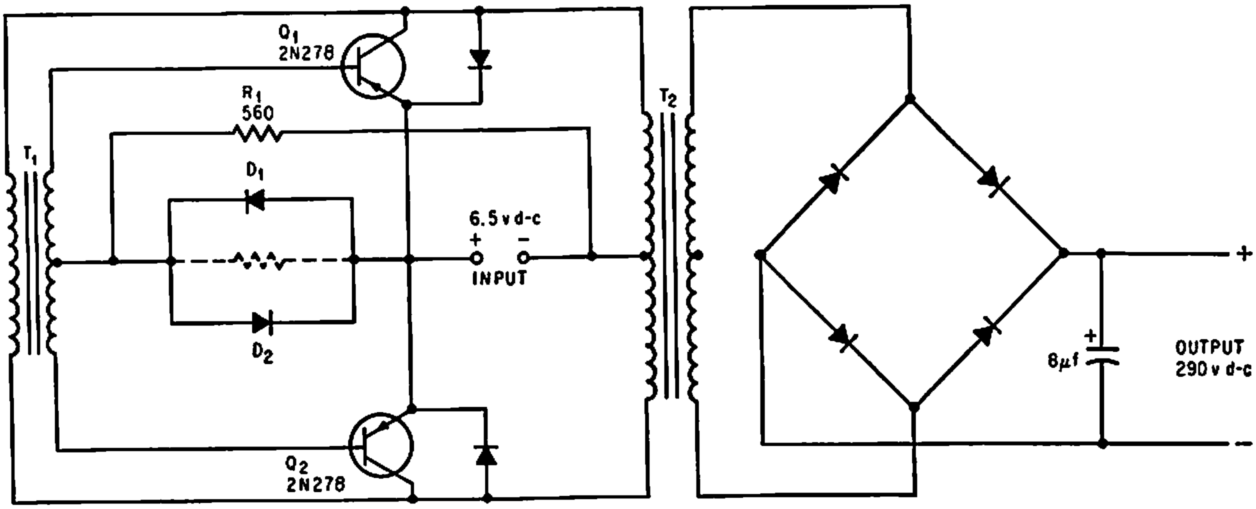
280 V D-C AT 20 W FROM 12 V D-C—Arrangement is compact low-cost means of obtaining high-voltage d-c supply from batteries. Can be used as d-c/a-c inverter by removing bridge rectifier, in which case output is 280 V a-c at 16 kHz. Article gives design criteria and detailed instructions for designing and winding pot-core transformer.—R. A. Yodlowski, Designing A 12 Volt DC to High Voltage DC Converter, General Electric, Syracuse, N.Y., No. 90.75, 1969.


− T1
R1 27K
MC1
6
5
4
3
Q1 2N1183A
28 Vdc
C1 .047uf
R2 150
+ T2
1
2
R3 100 1W
C2 .02uf ±10% 600V
CR1 1N2071
C3 + 8uf 250V
R4 200K
+ T3
− T4

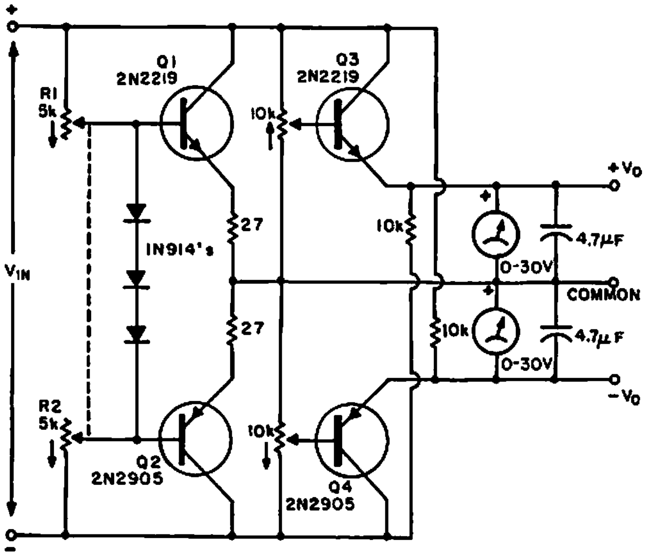
28–170 V D-C/D-C CONVERTER—Burroughs VC28-170-1 module was developed for operating Nixie tubes, driver modules, and other applications where required high-level d-c voltage is not available. Conversion of d-c voltage level is achieved with oscillator Q1, transformer, and rectifier. Maximum output current is 30 mA, with 4-V p-p ripple at full load.—DC-DC Converter, Burroughs, Plainfield, N.J., No. 1087A, 1967.


C1 .1uf
R1 1500
R2 27
Q1 2N1193
7
8
3
4
5
6
9
10
MC1
− +
T1 T2
12Vdc
Q2 2N404A
R3 27
2
1
CR1 1N2071
C2 680uuf
C3 4uf
R4 200K
T3 +
T4 −

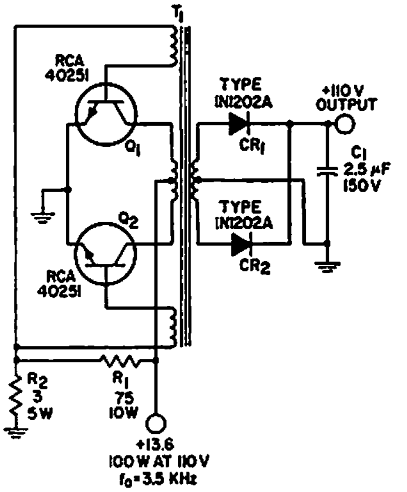
12–170 V D-C/D-C CONVERTER—Burroughs VC12-170-1 module can be used where high-level d-c voltage is not available, as for operating Nixies and driver modules. Step-up of d-c voltage is achieved by transistor oscillator Q1-Q2, transformer, and rectifier. Maximum output current is 30 mA, with 4-V p-p ripple at full load.—DC-DC Converter, Burroughs, Plainfield, N.J., No. 1087A, 1967.


Q_1 2N278
R_1 560
D_1
T_1
T_2
6.5 v d-c
+ −
INPUT
D_2
Q_2 2N278
+
8µf
OUTPUT 290 v d-c
+
−

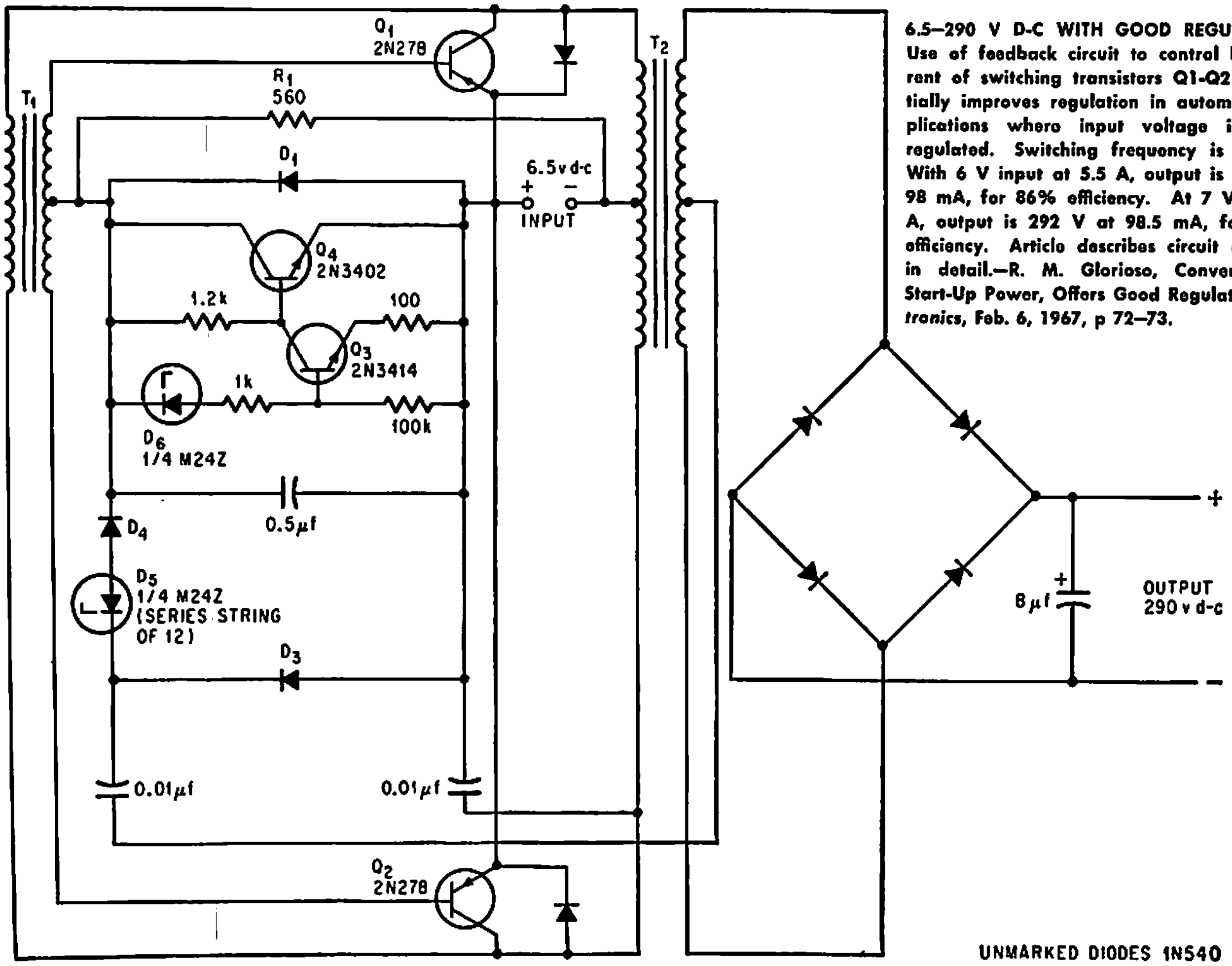
CUTTING START-UP POWER—Base return resistor in conventional d-c/d-c converter (shown dotted and normally 30 ohms) is replaced by back-to-back diodes D1-D2, to reduce large currents needed to develop starting voltage for switching transistors Q1-Q2 and thereby reduce power consumption.—R. M. Glorioso, Converter Cuts Start-Up Power, Offers Good Regulation, *Electronics*, Feb. 6, 1967, p 72–73.


+
R1
5k
Q1
2N2219
Q3
2N2219
10k
+Vo
IN914's
27
10k
+
4.7μF
0-30V
V_{IN}
COMMON
27
10k
+
4.7μF
0-30V
R2
5k
10k
Q2
2N2905
Q4
2N2905
-Vo
-

BOTH POLARITIES FROM ONE—When connected to single ungrounded power supply up to 40 V d-c, circuit provides both positive and negative voltages that are independently adjustable and can furnish up to 50 mA. Ideal for supplementing costly bench power supplies in circuit development laboratories. —C. Sowell, Jr., One Power Supply Does the Work of Two, *Electronic Design*, April 26, 1967, p 241–242.

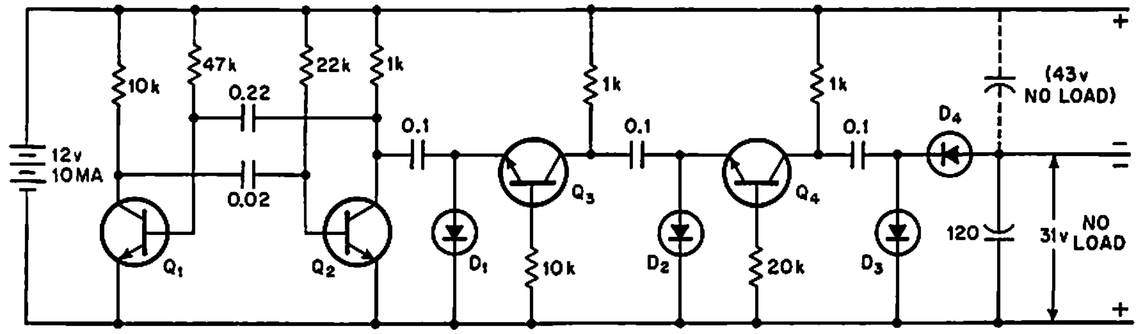

T_1
RCA
40251
Q_1
TYPE
IN1202A
CR_1
+110V
OUTPUT
C_1
2.5μF
150V
TYPE
IN1202A
CR_2
Q_2
RCA
40251
R_2
3
5W
R_1
75
10W
+13.6
100W AT 110V
f_0=3.5 KHz

13.6 V D-C TO 3.5 KHZ TO 110 V D-C—Delivers d-c power output of 100 W. Book gives detailed procedure for selecting optimum transistors and component values for achieving efficiency above 75% at rated load. —"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 183.


Q_1
2N278
T_1
R_1
560
D_1
T_2
6.5vd-c
+
-
INPUT
Q_4
2N3402
1.2k
100
Q_3
2N3414
1k
100k
D_6
1/4 M24Z
0.5μf
D_4
D_5
1/4 M24Z
(SERIES STRING
OF 12)
D_3
+
8μf
OUTPUT
290 v d-c
-
0.01μf
0.01μf
Q_2
2N278

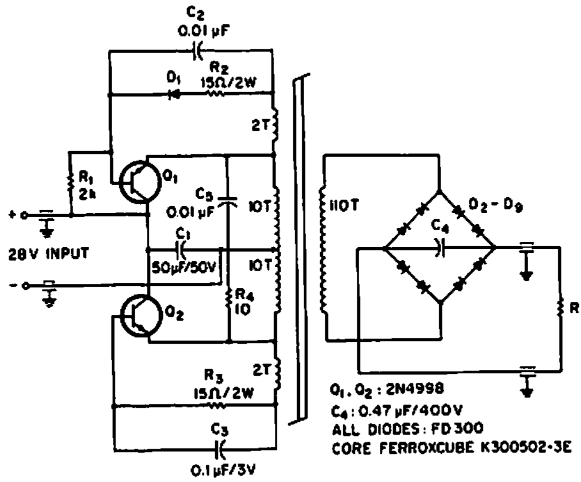
6.5–290 V D-C WITH GOOD REGULATION—Use of feedback circuit to control base current of switching transistors Q1-Q2 substantially improves regulation in automotive applications where input voltage is poorly regulated. Switching frequency is 1.2 kHz. With 6 V input at 5.5 A, output is 290 V at 98 mA, for 86% efficiency. At 7 V and 5.8 A, output is 292 V at 98.5 mA, for 70.7% efficiency. Article describes circuit operation in detail.—R. M. Glorioso, Converter Cuts Start-Up Power, Offers Good Regulation, *Electronics*, Feb. 6, 1967, p 72–73.

UNMARKED DIODES 1N540

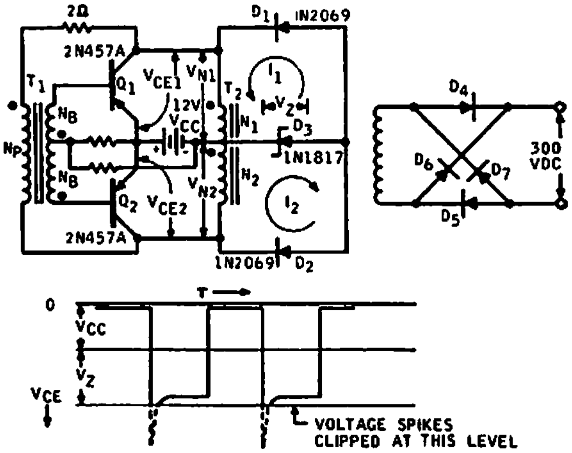

+
12v
10MA
10k
47k
0.22
0.02
22k
1k
Q1
Q2
0.1
D1
10k
Q3
1k
0.1
D2
20k
Q4
1k
0.1
D3
D4
(43v NO LOAD)
120
31v NO LOAD
−
+

D1 – D4 1N34
Q1 – Q4 2N3704
CAPACITORS IN MICROFARADS

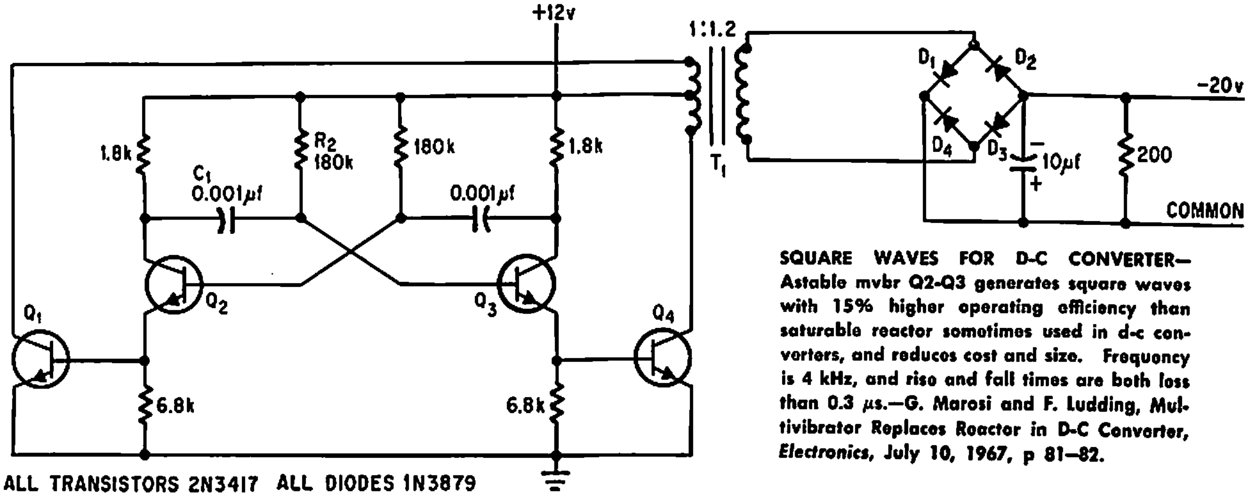
TRANSISTOR-SWITCHED SERIES-PARALLEL CAPACITORS—When Q2 is off, all three 0.1-µF capacitors charge to supply voltage less drops in diodes and 1K resistors. Q2 is part of free-running mvbr (about 1.35 kHz) that initiates switching action. When Q2 comes on for next half-cycle, Q3 and Q4 are forward-biased into conduction through capacitors to place all three 0.1-µF capacitors in series-aiding for transferring their charge through D4 to 120-µF output capacitor. Dashed line shows how extra stage of voltage multiplication can be obtained by connecting output capacitor to positive supply.—H. R. Mallory, Capacitors Add Up In Voltage Multiplier, *Electronics*, March 2, 1970, p 104.


C2
0.01 µF
R2
15Ω/2W
D1
2T
R1
2k
Q1
C5
0.01µF
10T
C1
50µF/50V
10T
R4
10
Q2
+
28V INPUT
−
R3
15Ω/2W
2T
C3
0.1µF/3V
110T
D2 - D9
C4
RL
Q1, Q2 : 2N4998
C4 : 0.47 µF/400V
ALL DIODES : FD300
CORE FERROXCUBE K300502-3E

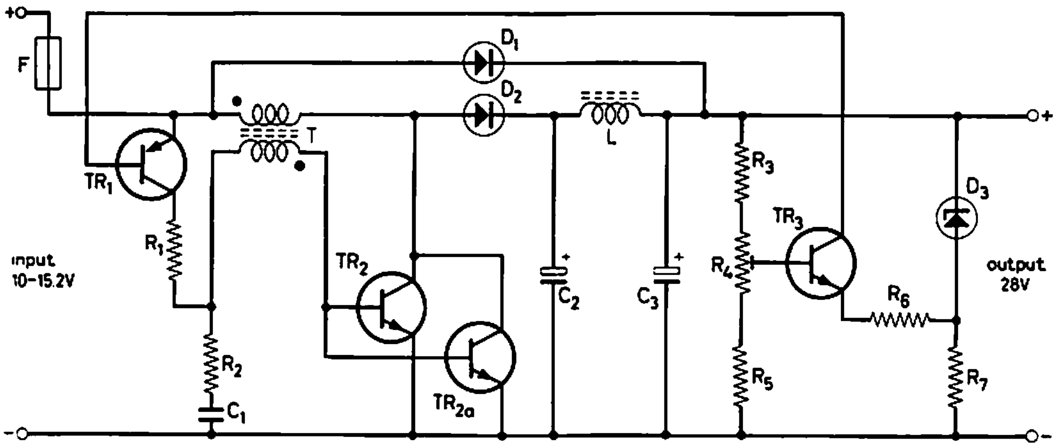
40 W USING HIGH-FREQUENCY TRANSISTORS—Article gives nomograms for output power and transformer design calculations, with 40-W circuit as example of design procedure. Inverter frequency is 46.5 kHz.—C. W. Young, Nomograms Simplify Design of DC-To-DC Convertors, *EEE*, June 1970, p 46—47.


2Ω
D1 1N2069
2N457A
T1
Q1
VCE1
VN1
12V
VCC
T2
I1
VZ
D3
1N1817
NB
NP
NB
N1
N2
VN2
Q2
VCE2
I2
2N457A
1N2069 D2
D4
D6
D7
D5
300 VDC
0
T
VCC
VZ
VCE
VOLTAGE SPIKES CLIPPED AT THIS LEVEL

SPIKE-CLIPPING ZENER—Single zener D3 protects transistors in d-c converter from spikes that may be several times supply voltage, occurring when transistor current switches off through leakage inductance of power transformer.—P. Vergez, Transient Clipper For DC Converters, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 208.


+12v
1:1.2
T1
D1
D2
D4
D3
−20v
10µf
200
COMMON
1.8k
R2
180k
180k
1.8k
C1
0.001µf
0.001µf
Q1
Q2
Q3
Q4
6.8k
6.8k
ALL TRANSISTORS 2N3417 ALL DIODES 1N3879

SQUARE WAVES FOR D-C CONVERTER—Astable mvbr Q2-Q3 generates square waves with 15% higher operating efficiency than saturable reactor sometimes used in d-c converters, and reduces cost and size. Frequency is 4 kHz, and rise and fall times are both less than 0.3 µs.—G. Marosi and F. Ludding, Multivibrator Replaces Reactor in D-C Converter, *Electronics*, July 10, 1967, p 81—82.

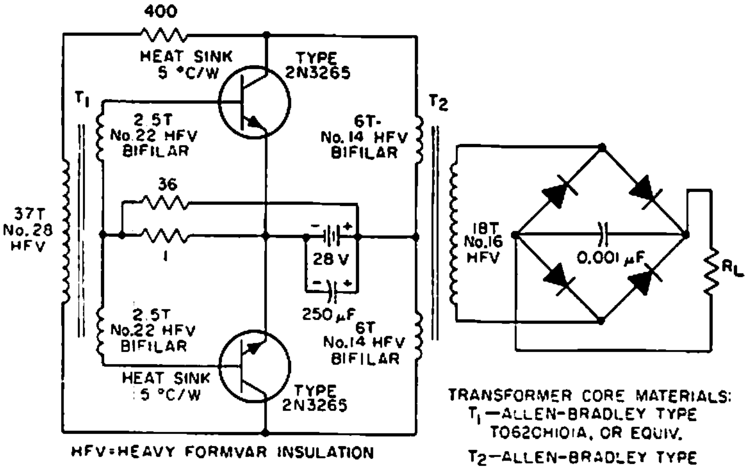

+
F
D1
D2
T
L
TR1
R1
input
10-15.2V
R2
C1
TR2
TR2a
C2
C3
R3
R4
R5
TR3
R6
D3
R7
output
28V
+
-
-

$R_1 = 33\ \Omega$
$R_2 = 10\ \Omega$
$R_3 = 10\ \text{k}\Omega$
$R_4 = 4.7\ \text{k}\Omega$
$R_5 = 2.7\ \text{k}\Omega$
$R_6 = 680\ \Omega$
$R_7 = 1\ \text{k}\Omega$

Capacitors

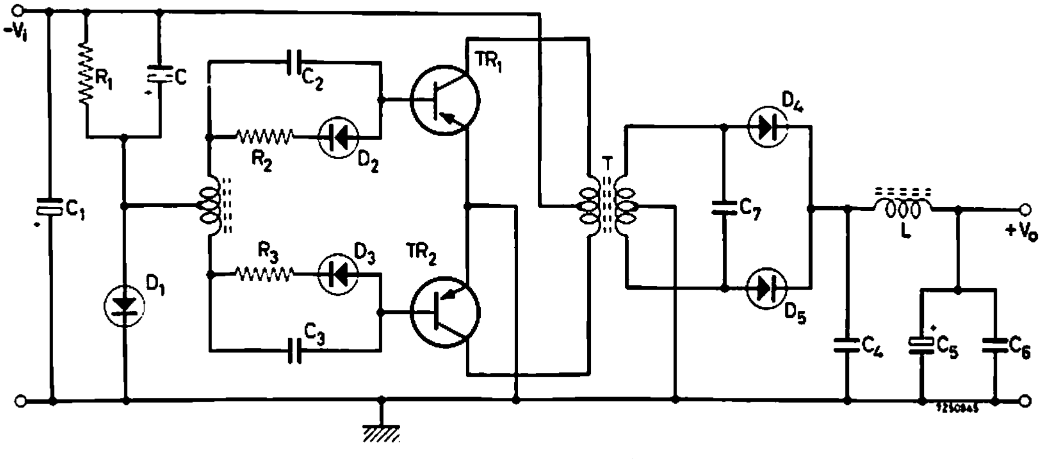
$C_1 = 0.1\ \mu\text{F}$
$C_2 = 12.5\ \mu\text{F}$
$C_3 = 500\ \mu\text{F}$

12 V D-C TO 28 V D-C STABILIZED—Delivers up to 800 mA with 80% efficiency, and will operate with supply voltages from 11 to 15 V. Oscillator frequency of 20 kHz gives noiseless operation and economically small design. Report gives winding data for transformer and choke. TR1 is BCY38, TR3 is BC108, and other transistors are BD121. D1 is BY126, D2 is BYX30/200R, and D3 is BZY94-C22.—J. M. Siemensma, A 23 W Voltage-Stabilized D. C. Converter, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 439, 1967.


400
HEAT SINK
5 °C/W
TYPE
2N3265
T1
2.5T
No.22 HFV
BIFILAR
6T-
No.14 HFV
BIFILAR
T2
37T
No.28
HFV
36
1
28V
250μF
2.5T
No.22 HFV
BIFILAR
6T
No.14 HFV
BIFILAR
HEAT SINK
5 °C/W
TYPE
2N3265
18T
No.16
HFV
0.001μF
RL
HFV=HEAVY FORMVAR INSULATION

TRANSFORMER CORE MATERIALS:
T1—ALLEN-BRADLEY TYPE
T062CH101A, OR EQUIV.
T2—ALLEN-BRADLEY TYPE
U2625C133A, OR EQUIV.

250-W 50-KHZ D-C/D-C—Sample circuit shown is used to explain procedure for designing practical high-speed two-transformer push-pull converter. Operates from 28-V d-c supply and delivers 80 to 90 V d-c depending on load.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 194.


-Vi
R1
C
C1
C2
R2
D2
D1
R3
D3
C3
TR1
TR2
T
D4
D5
C7
L
+Vo
C4
C5
C6

$R_1 = 270\ \Omega$
$R_2 = 18\ \Omega$
$R_3 = 18\ \Omega$

Capacitors

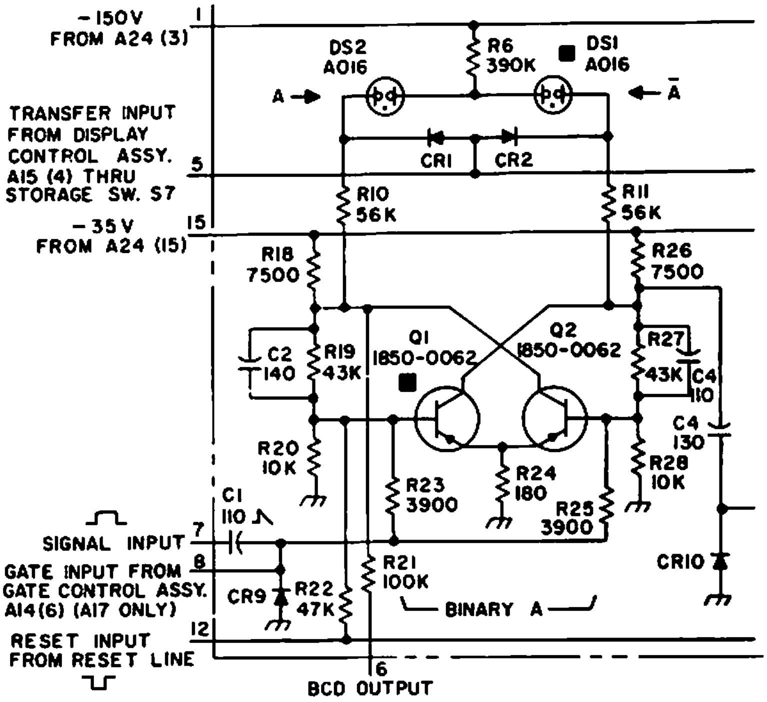
$C = 8\ \mu\text{F}$
$C_1 = 100\ \mu\text{F}$
$C_2 = 820\ \text{nF}$
$C_3 = 820\ \text{nF}$
$C_4 = 1.8\ \mu\text{F}$
$C_5 = 8\ \mu\text{F}$
$C_6 = 1\ \mu\text{F}$
$C_7 = 1\ \text{nF}$

20-KHZ 60-W D-C CONVERTER—Use of transistors having high cutoff frequencies and power diodes with shorter switching times permits operation at 20 kHz where transformer noise is outside audible range, and gives reduction in size of transformer and filter components. Transistors are AU103 on heat sinks. D1 is BYZ13, D2 and D3 are BYX10, and D4 and D5 are BY118. Report gives winding data. Output is 60 W, at about 75% efficiency. Nominal input is 13.8 V d-c and output is 40 V d-c.—A. H. Hilbers, D. C. Converters Operating at 20 KHZ, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 436, 1966.

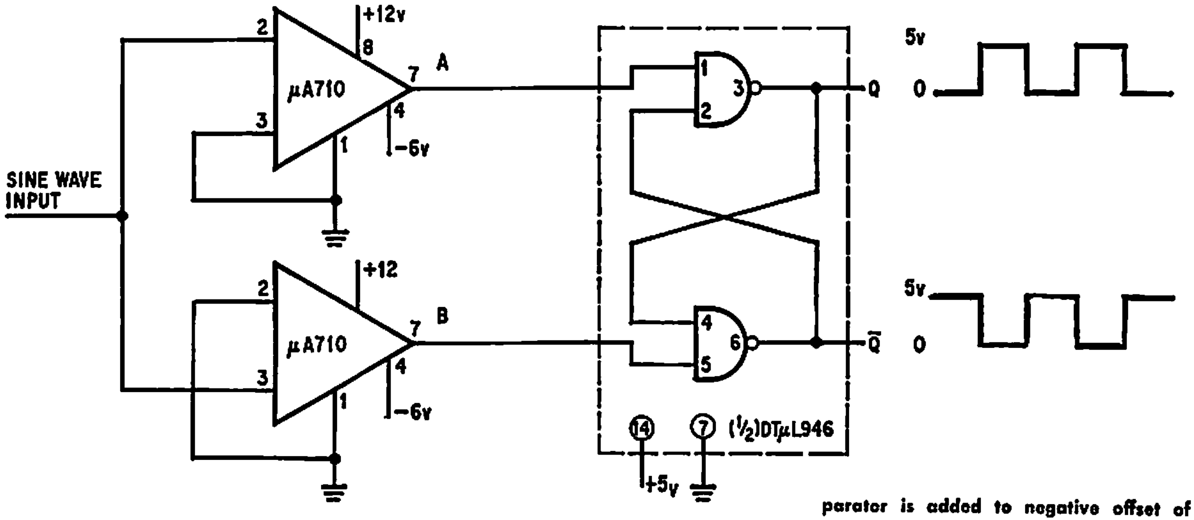
CHAPTER 18

Converter Circuits—General

NEON BINARY-DECIMAL—Circuit shows one stage of binary counter developed by Hewlett-Packard, in which neon glow lamps and solid-state photoconductor elements perform decoding logic and necessary gain for driving decimal indicators. Light from neons falls on group of photocells to provide current path for operation of visual decimal display. (Book shows and describes photocell display matrix). Diodes CR1 and CR2 enable information to be stored while another counting operation proceeds. Circuit cycles in 10 counts instead of normal 16, and drives decimal display.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 130–135.

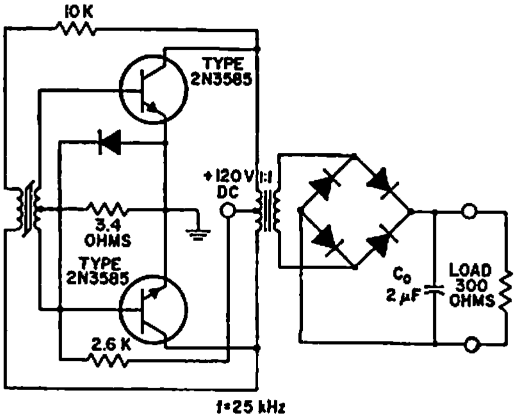


-150V FROM A24 (3)
1
DS2 A016
R6 390K
DS1 A016
A
Ā
TRANSFER INPUT FROM DISPLAY CONTROL ASSY. A15 (4) THRU STORAGE SW. S7
5
CR1
CR2
R10 56K
R11 56K
-35V FROM A24 (15)
15
R18 7500
R26 7500
C2 140
R19 43K
Q1 1850-0062
Q2 1850-0062
R27 43K
C4 110
C4 130
R20 10K
R28 10K
C1 110
R23 3900
R24 180
R25 3900
SIGNAL INPUT
7
GATE INPUT FROM GATE CONTROL ASSY. A14(6) (A17 ONLY)
8
CR9
R22 47K
R21 100K
BINARY A
CR10
RESET INPUT FROM RESET LINE
12
6
BCD OUTPUT

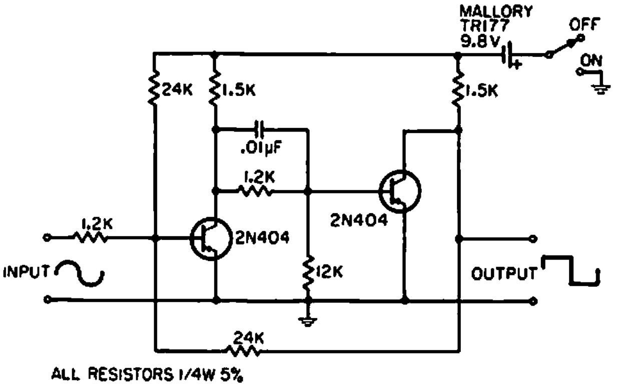


SINE WAVE INPUT
+12v
μA710
2
3
8
7
4
1
A
-6v
+12
μA710
B
-6v
1
2
3
3
4
5
6
Q
Q̄
14
7
(½)DTμL946
+5v
5v
0
5v
0

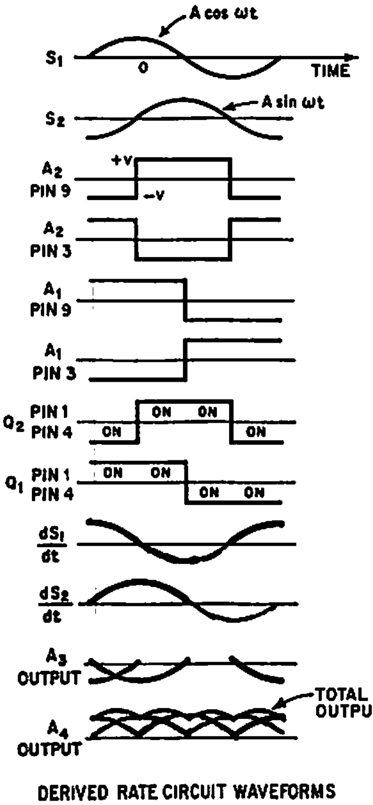
SINE-SQUARE CONVERTER—Two IC comparators convert sine waves to symmetrical square waves while operating in noise with wide temperature and amplitude variations. Outputs of comparators trigger R-S flip-flop on their edges. Positive offset from one comparator is added to negative offset of the other to maintain symmetry.—G. S. Oshiro, Two IC Comparators Improve Threshold Converter, *Electronics*, Dec. 23, 1968, p 59.


10K
TYPE 2N3585
+120V DC
1:1
3.4 OHMS
TYPE 2N3585
2.6 K
C_o 2 μF
LOAD 300 OHMS
f=25 kHz

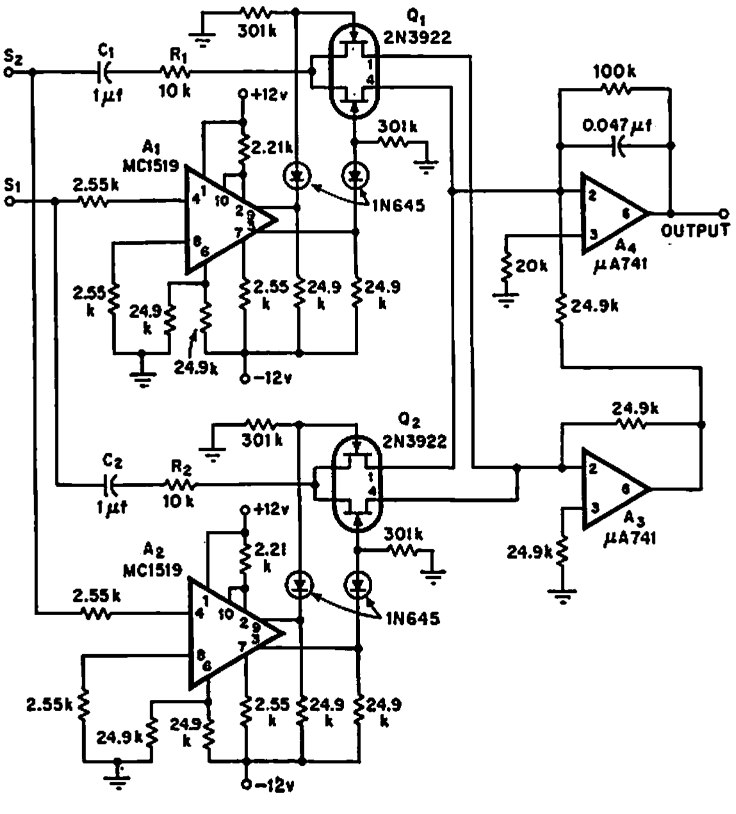
100-W 25-KHZ CONVERTER—Uses pulse switching techniques and two transformers to provide high d-c output voltage and high-speed operation. Book discusses load lines for optimum performance.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 98.

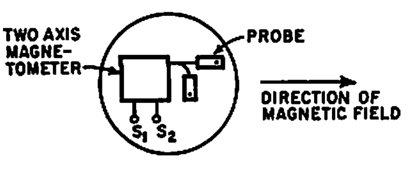

MALLORY TR177 9.8V
OFF
ON
24K
1.5K
1.5K
.01μF
1.2K
2N404
1.2K
2N404
INPUT
12K
OUTPUT
24K
ALL RESISTORS 1/4W 5%

SINE-SQUARE CONVERTER—Schmitt trigger converts output of 600-ohm sine-wave signal generator to square waves required for testing digital equipment.—J. Shagena and A. Mall, Plug-In Squaring-Unit for Signal Generator, *EEE*, Oct. 1966, p 138.

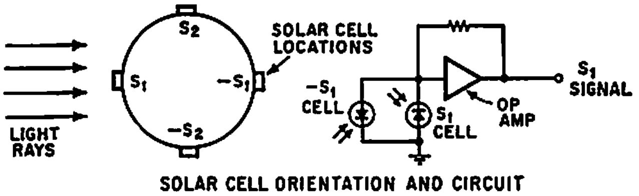


DERIVED RATE CIRCUIT WAVEFORMS


S_2
C_1 1μf
R_1 10 k
301k
Q_1 2N3922
+12v
A_1 MC1519
2.21k
301k
S_1
2.55k
1N645
100k
0.047μf
OUTPUT
A_4 μA741
20k
24.9k
2.55 k
24.9 k
24.9k
2.55 k
24.9 k
24.9 k
−12v
301k
Q_2 2N3922
24.9k
C_2 1μf
R_2 10 k
+12v
A_3 μA741
24.9k
A_2 MC1519
2.21 k
301k
2.55k
1N645
2.55k
24.9k
24.9 k
2.55 k
24.9 k
24.9 k
−12v

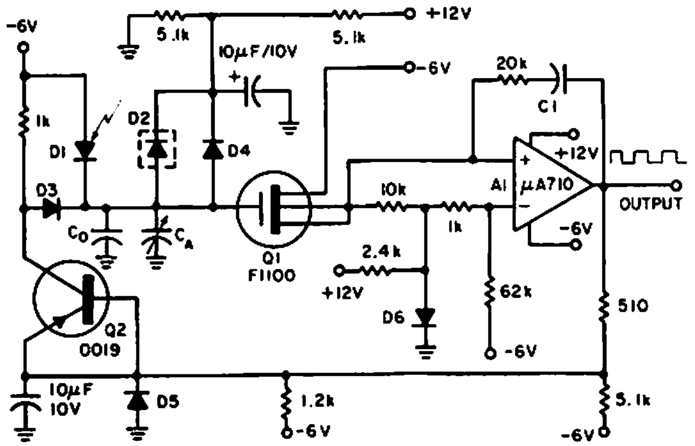

TWO AXIS MAGNETOMETER
PROBE
S_1 S_2
DIRECTION OF MAGNETIC FIELD

MAGNETOMETER ORIENTATION

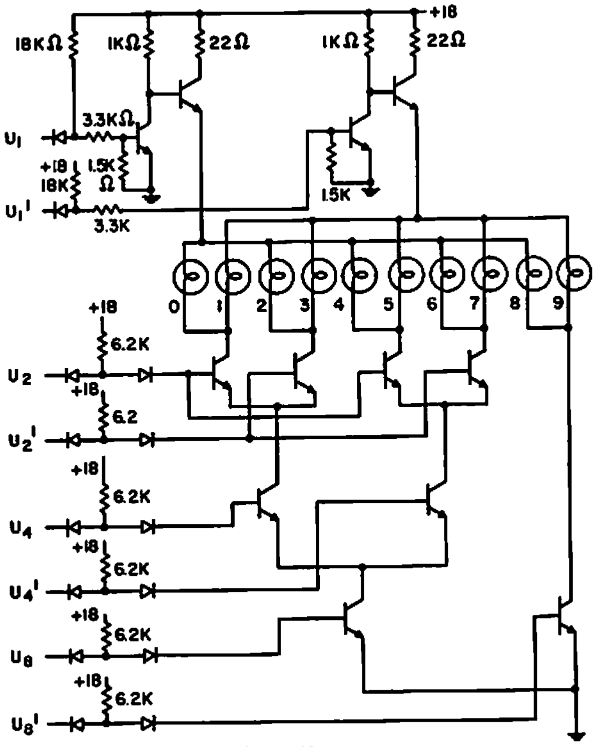

LIGHT RAYS
S_2
S_1
$-S_1$
$-S_2$
SOLAR CELL LOCATIONS
$-S_1$ CELL
S_1 CELL
OP AMP
S_1 SIGNAL

SOLAR CELL ORIENTATION AND CIRCUIT

ROLL RATE TO D-C VOLTAGE—Sensors on periphery of rocket or space vehicle generate sinusoidal inputs at S1 and S2 in quadrature, with frequency proportional to roll rate of vehicle. Inputs are differentiated to produce new signals whose amplitudes are proportional to angular frequency. Negative half-cycles are inverted by amplifier and summed with positive half-cycles to produce d-c output proportional to roll rate.—W. A. Cooke, IC's Gate FET's for Roll Rate Data, *Electronics*, Feb. 16, 1970, p 105—106.

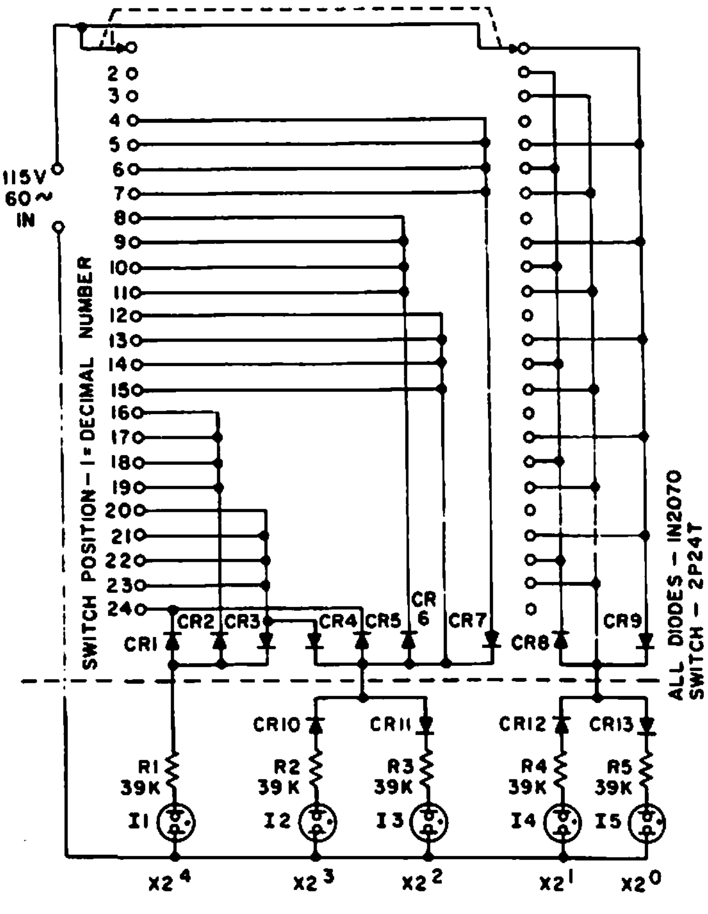

-6V
5.1k
+12V
10μF/10V
-6V
20k
C1
1k
D1
D2
D4
D3
C0
CA
Q1
F1100
10k
1k
A1
μA710
+12V
-6V
OUTPUT
2.4k
+12V
D6
62k
-6V
510
Q2
0019
10μF
10V
D5
1.2k
-6V
5.1k
-6V

LIGHT-TO-FREQUENCY CONVERTER—Input impedance of mosfet Q1 is 10 teraohms, as required for obtaining linear relationship between light input on photodiode D1 and square-wave output frequency. Opamp functions as one-shot for generating 0.1-μs reset pulses. Used in exposure control for photolithographic equipment, in which output pulses are fed into counter that turns off light source at predetermined count. Can be calibrated so each pulse corresponds to exposure of 0.1 mW-s.—H. Murphy, Count Your Foot-Candles with Photodiodes, *Electronic Design*, Aug. 15, 1968, p 206–207.


+18
18KΩ
1KΩ
22Ω
1KΩ
22Ω
3.3KΩ
U1
+18
18K
1.5K Ω
U1'
3.3K
1.5K
0
1
2
3
4
5
6
7
8
9
+18
6.2K
U2
+18
6.2
U2'
+18
6.2K
U4
+18
6.2K
U4'
+18
6.2K
U8
+18
6.2K
U8'

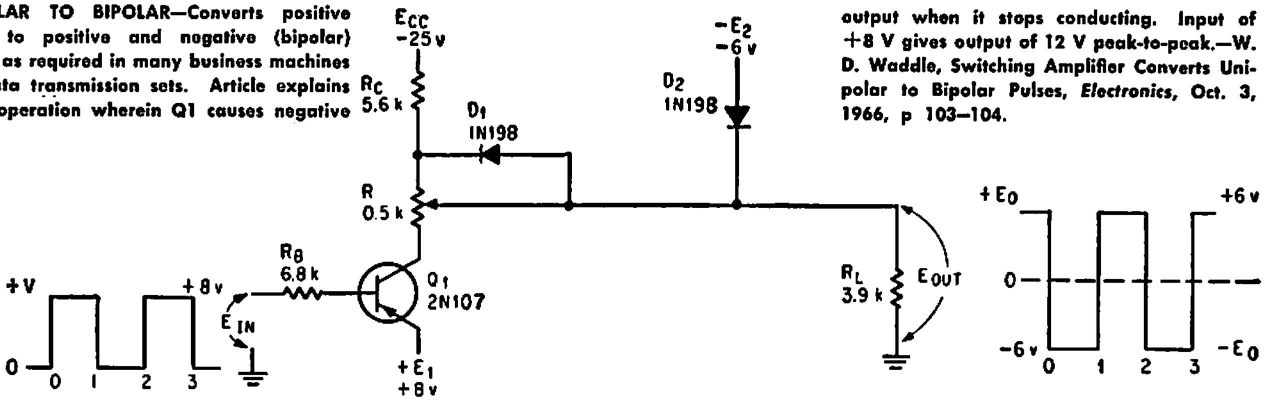
14 DIODES (IN4148)
12 TRANSISTORS (2N3415)
LAMPS 1815 200 MA. @ 14V

BINARY-TO-DECIMAL DECODER DRIVERS—Transistor matrix provides both logic and amplification for lighting appropriate one of ten indicator lamps for decimal display when input signal is in 8-4-2-1 code.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 11.

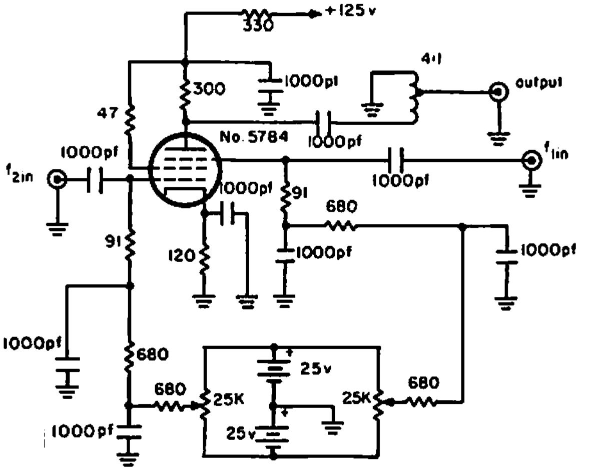

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
115V
60~
IN
SWITCH POSITION—1=DECIMAL NUMBER
CR1
CR2
CR3
CR4
CR5
CR 6
CR7
CR8
CR9
CR10
CR11
CR12
CR13
R1 39K
R2 39K
R3 39K
R4 39K
R5 39K
I1
I2
I3
I4
I5
X2⁴
X2³
X2²
X2¹
X2⁰
ALL DIODES – IN2070
SWITCH – 2P24T

NEON DECIMAL-BINARY—Demonstrates binary arithmetic, using A072 neon lamps in simple circuit. Rotary switch permits 24 bits of information to be transmitted to remote visual display.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 136.

UNIPOLAR TO BIPOLAR—Converts positive pulses to positive and negative (bipolar) pulses, as required in many business machines and data transmission sets. Article explains circuit operation wherein Q1 causes negative output when it stops conducting. Input of +8 V gives output of 12 V peak-to-peak.—W. D. Waddle, Switching Amplifier Converts Unipolar to Bipolar Pulses, *Electronics*, Oct. 3, 1966, p 103–104.

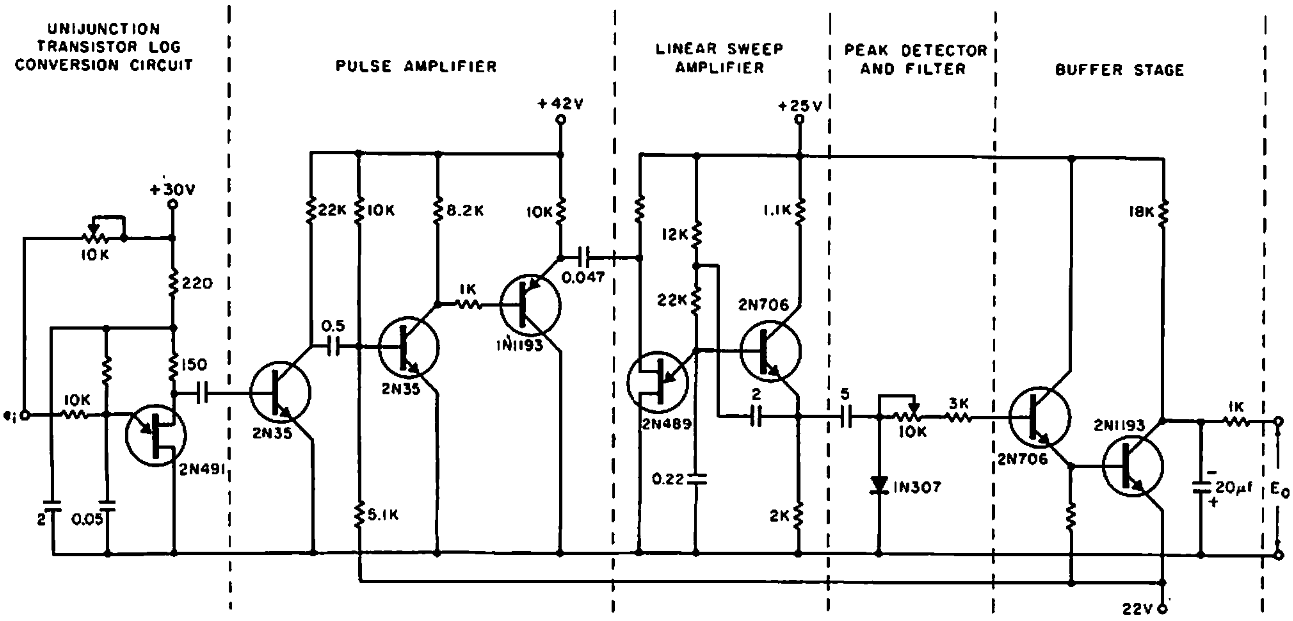


E_{CC} −25 v
R_C 5.6 k
D_1 1N198
$-E_2$ −6 v
D_2 1N198
R 0.5 k
R_B 6.8 k
+V
+8 v
E_{IN}
0
0 1 2 3
Q_1 2N107
$+E_1$ +8 v
R_L 3.9 k
E_{OUT}
+Eo
+6 v
0
−6 v
0 1 2 3
−Eo



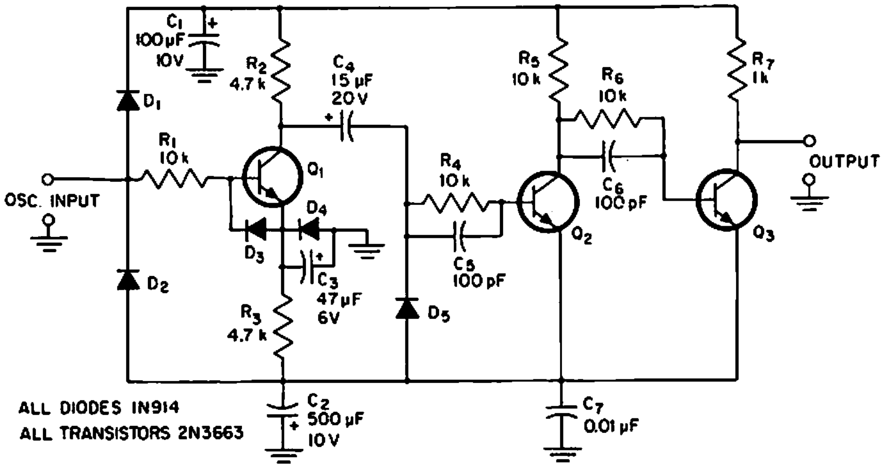
330
+125 v
300
1000pf
4:1
output
47
No. 5784
1000pf
f_{1in}
f_{2in}
1000pf
1000pf
91
680
1000pf
91
120
1000pf
1000pf
1000pf
680
680
25K
25v
25K
680
25v
1000pf

PENTODE MIXER—Developed for use in binary combination of oscillators and mixers for generating large number of discrete frequencies for phased (electronic scanning) radar. With 105 MHz at 0.7 rms applied to control grid and 40 MHz at same level applied to suppressor grid, second harmonic of 40-MHz signal is down 34 dB and all other harmonics are more than 50 dB below desired output signal.—G. F. Ross, Binary Generation of Frequencies Saves on Hardware, *Electronic Design*, Nov. 23, 1964, p 38–42 and 44–47.



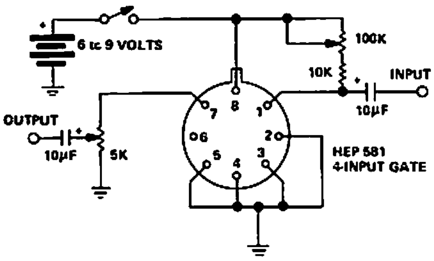
UNIJUNCTION TRANSISTOR LOG CONVERSION CIRCUIT
PULSE AMPLIFIER
LINEAR SWEEP AMPLIFIER
PEAK DETECTOR AND FILTER
BUFFER STAGE
+30V
10K
220
150
10K
e_i
2N491
2
0.05
+42V
22K
10K
8.2K
10K
2N35
0.5
2N35
1K
1N1193
0.047
5.1K
+25V
12K
1.1K
22K
2N706
2N489
0.22
2
2K
5
10K
3K
1N307
2N706
18K
2N1193
1K
20μf
E_0
22V

LINEAR TO LOGARITHMIC—Provides logarithmic d-c output for linear d-c input, using ujt in R-C relaxation oscillator network. Output pulses of ujt are amplified and used to synchronize linear sweep generator-amplifier. Resulting sawtooth pulses go through peak detector and filter to buffer amplifier that delivers desired d-c voltage, proportional to period of sync pulses and therefore proportional to natural logarithm of input voltage.—J. Sheehy, Device Provides DC Linear To Logarithmic Conversion, *Electronic Design*, July 6, 1964, p 50–51.

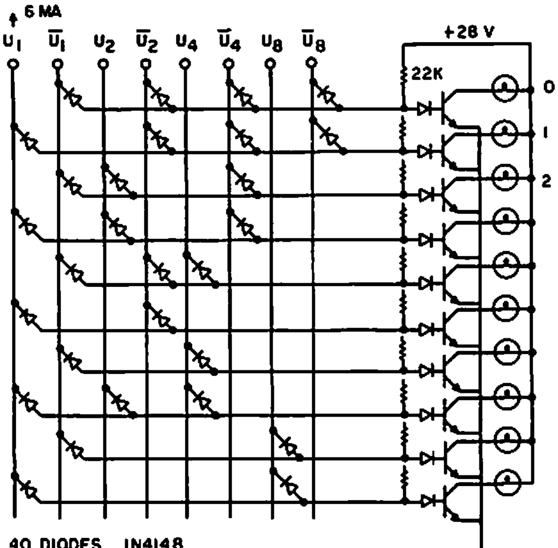

C1
100 μF
10V
R2
4.7 k
C4
15 μF
20V
R5
10 k
R6
10 k
R7
1k
D1
R1
10 k
Q1
OSC. INPUT
D4
D3
C3
47 μF
6V
R4
10 k
C5
100 pF
Q2
C6
100 pF
Q3
OUTPUT
D2
R3
4.7 k
D5
C2
500 μF
10V
C7
0.01 μF

ALL DIODES IN914
ALL TRANSISTORS 2N3663

SIGNAL-POWERED SINE-SQUARE—Delivers square-wave output in range of 2 to 16 V p-p at frequency of 600-ohm oscillator feeding input, in range of 5 Hz to 600 kHz. Circuit derives its own positive and negative supply voltages by rectification of input signal in D1 and D2. Output waveform is essentially independent of frequency, with 20-ns rise time and 30-ns fall time.—D. R. Morgan, Signal-Powered Sine-To-Square Wave Converter, *EEE*, Nov. 1969, p 107—108.

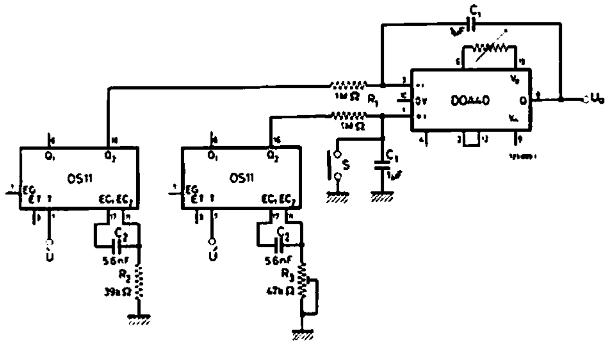

6 to 9 VOLTS
100K
10K
INPUT
10μF
OUTPUT
10μF
5K
8
7
1
6
2
5
4
3
HEP 581
4-INPUT GATE

SINE TO SQUARE-WAVE IC—Converts any audio signal generator with at least 2 V p-p output to high-quality square-wave generator. —"Tips on Using IC's," HMA-32, Motorola, Phoenix, Ariz., 1968.

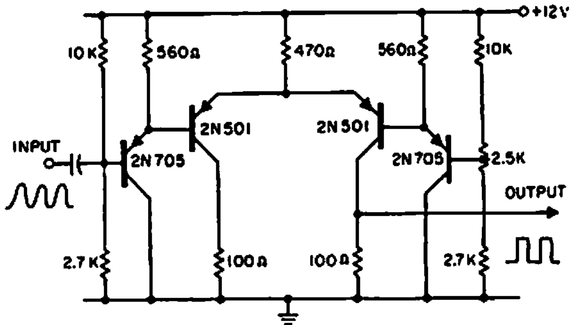

6 MA
U1
Ū1
U2
Ū2
U4
Ū4
U8
Ū8
+28 V
22K
0
1
2

40 DIODES IN4148
10 TRANSISTORS (2N3417)
LAMPS NO. 1829 40 MA @ 28V

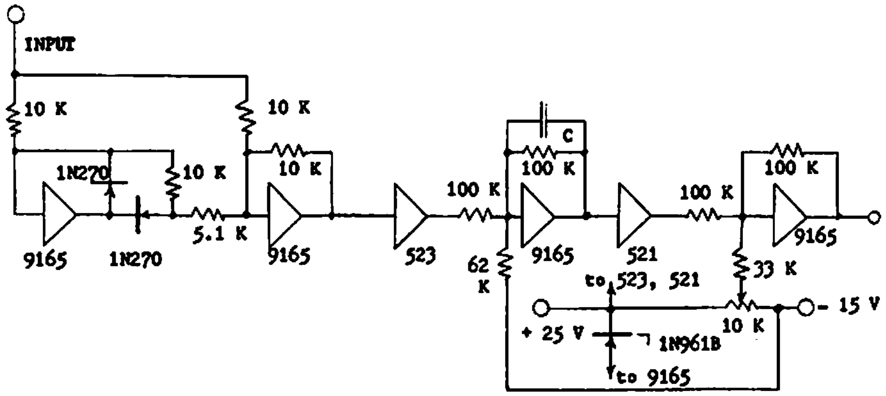
BINARY-TO-DECIMAL CONVERTER—Binary signal in 8-4-2-1 code is converted by diode matrix to decimal code which lights one of ten lamps, each having a transistor driver.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 11.


C1
1μF
DOA40
Uo
1MΩ
R1
1MΩ
C1
1μF
S
OS11
Q1
Q2
EC1 EC2
U
C2
56nF
R2
39kΩ
OS11
Q1
Q2
EC1 EC2
U
C2
56nF
R3
47kΩ

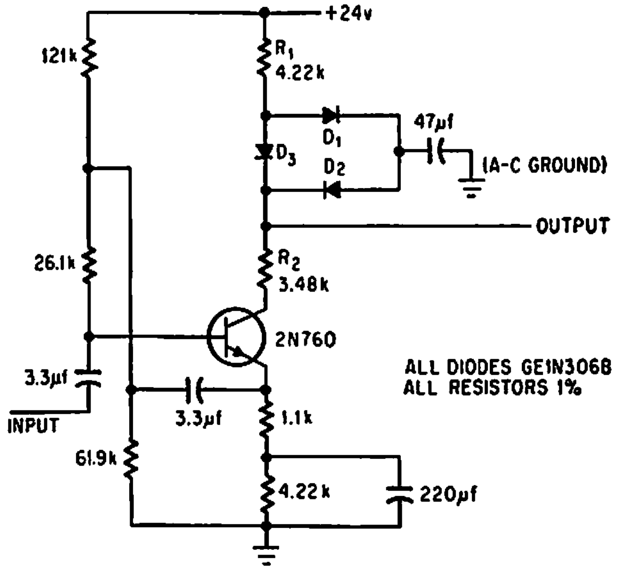
DIGITAL CONTROL OF VOLTAGE—Two parallel trains of information pulses are applied to balanced input terminals of Philips DOA40 IC opamp through two OS11 IC monostable mvbrs. With DOA40 externally connected as difference amplifier and integrator, output voltage Uo is proportional to difference between number of input pulses arriving per unit of time. This voltage is held even when no further pulses are delivered.—Electronic Potentiometer With 40- and 10-Series Circuit Blocks, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands.


+12V
10K
560Ω
470Ω
560Ω
10K
2N501
2N501
INPUT
2N705
2N705
2.5K
OUTPUT
2.7K
100Ω
100Ω
2.7K

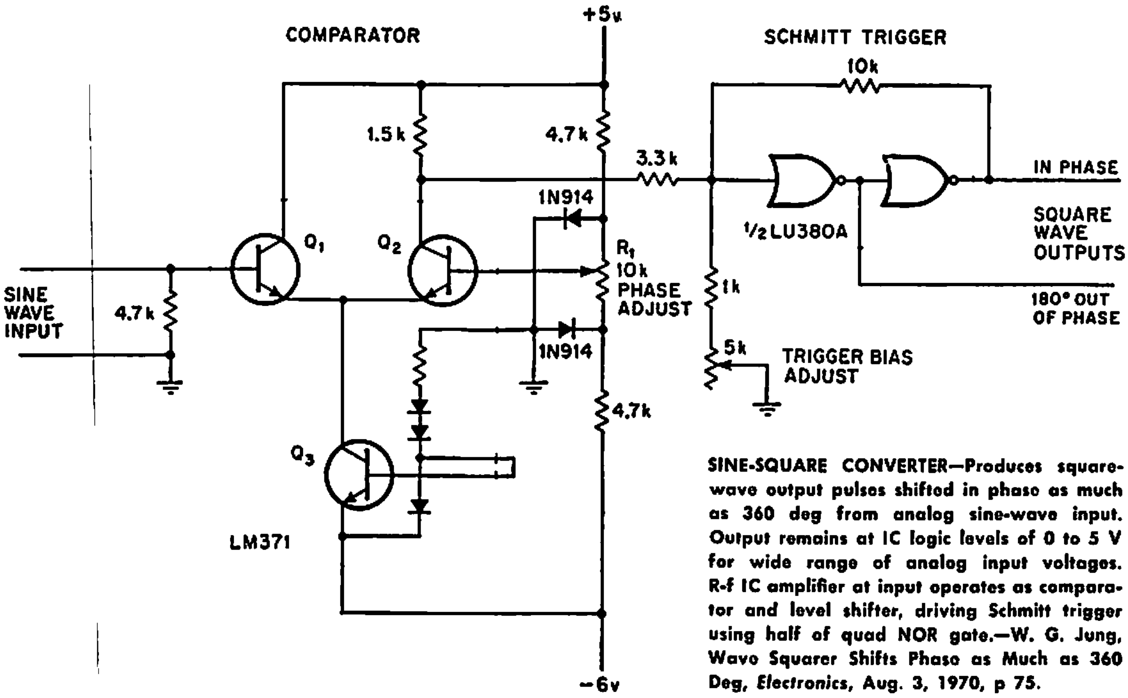
SINE-SQUARE CONVERTER—For 5-MHz sinewave input at 2 V p-p, output is 2-V p-p square wave having rise time of about 20 ns. Circuit uses emitter-coupled limiter in which rise time is limited only by switching times of transistors.—H. Hahn, Emitter-Coupled Limiter Produces HF Square Waves, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 66.


INPUT
10 K
10 K
1N270
10 K
10 K
5.1 K
9165
1N270
9165
523
100 K
C
100 K
9165
62 K
521
to 523, 521
100 K
100 K
9165
33 K
10 K
- 15 V
+ 25 V
1N961B
to 9165

RMS TO D-C—Provides d-c output voltage directly proportional to rms value of input voltage. Input passes through a-c/d-c converter, polar squaring, integrating, and square-root operations. Input levels are limited to about 5 V peak or 3.5 V rms. Requires both 15-V bipolar d-c and 25 V d-c supplies for OEI IC units. Upper frequency limit is about 10 kHz and accuracy is 3%.—A True RMS To DC Converter, Optical Electronics, Tucson, Ariz., No. 10058.


+24v
R1
4.22k
121k
47μf
D1
D3
D2
(A-C GROUND)
OUTPUT
26.1k
R2
3.48k
2N760
ALL DIODES GE1N3068
ALL RESISTORS 1%
3.3μf
INPUT
3.3μf
1.1k
61.9k
4.22k
220μf

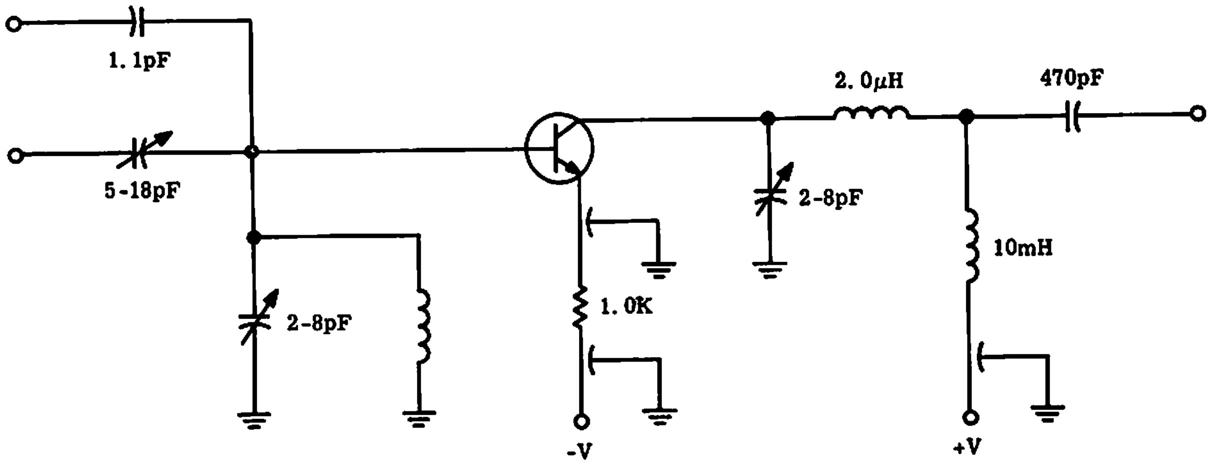
DIODE BIAS SUPPLY—Data-compressing converter delivers output voltage proportional to logarithm of a-c input over 36-dB range. Bias voltage is provided by single diode, instead of with separate batteries usually required.—R. K. Nisbett, Diode Bias Replaces Batteries in Logarithmic Converter, *Electronics*, Nov. 14, 1966, p 123–124.


+5v
COMPARATOR
SCHMITT TRIGGER
10k
1.5k
4.7k
3.3k
IN PHASE
1N914
Q1
Q2
R1
10k
PHASE ADJUST
1/2 LU380A
SQUARE WAVE OUTPUTS
SINE WAVE INPUT
4.7k
1k
180° OUT OF PHASE
1N914
5k
TRIGGER BIAS ADJUST
4.7k
Q3
LM371
-6v

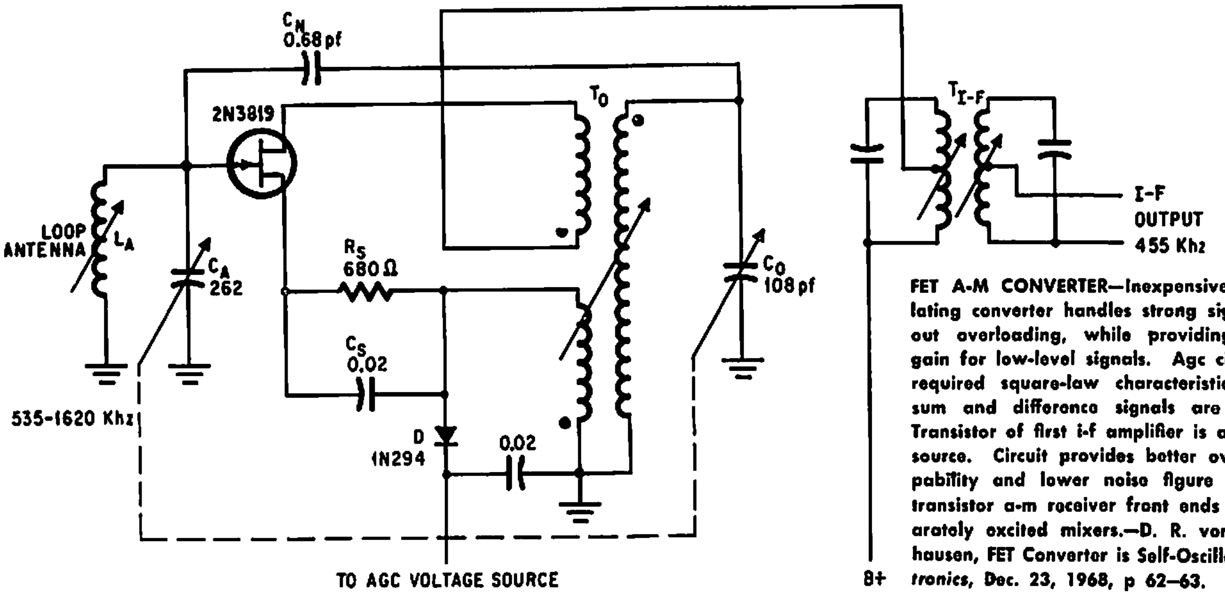
SINE-SQUARE CONVERTER—Produces square-wave output pulses shifted in phase as much as 360 deg from analog sine-wave input. Output remains at IC logic levels of 0 to 5 V for wide range of analog input voltages. R-f IC amplifier at input operates as comparator and level shifter, driving Schmitt trigger using half of quad NOR gate.—W. G. Jung, Wave Squarer Shifts Phase as Much as 360 Deg, *Electronics*, Aug. 3, 1970, p 75.

CHAPTER 19

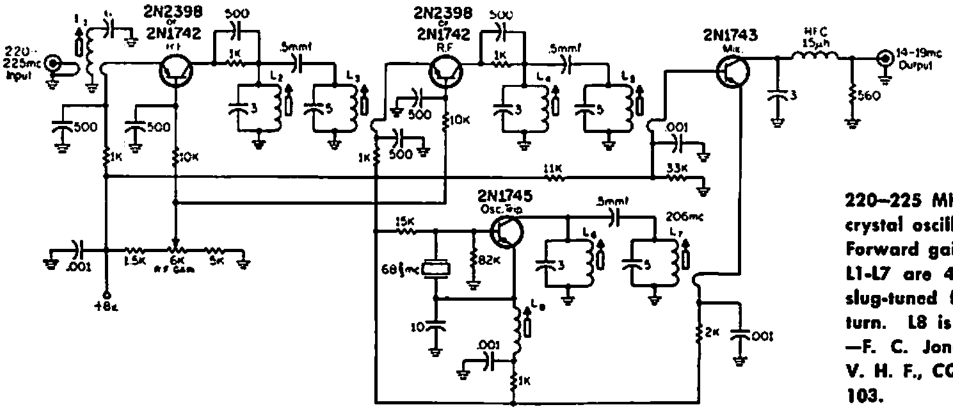
Converter Circuits—Radio


1. 1pF
5-18pF
2-8pF
1. 0K
-V
2. 0μH
2-8pF
470pF
10mH
+V

25 DB CONVERSION GAIN—With 300-MHz local oscillator signal (fed through 1.1 pF) and 250-MHz r-f signal injected into base of MM1941 transistor, output is 50 MHz. Report gives design procedure.—E. Klein, Transistor Mixer Design Using Admittance Parameters, Motorola, Phoenix, Ariz., AN-238, 1967.

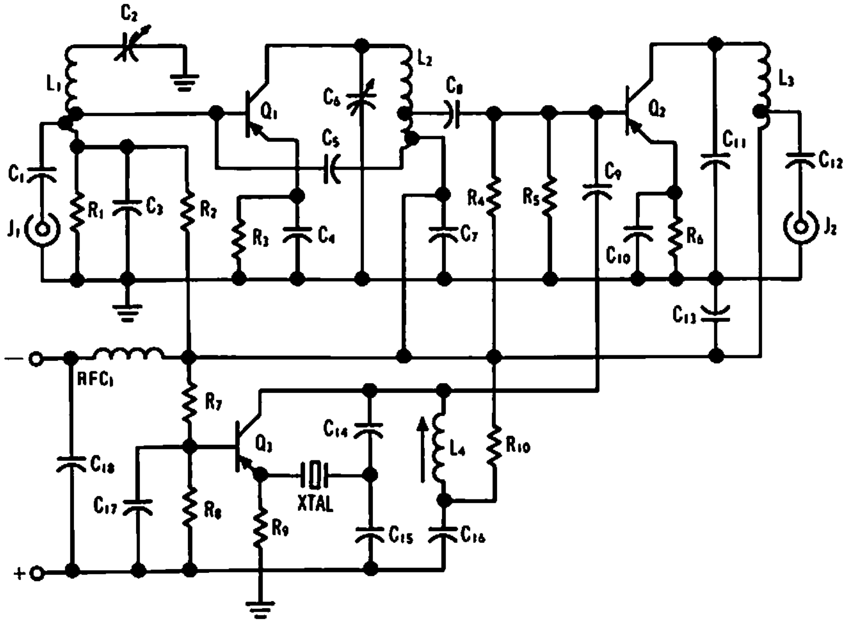

C_N
0.68 pf
2N3819
T_O
LOOP ANTENNA
L_A
C_A
262
R_S
680 Ω
C_S
0.02
D
1N294
0.02
C_O
108 pf
535-1620 Khz
TO AGC VOLTAGE SOURCE
T_{I-F}
I-F OUTPUT 455 Khz
B+

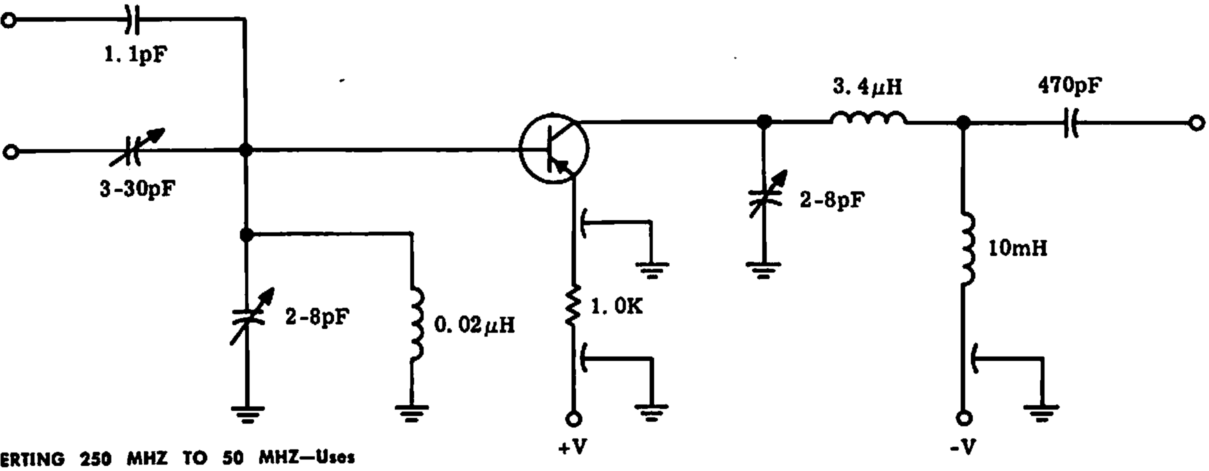
FET A-M CONVERTER—Inexpensive self-oscillating converter handles strong signals without overloading, while providing required gain for low-level signals. Agc circuit gives required square-law characteristic, so only sum and difference signals are produced. Transistor of first i-f amplifier is agc voltage source. Circuit provides better overload capability and lower noise figure than most transistor a-m receiver front ends using separately excited mixers.—D. R. von Recklinghausen, FET Converter is Self-Oscillating, *Electronics*, Dec. 23, 1968, p 62–63.


2N2398 or 2N1742
RF
2N2398 or 2N1742
R.F
2N1743
Mix.
HFC 15μh
14-19mc Output
220-225mc Input
500
1K
.5mmf
L2
L3
L4
L5
3
5
500
500
1K
10K
10K
1K
500
500
.001
11K
33K
560
2N1745
Osc.Trip.
.5mmf
206mc
15K
82K
68⅔mc
L6
L7
L8
10
.001
1K
2K
.001
1.5K
6K
RF Gain
5K
+8v

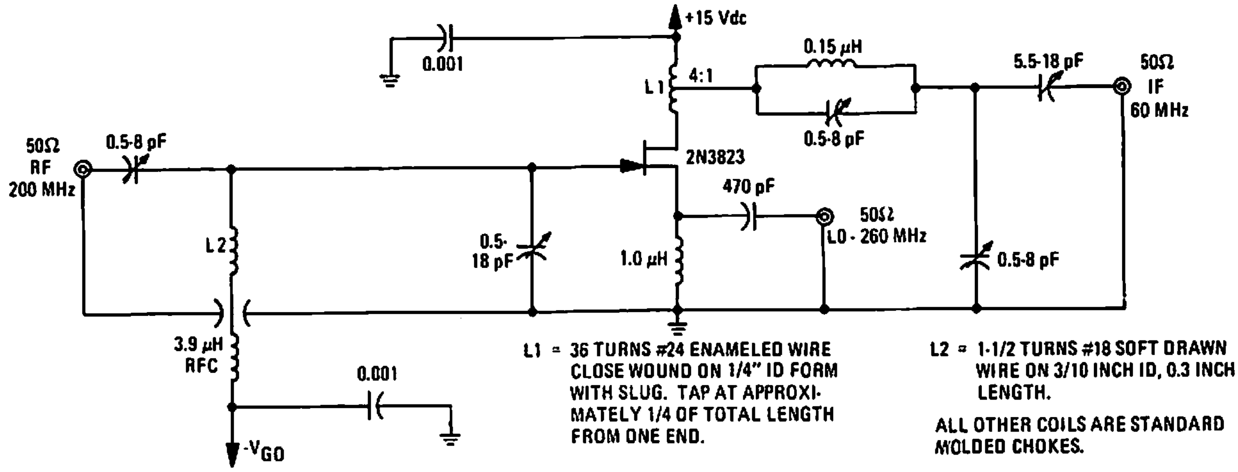
220–225 MHZ to 14–19 MHZ—Uses overtone crystal oscillator having tuned emitter circuit. Forward gain control acts on both r-f stages. L1-L7 are 4 turns No. 20 on ¼ inch brass slug-tuned forms. All coupling loops are 1 turn. L8 is 13 turns No. 24 on same form. —F. C. Jones, Transistorized Converters for V. H. F., CQ, Nov. 1966, p 36–40 and 102–103.

6-METER CONVERTER—If connected between antenna and antenna terminals of receiver that can be tuned to 7 MHz, permits reception of 50–54 MHz amateur band. Gives overall gain of 30 dB, with sensitivity of 1 μV for 10 dB s/n ratio at receiver audio output with 30% modulated signal. Article gives construction and alignment details. Crystal is 43-MHz third-overtone. Coil-winding data is given. Parts values are: R1 5.1K; R2 8.2K; R3 1.2K; R4 11K; R5 10K; R6 2K; R7 12K; R8 2.2K; R9 470; R10 1K; C1 0.003 μF; C2, C6 5-80 pF trimmer; C3, C7 0.1 μF; C4 0.01 μF; C5 18 pF; C8 0.001 μF; C9 5 pF; C10 0.05 μF; C11 25-380 pF trimmer; C12, C13, C16, C17, C18 0.02 μF; C14 12 pF; C15 82 pF; Q1, Q3 HEP3; Q2 HEP2; RFC1 18 μH; XTAL 43-MHz third-overtone.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 57–62.


C2
L1
L2
L3
Q1
Q2
Q3
C1
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
J1
J2
RFC1
L4
XTAL
−
+


1.1pF
3-30pF
2-8pF
0.02μH
1.0K
2-8pF
3.4μH
470pF
10mH
+V
-V

CONVERTING 250 MHZ TO 50 MHZ—Uses 2N3308 transistor, with base injection for both 250-MHz r-f signal and 300-MHz local oscillator signal fed through 1.1 pF. Report gives complete design procedure. Conversion gain is about 25 dB for 1 V input from local oscillator and 1.8 mV r-f input.—E. Klein, Transistor Mixer Design Using Admittance Parameters, Motorola, Phoenix, Ariz., AN-238, 1967.

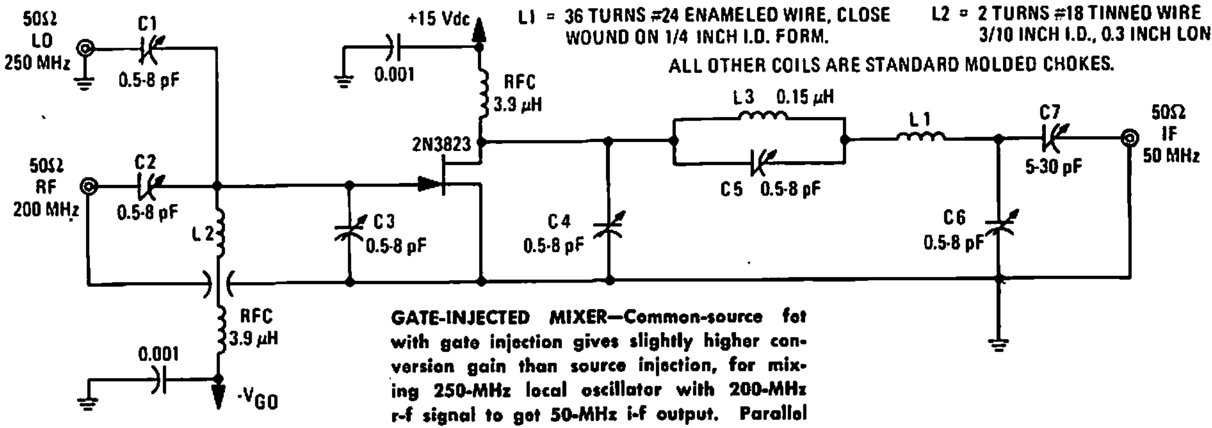

+15 Vdc
0.001
L1
4:1
0.15 μH
0.5-8 pF
5.5-18 pF
50Ω
IF
60 MHz
50Ω
RF
200 MHz
0.5-8 pF
2N3823
470 pF
50Ω
LO - 260 MHz
L2
0.5-
18 pF
1.0 μH
0.5-8 pF
3.9 μH
RFC
0.001
-V_{GO}

L1 = 36 TURNS #24 ENAMELED WIRE CLOSE WOUND ON 1/4" ID FORM WITH SLUG. TAP AT APPROXIMATELY 1/4 OF TOTAL LENGTH FROM ONE END.

L2 = 1-1/2 TURNS #18 SOFT DRAWN WIRE ON 3/10 INCH ID, 0.3 INCH LENGTH.

ALL OTHER COILS ARE STANDARD MOLDED CHOKES.

PARALLEL-TRAP MIXER—Trap removes 260-MHz local oscillator signal in 200-MHz common-source source-injection fet mixer. Autotransformer provides high-impedance matching at output. Conversion gain is 10 dB, noise figure 6.8 dB, and bandwidth 2.2 MHz.—S. P. Kwok, A Unified Approach to Optimum FET Mixer Design, Motorola, Phoenix, Ariz., AN-410, 1967.


50Ω
LO
250 MHz
C1
0.5-8 pF
+15 Vdc
0.001
RFC
3.3 μH
L3 0.15 μH
L1
C7
50Ω
IF
50 MHz
50Ω
RF
200 MHz
C2
0.5-8 pF
2N3823
C5 0.5-8 pF
5-30 pF
L2
C3
0.5-8 pF
C4
0.5-8 pF
C6
0.5-8 pF
RFC
3.9 μH
0.001
-V_{GO}

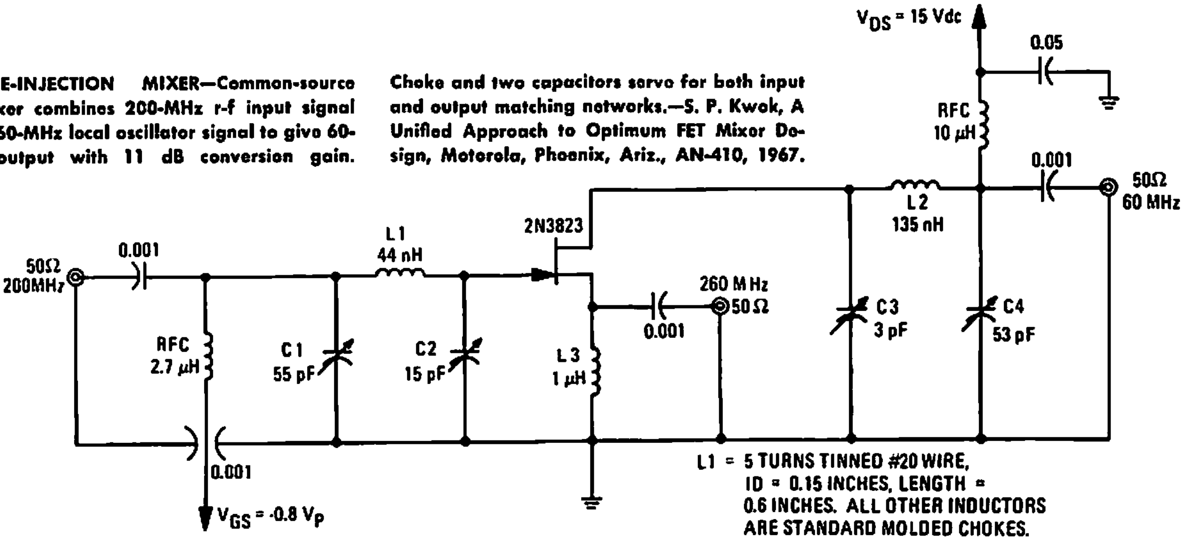
L1 = 36 TURNS #24 ENAMELED WIRE, CLOSE WOUND ON 1/4 INCH I.D. FORM.

L2 = 2 TURNS #18 TINNED WIRE 3/10 INCH I.D., 0.3 INCH LONG.

ALL OTHER COILS ARE STANDARD MOLDED CHOKES.

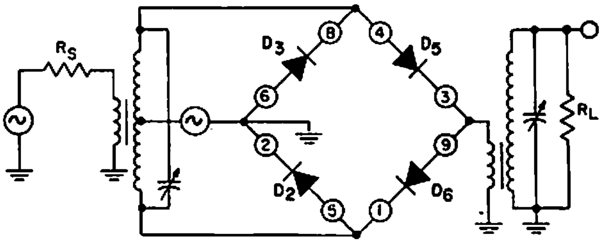
GATE-INJECTED MIXER—Common-source fet with gate injection gives slightly higher conversion gain than source injection, for mixing 250-MHz local oscillator with 200-MHz r-f signal to get 50-MHz i-f output. Parallel trap in output removes local oscillator signal. —S. P. Kwok, A Unified Approach to Optimum FET Mixer Design, Motorola, Phoenix, Ariz., AN-410, 1967.

SOURCE-INJECTION MIXER—Common-source fet mixer combines 200-MHz r-f input signal with 260-MHz local oscillator signal to give 60-MHz output with 11 dB conversion gain. Choke and two capacitors serve for both input and output matching networks.—S. P. Kwok, A Unified Approach to Optimum FET Mixer Design, Motorola, Phoenix, Ariz., AN-410, 1967.

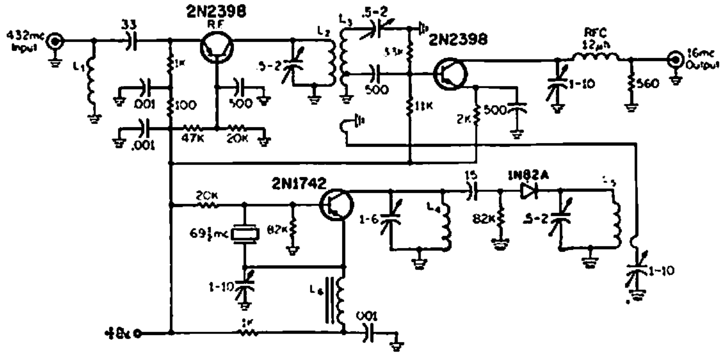

V_{DS} = 15 Vdc
0.05
RFC
10 μH
0.001
50Ω
60 MHz
L2
135 nH
2N3823
L1
44 nH
50Ω
200MHz
0.001
260 MHz
50Ω
0.001
RFC
2.7 μH
C1
55 pF
C2
15 pF
L3
1 μH
C3
3 pF
C4
53 pF
0.001
V_{GS} = -0.8 V_P

L1 = 5 TURNS TINNED #20 WIRE, ID = 0.15 INCHES, LENGTH = 0.6 INCHES. ALL OTHER INDUCTORS ARE STANDARD MOLDED CHOKES.

HALF-WAVE CARRIER SWITCH—Addition of two diodes (from CA3019 diode IC array) to conventional balanced mixer effectively doubles desired output voltage and halves undesired oscillator signal at output. Improvement in conversion gain cannot be realized above 20 MHz, because of capacitances associated with IC diodes.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 305.



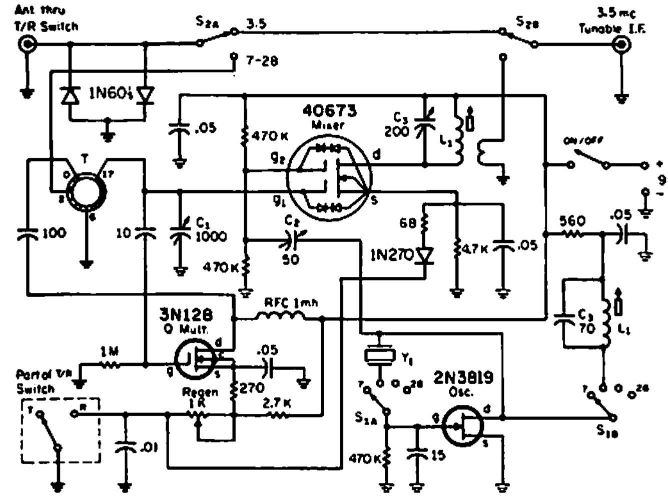
R_S
D_3
D_5
D_2
D_6
8
4
6
3
2
9
5
1
R_L



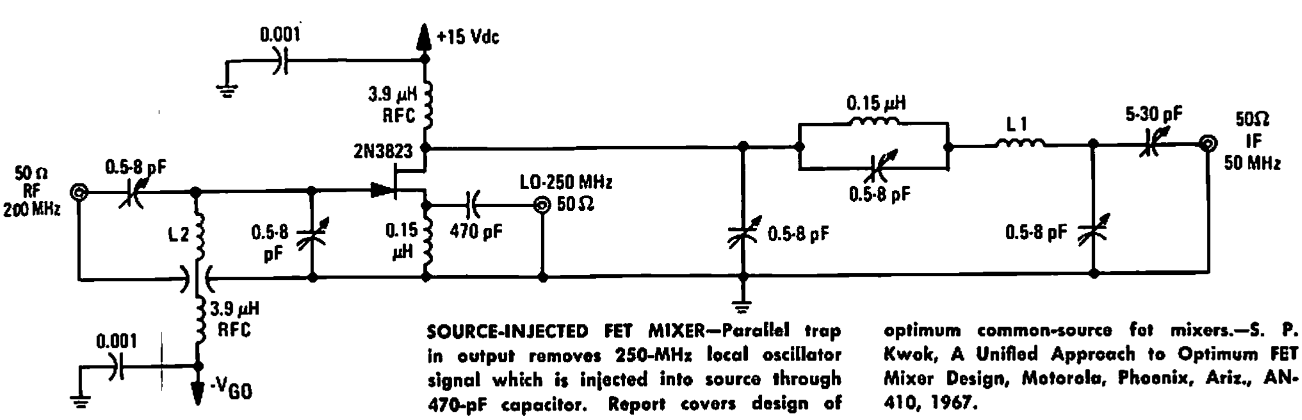
432mc Input
L_1
33
2N2398
RF
1K
.001
100
.001
47K
20K
500
.5-2
L_2
L_3
.5-2
33K
500
11K
2N2398
2K
500
RFC
12μh
1-10
560
16mc Output
2N1742
20K
69⅔mc
82K
1-10
L_6
1K
.001
+18v
1-6
L_4
15
1N82A
82K
.5-2
L_5
1-10

432 MHZ TO 16 MHZ—Overtone crystal shown is used for 16-MHz i-f; for 14-MHz i-f, use 69⅔ MHz crystal. Oscillator output is doubled in frequency by 1N82A diode. Article gives winding data for all coils.—F. C. Jones, Transistorized Converters for V. H. F., CQ, Nov. 1966, p 36–40 and 102–103.

ALL-BAND—High-Q toroidal antenna coil tunes from 7 to 28 MHz without bandswitching. L1 is 12-μH tube-type antenna coil in reverse. Use 10.5 MHz for Y1 and 1.5 μH for L2 to cover 7-MHz band, 17.5 MHz and 0.9 μH for 14 MHz, 24.5 MHz and 0.6 μH for 21 MHz, and 31.5 MHz and 0.5 μH for 28 MHz.—R. Jayaraman, A Deluxe 40673 Converter, CQ, Feb. 1970, p 46–48.

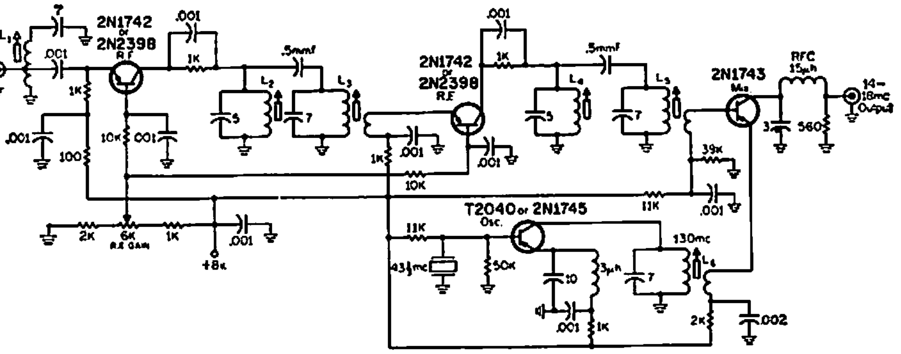


Ant thru T/R Switch
S_{2A}
3.5
7-28
S_{2B}
3.5mc Tunable I.F.
1N60's
T
0
17
8
6
100
10
C_1
1000
.05
470K
470K
40673
Mixer
g_2
g_1
d
s
C_2
50
C_3
200
L_1
ON/OFF
+
9v.
−
68
1N270
4.7K
.05
560
.05
C_3
70
L_1
3N128
Q Mult.
RFC 1mh
1M
g
d
s
.05
Partial T/R Switch
T
R
Regen
1K
270
2.7K
.01
Y_1
7
28
S_{1A}
470K
15
2N3819
Osc.
g
d
s
S_{1B}

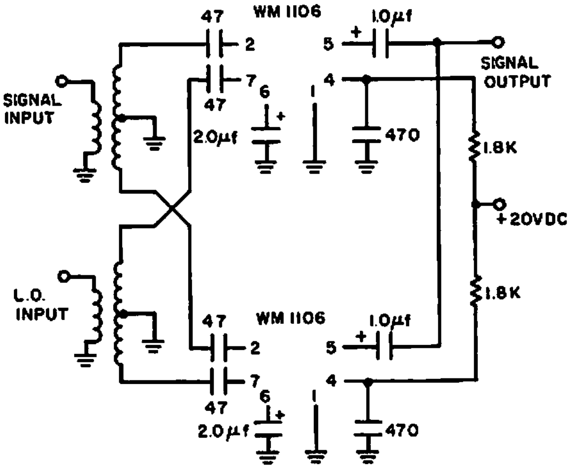


0.001
+15 Vdc
3.9 μH
RFC
2N3823
50 Ω
RF
200 MHz
0.5-8 pF
L2
0.5-8
pF
0.15
μH
470 pF
LO-250 MHz
50 Ω
0.15 μH
0.5-8 pF
L1
5-30 pF
50Ω
IF
50 MHz
0.5-8 pF
0.5-8 pF
3.9 μH
RFC
0.001
-V_{GO}

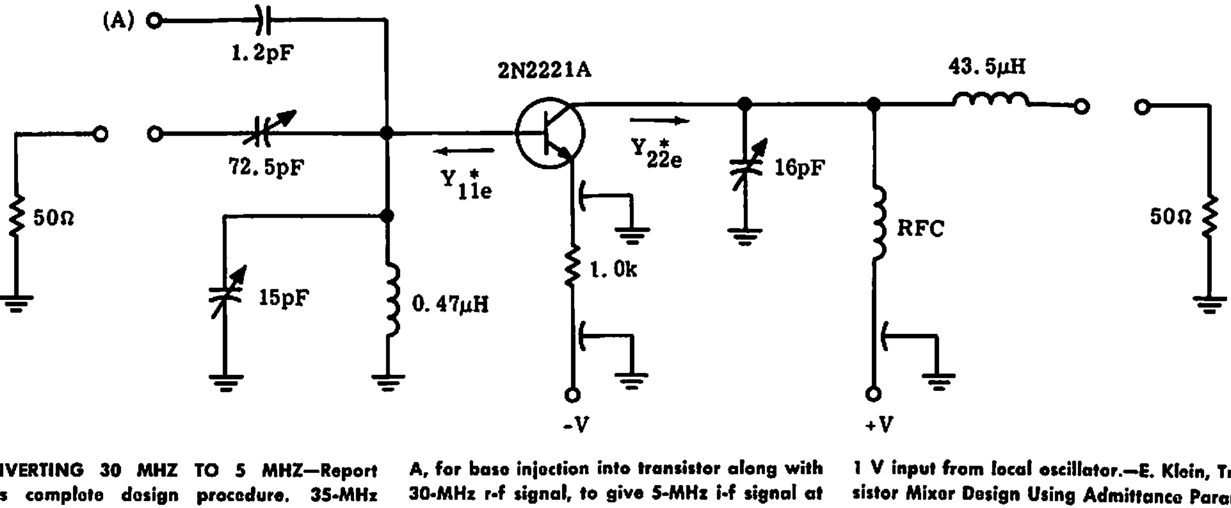
SOURCE-INJECTED FET MIXER—Parallel trap in output removes 250-MHz local oscillator signal which is injected into source through 470-pF capacitor. Report covers design of optimum common-source fet mixers.—S. P. Kwok, A Unified Approach to Optimum FET Mixer Design, Motorola, Phoenix, Ariz., AN-410, 1967.


144-148mc Input
L1
7
.001
1K
.001
100
2N1742 or 2N2398 RF
.001
1K
10K
.001
.5mmf
L2
L3
5
7
2K
6K R.F. GAIN
1K
.001
+8v
2N1742 or 2N2398 RF
.001
1K
.001
1K
.001
10K
.5mmf
L4
L5
5
7
2N1743 Mix
RFC 15μh
3
560
14-18mc Output
39K
11K
.001
T2040 or 2N1745 Osc.
11K
43⅓mc
50K
10
3μh
7
130mc
L6
.001
1K
2K
.002

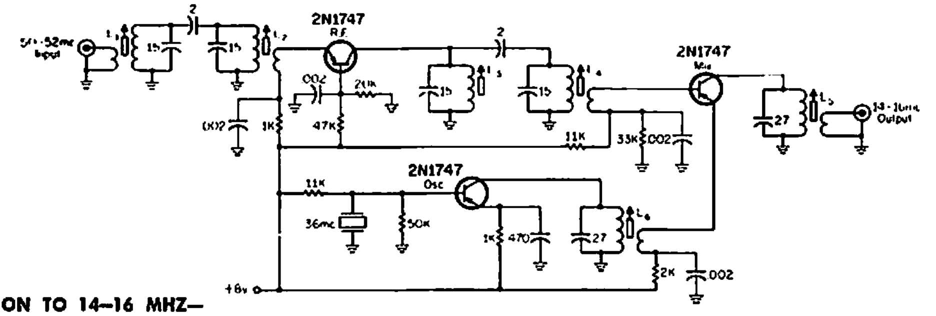
144–148 MHz TO 14–18 MHz—Overtone crystal oscillator furnishes 130 MHz signal to mixer. Has excellent frequency stability. Includes forward-type manual r-f gain control. All coils are 3 turns of number 20 wound on ⅜ inch brass slug-tuned forms. L1 is tapped at 1 turn, while L3, L4, and L5 have 1-turn secondaries.—F. C. Jones, Transistorized Converters for V. H. F., CQ, Nov. 1966, p 36–40 and 102–103.


47
WM 1106
1.0μf
2
5
+
SIGNAL OUTPUT
SIGNAL INPUT
7
6
47
1
4
2.0μf
+
470
1.8K
+20VDC
1.8K
L.O. INPUT
47
WM 1106
1.0μf
2
5
+
7
6
4
1
47
2.0μf
+
470

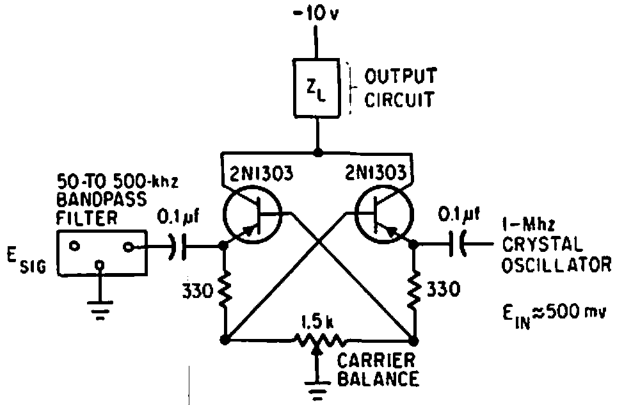
1 MHZ FROM 60 MHZ—Provides 20-dB suppression of 60-MHz i-f input signal and local oscillator signal in output, yet employs only simple fixed-tuned circuits using IC video amplifiers. Conversion gain is 5 dB. Uses double-balanced down converter.—S. G. Shepherd and A. E. Seman, Design With Integrated Circuits at 60 Mc, *Electronic Design*, Aug. 2, 1965, p 30–33.


(A)
1.2pF
72.5pF
50Ω
15pF
0.47μH
2N2221A
Y*11e
Y*22e
1.0k
-V
16pF
RFC
+V
43.5μH
50Ω

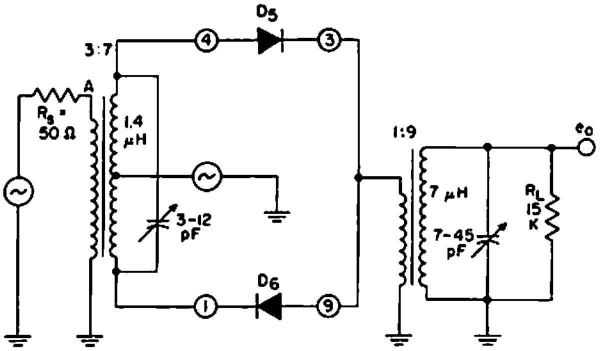
CONVERTING 30 MHZ TO 5 MHZ—Report gives complete design procedure. 35-MHz local oscillator signal is injected at terminal A, for base injection into transistor along with 30-MHz r-f signal, to give 5-MHz i-f signal at output. Conversion gain is above 30 dB for 1 V input from local oscillator.—E. Klein, Transistor Mixer Design Using Admittance Parameters, Motorola, Phoenix, Ariz., AN-238, 1967.


50-52mc Input
L1
15
2
15
L2
2N1747
RF
.002
20k
.002
1K
47K
2
15
L3
15
L4
11K
33K
.002
2N1747
Mix
27
L5
14-16mc Output
2N1747
Osc
11K
36mc
50K
1K
470
27
L6
2K
.002
+6v

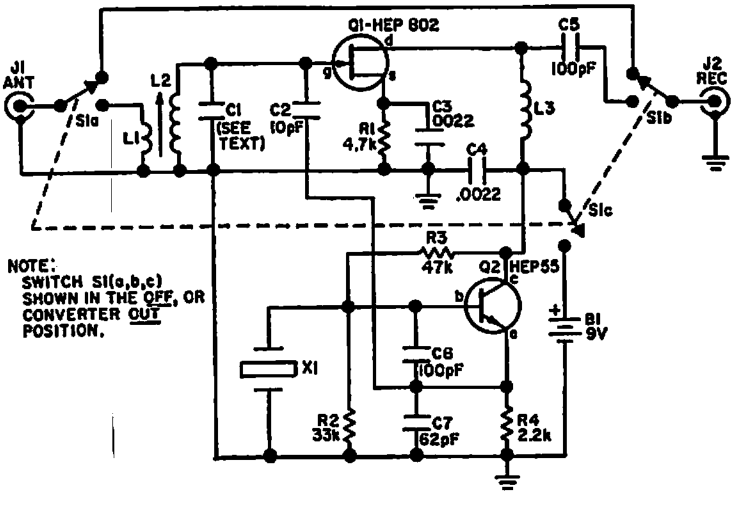
50–52 MHZ CONVERSION TO 14–16 MHZ—Four tuned circuits give good image suppression and i-f signal rejection. Can be used with either tube or transistor receiver that tunes to output frequency.—F. C. Jones, Transistorized Converters for V. H. F., CQ, Nov. 1966, p 36–40 and 102–103.


-10 v
Z_L
OUTPUT CIRCUIT
2N1303
2N1303
50-TO 500-khz BANDPASS FILTER
0.1 µf
E_SIG
0.1 µf
1-Mhz CRYSTAL OSCILLATOR
330
330
1.5 k
E_IN ≈ 500 mv
CARRIER BALANCE

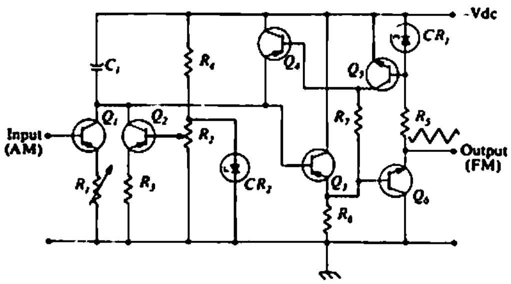
LOW-COST MIXER FOR 1-MHZ CARRIER—Two-transistor mixer eliminates costly transformer required by diode quad, and also provides conversion gain. Circuit cancels fundamental frequency and produces two sidebands across output load—for even-order harmonics of input and carrier. Crystal input amplitude is ten times 60-mV input signal amplitude.—L. E. Geisler, Cross-Coupled Transistors Form Balanced Mixer, *Electronics*, Oct. 17, 1966, p 91.


D5
3:7
4
3
A
R_s = 50 Ω
1.4 µH
3-12 pF
1:9
e_o
7 µH
7-45 pF
R_L 15 K
D6
1
9

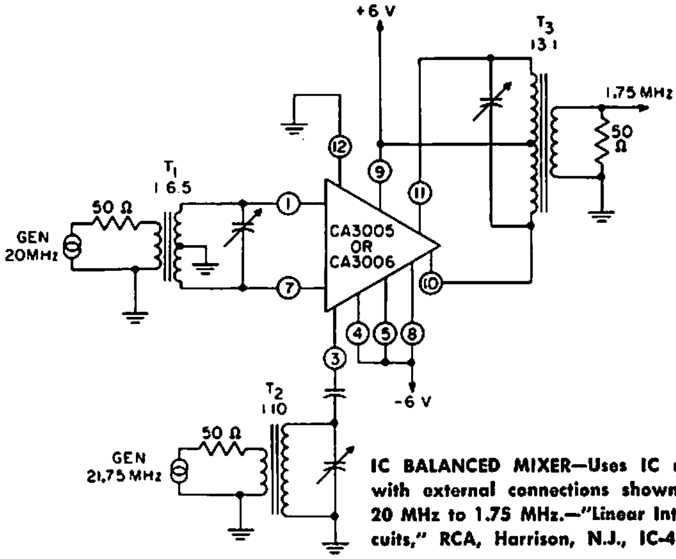
BALANCED MIXER—Uses two diodes in CA3019 diode IC array. Conversion gain for 45-MHz input signal and 55-MHz oscillator signal varies from −6 to −15 dB depending on oscillator voltage amplitude, and is −6 dB for 0.7 V.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 305.


Q1-HEP 802
d
g
s
C5
100pF
J1 ANT
J2 REC
S1a
S1b
L2
L1
C1 (SEE TEXT)
C2 10pF
R1 4.7k
C3 .0022
L3
C4 .0022
S1c
NOTE: SWITCH S1(a,b,c) SHOWN IN THE OFF, OR CONVERTER OUT POSITION.
R3 47k
Q2 HEP55
c
b
e
B1 9V
C6 100pF
X1
R2 33k
C7 62pF
R4 2.2k

AUTO POLICE-BAND CONVERTER—Uses single fet Q1 as mixer for receiving any 1-MHz band between 25 and 55 MHz on any auto or portable radio. Article gives instructions for calculating crystal frequency for oscillator Q2 to receive desired band. F-m signals in emergency and business bands are received by tuning auto radio off to one side, to take advantage of slope detection. Value of C1 is 33 pF for 25 to 35 MHz, 15 pF for 35 to 45 MHz, and 10 pF for 45 to 55 MHz. Construction details are given.—Edward A. Morris, Build SimCon, *Elementary Electronics*, Mar.–Apr. 1970, p 57–62.


-Vdc
C1
R4
Q4
Q5
CR1
Input (AM)
Q1
Q2
R2
R7
R5
Output (FM)
R1
R3
CR2
Q3
Q6
R6

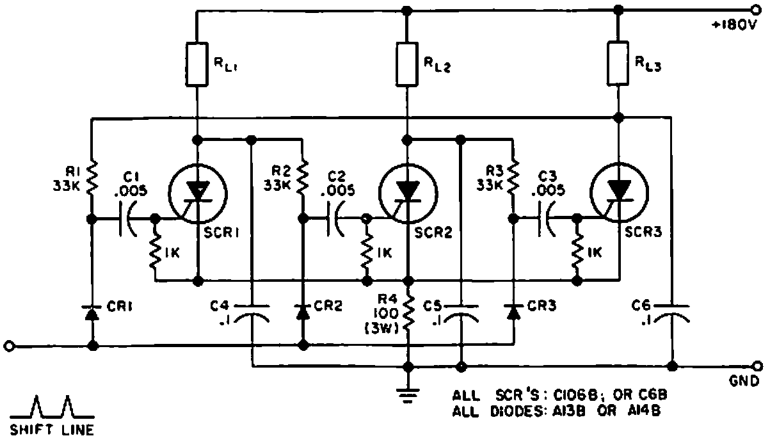
A-M TO F-M CONVERTER—Converts amplitude-modulated information to frequency-modulated information, with output frequency proportional to amplitude of input signal. R1 controls percentage of modulation or maximum number of cycles that signal will deviate from carrier position. Uses form of relaxation oscillator for conversion, with sawtooth output formed by charge and discharge of C1.—"Selected Electronic Circuitry," NASA SP-5046, Government Printing Office, Washington, D.C., p 16.


+6 V
T3
13:1
1.75 MHz
50 Ω
T1
1:6.5
50 Ω
GEN 20MHz
12
9
11
1
7
10
CA3005 OR CA3006
4
5
8
3
-6 V
T2
1:10
50 Ω
GEN 21.75 MHz

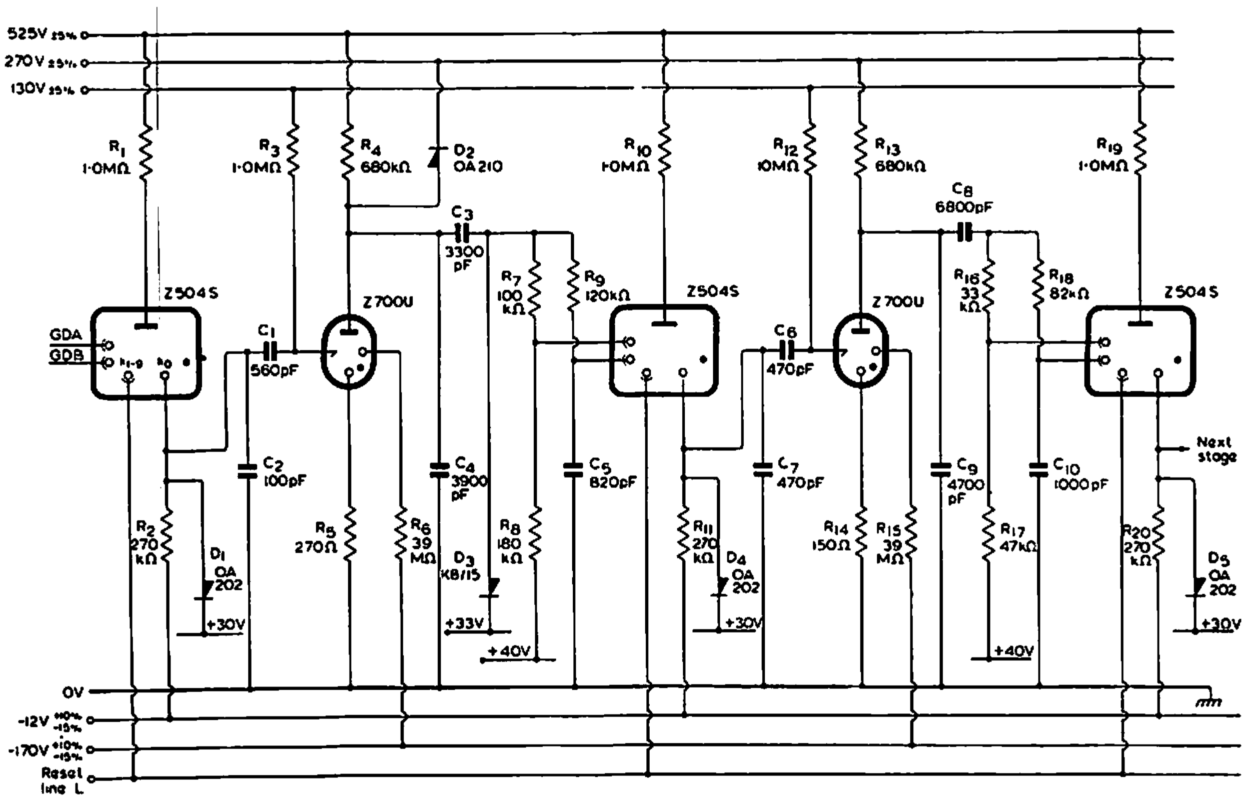
IC BALANCED MIXER—Uses IC r-f amplifier with external connections shown to convert 20 MHz to 1.75 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 227.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

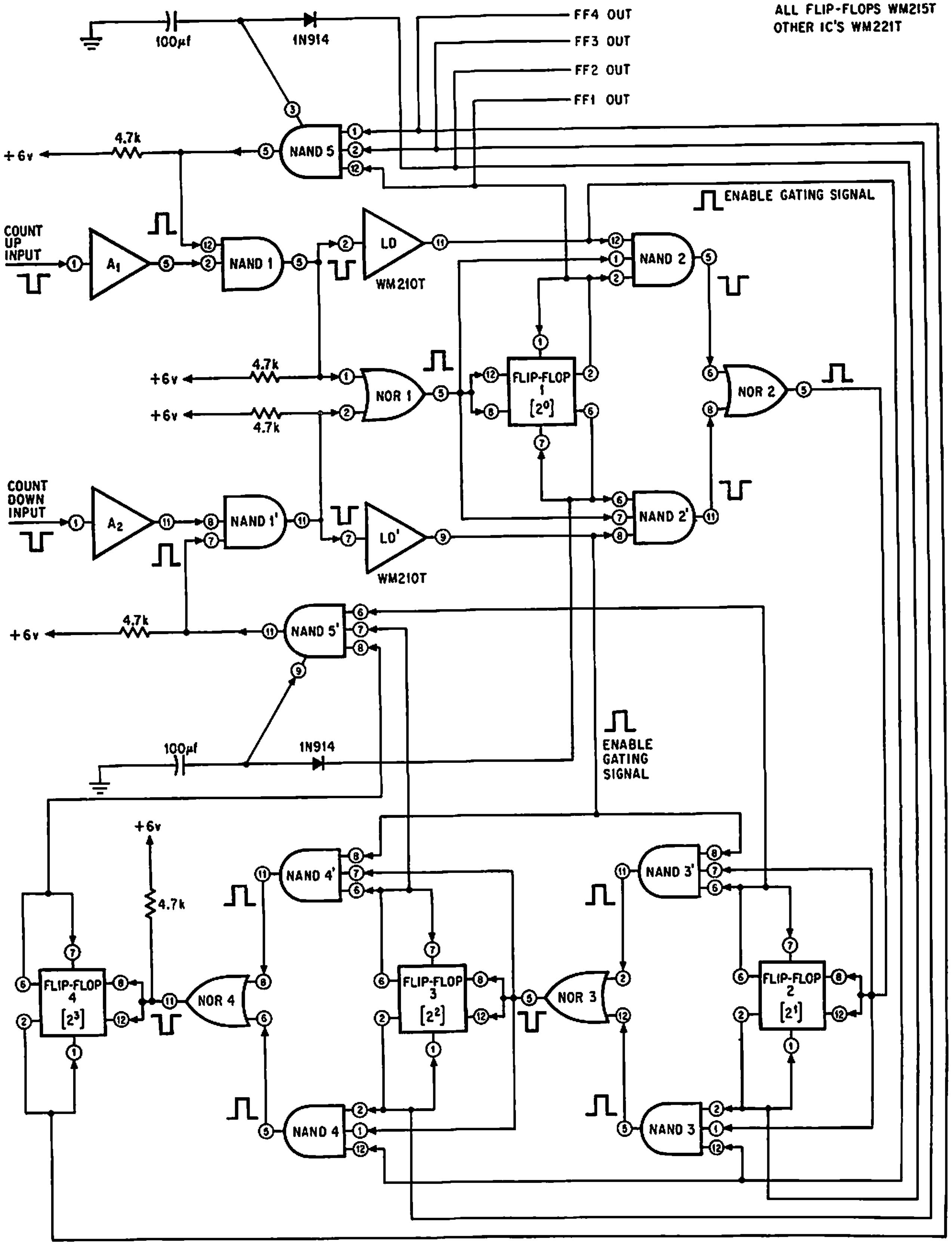
CHAPTER 20
Counter Circuits


+180V
R_{L1}
R_{L2}
R_{L3}
R1 33K
C1 .005
SCR1
1K
R2 33K
C2 .005
SCR2
1K
R3 33K
C3 .005
SCR3
1K
CR1
C4 .1
CR2
R4 100 (3W)
C5 .1
CR3
C6 .1
GND
ALL SCR'S: C106B; OR C6B
ALL DIODES: A13B OR A14B
SHIFT LINE

CATHODE-COUPLED SCR RING—Will drive high-voltage loads requiring currents up to 50 mA. Chief advantage is that square waves across each load are undistorted and free from commutation transients. Chief drawback is limitation placed on circuit speed by large values of commutating capacitors C4, C5, and C6.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 26.

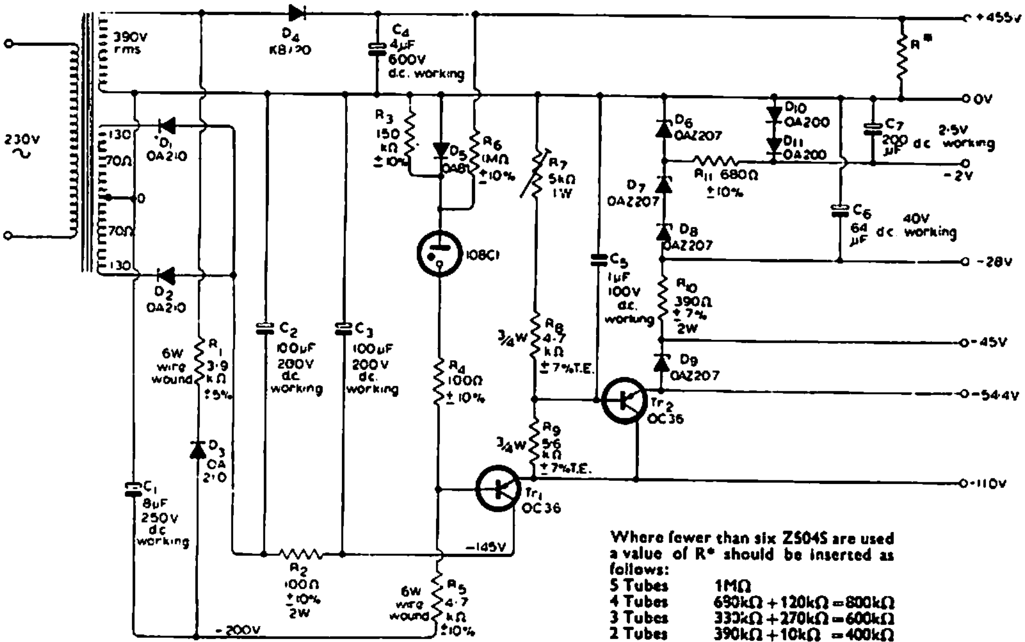

525V ±5%
270V ±5%
130V ±5%
R_1 1·0MΩ
R_3 1·0MΩ
R_4 680kΩ
D_2 OA210
R_{10} 1·0MΩ
R_{12} 10MΩ
R_{13} 680kΩ
R_{19} 1·0MΩ
C_3 3300 pF
C_8 6800pF
R_7 100 kΩ
R_9 120kΩ
R_{16} 33 kΩ
R_{18} 82kΩ
Z504S
Z700U
Z504S
Z700U
Z504S
GDA
GDB
k1-9
k0
C_1 560pF
C_6 470pF
C_2 100pF
C_4 3900 pF
C_5 820pF
C_7 470pF
C_9 4700 pF
C_{10} 1000pF
Next stage
R_2 270 kΩ
D_1 OA 202
+30V
R_5 270Ω
R_6 39 MΩ
D_3 K8/15
+33V
R_8 180 kΩ
+40V
R_{11} 270 kΩ
D_4 OA 202
+30V
R_{14} 150Ω
R_{15} 39 MΩ
R_{17} 47kΩ
+40V
R_{20} 270 kΩ
D_5 OA 202
+30V
0V
-12V +10% -15%
-170V +10% -15%
Reset line L

4-KHZ COUNTER CHAIN—Uses three gas-filled decade counter tubes, for counting units, tens, and hundreds at maximum speed of 4 kHz. First two tubes are coupled by 400-Hz cold-cathode trigger tube circuits, and last two tubes are coupled by 40-Hz circuit. Chain can be continued with 40-Hz coupling circuits.—G. F. Jaynes and S. Zilkha, Trigger Tube Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 16–25.


ALL FLIP-FLOPS WM215T
OTHER IC'S WM221T

FF4 OUT
FF3 OUT
FF2 OUT
FF1 OUT
100μf
1N914
+6v
4.7k
NAND 5
COUNT UP INPUT
A₁
NAND 1
LD
WM210T
ENABLE GATING SIGNAL
NAND 2
NOR 1
FLIP-FLOP 1 [2⁰]
NOR 2
COUNT DOWN INPUT
A₂
NAND 1'
LD'
WM210T
NAND 2'
NAND 5'
ENABLE GATING SIGNAL
NAND 4'
NAND 3'
FLIP-FLOP 4 [2³]
NOR 4
FLIP-FLOP 3 [2²]
NOR 3
FLIP-FLOP 2 [2¹]
NAND 4
NAND 3

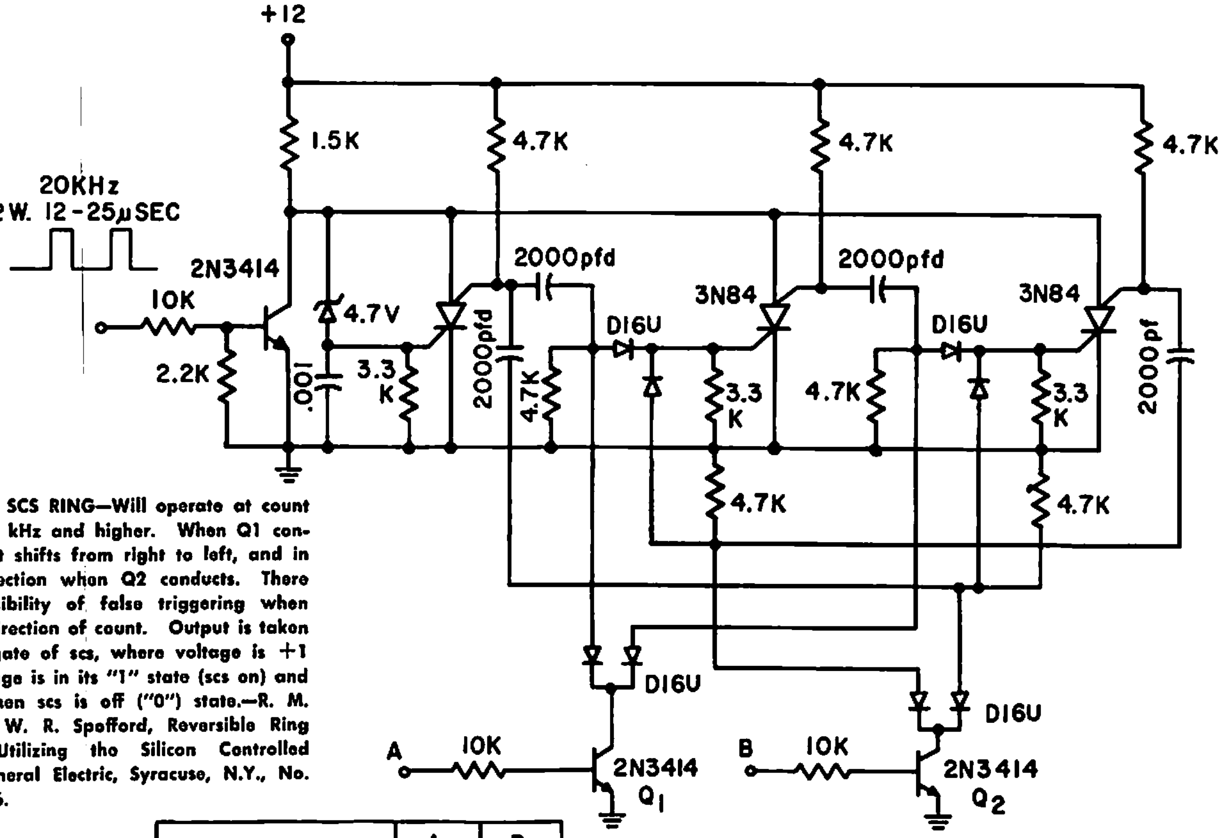
REVERSIBLE COUNTER WITH IC'S—Four stages are shown, to give general solution involving use of NAND gates and other digital IC's. Two identical serial counters share single set of flip-flops but reset in opposite directions. Article gives step-by-step description of counter operation. Switching speed is 150 ns.—L. J. Brocato, Digital IC's Shrink Reversible Counter, *Electronics*, Oct. 16, 1967, p 96–98.


390V rms
230V ~
130
70Ω
0
70Ω
130
D1 OA210
D2 OA210
D4 KB/20
C4 4μF 600V d.c. working
R1 3·9 kΩ ±5% 6W wire wound
D3 OA 210
C1 8μF 250V dc working
C2 100μF 200V dc working
C3 100μF 200V dc working
R2 100Ω ±10% 2W
-200V
R3 150 kΩ ±10%
D5 OA81
R6 1MΩ ±10%
108C1
R4 100Ω ±10%
R5 4·7 kΩ ±10% 6W wire wound
-145V
R7 5kΩ 1W
R8 4·7 kΩ ±7%T.E. ¾W
R9 5·6 kΩ ±7%T.E. ¾W
Tr1 OC36
Tr2 OC36
C5 1μF 100V d.c. working
D6 OAZ207
D7 OAZ207
D8 OAZ207
D9 OAZ207
R10 390Ω ±7% 2W
R11 680Ω ±10%
D10 OA200
D11 OA200
C7 200 μF 2·5V dc working
C6 64 μF 40V dc working
R*
+455V
0V
-2V
-28V
-45V
-54·4V
-110V

Where fewer than six Z504S are used a value of R* should be inserted as follows:

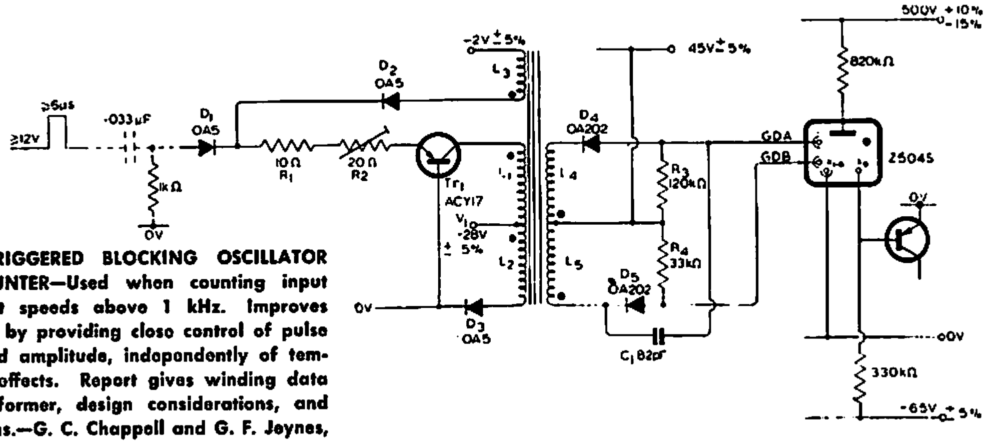
5 Tubes	1MΩ
4 Tubes	680kΩ + 120kΩ = 800kΩ
3 Tubes	330kΩ + 270kΩ = 600kΩ
2 Tubes	390kΩ + 10kΩ = 400kΩ
1 Tube	120kΩ + 82kΩ = 200kΩ

SIX-DECADE SCALER POWER SUPPLY—Provides all voltages required for six-decade scaler using Z504S decade stepping tube, with either photoelectric or triggered blocking-oscillator input.—G. C. Chappell and G. F. Jaynes, Transistor Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 26–38.

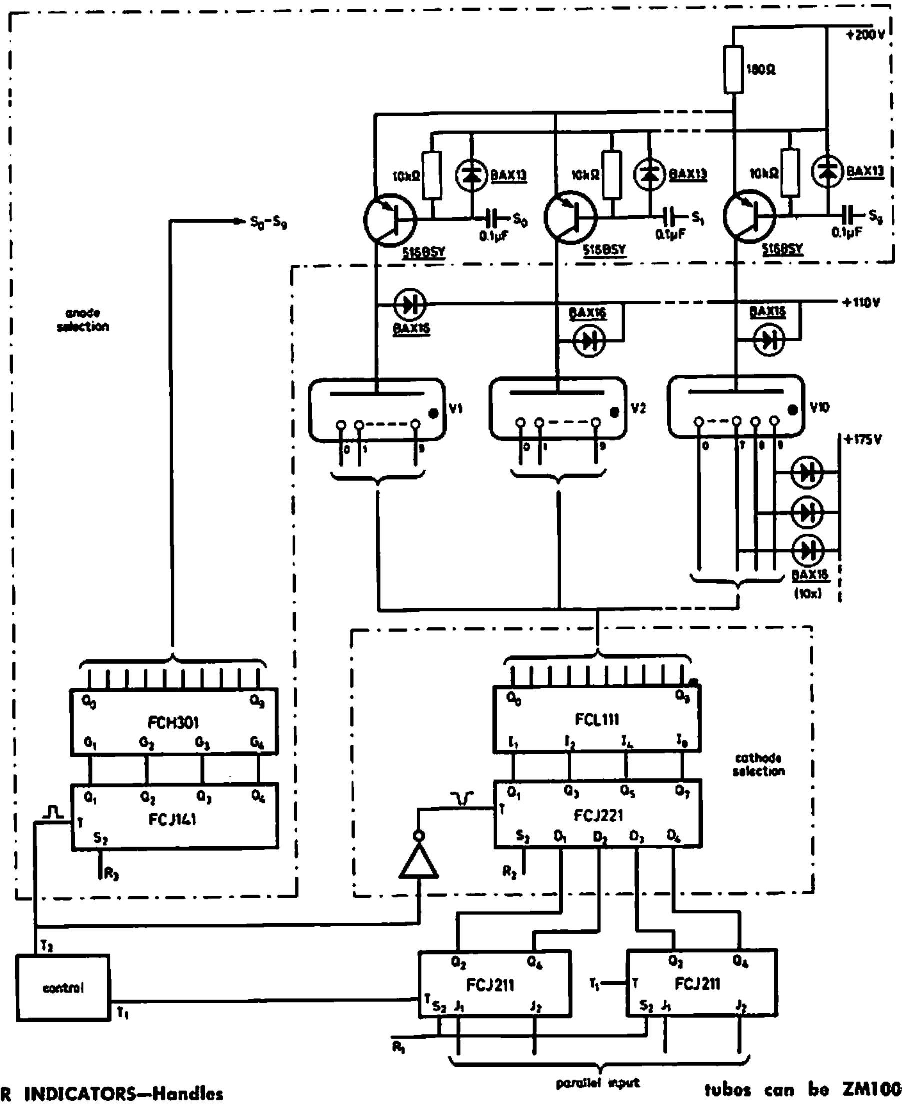

+12
20KHz
P.W. 12-25μSEC
10K
2.2K
2N3414
1.5K
4.7V
.001
3.3 K
4.7K
2000pfd
2000pfd
4.7K
D16U
3.3 K
4.7K
3N84
4.7K
2000pfd
4.7K
D16U
3.3 K
4.7K
3N84
4.7K
2000pf
D16U
D16U
A
10K
2N3414
Q1
B
10K
2N3414
Q2

REVERSIBLE SCS RING—Will operate at count rates of 20 kHz and higher. When Q1 conducts, count shifts from right to left, and in reverse direction when Q2 conducts. There is no possibility of false triggering when changing direction of count. Output is taken at anode gate of scs, where voltage is +1 V when stage is in its "1" state (scs on) and +12 V when scs is off ("0") state.—R. M. Muth and W. R. Spofford, Reversible Ring Counters Utilizing the Silicon Controlled Switch, General Electric, Syracuse, N.Y., No. 90.58, 1966.

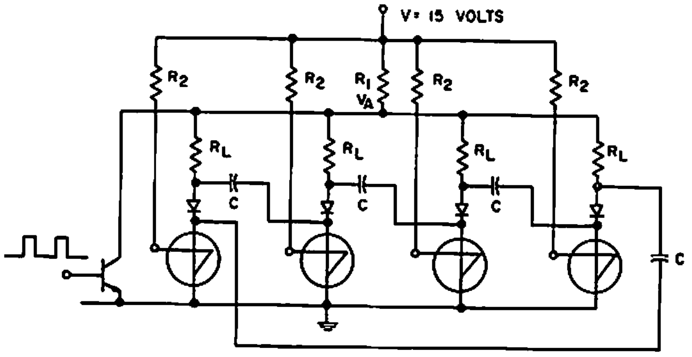
	A	B
COUNT LEFT	+12	0
COUNT RIGHT	0	+12


≥5µs
≥12V
·033µF
1kΩ
0V
D1
OA5
D2
OA5
10Ω
R1
20Ω
R2
-2V ± 5%
L3
Tr1
ACY17
V1
-28V
± 5%
L1
L2
0V
D3
OA5
D4
OA202
L4
L5
D5
OA202
C1 82pF
45V ± 5%
R3
120kΩ
R4
33kΩ
500V +10% −15%
820kΩ
GDA
GDB
Z504S
0V
0V
330kΩ
-65V ± 5%

4-KHZ TRIGGERED BLOCKING OSCILLATOR FOR COUNTER—Used when counting input signals at speeds above 1 kHz. Improves reliability by providing close control of pulse shape and amplitude, independently of temperature effects. Report gives winding data for transformer, design considerations, and waveforms.—G. C. Chappell and G. F. Joynes, Transistor Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 26–38.

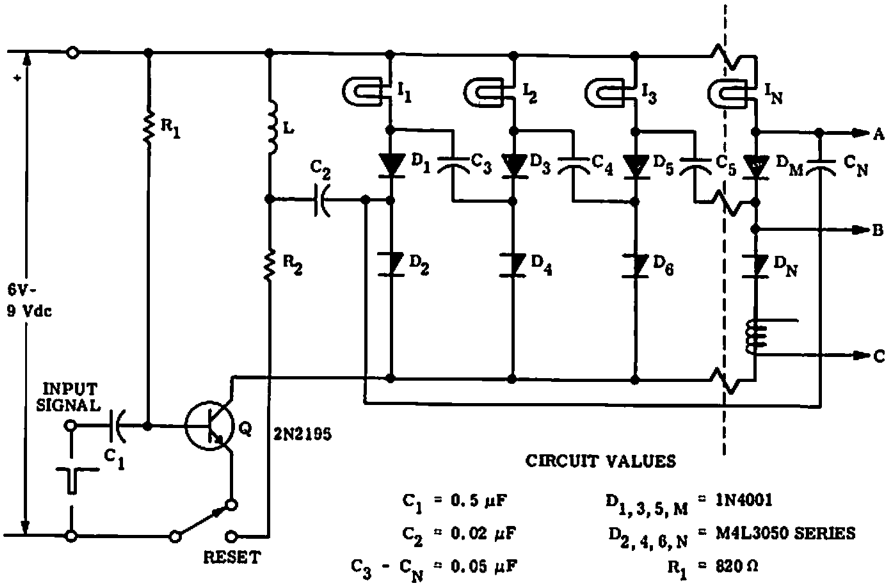

+200V
180Ω
10kΩ
BAX13
S0
0.1µF
S1
S9
S16BSY
S0–S9
anode selection
BAX16
+110V
V1
V2
V10
0
1
9
7
8
+175V
BAX16 (10x)
Q0
Q9
FCH301
Q1
Q2
Q3
Q4
FCJ141
T
S2
R3
FCL111
I1
I2
I4
I8
cathode selection
FCJ221
Q1
Q3
Q5
Q7
S2
D1
D2
D3
D4
R2
control
T2
T1
FCJ211
Q2
Q4
T
S2
J1
J2
R1
T1
parallel input

DYNAMIC DRIVE FOR INDICATORS—Handles ten numerical indicator tubes, of which three are shown. R1, R2, and R3 are reset terminals. Counter function is provided by Philips FCJ141 IC four-stage asynchronous decade counter producing NBCD-coded outputs. FCJ221 is Philips quadruple-latch flip-flop, FCJ211 is 4-bit shift register, and FCL111 is decoder-driver. Numerical indicator tubes can be ZM1000.—Ph. de Weger, Numerical Indicator Tube Drive Using the FC Family of Integrated Circuits, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 58, 1969.


V = 15 VOLTS
R2
R1
VA
RL
C

R1 = 2.2K
R2 = 8.2K
RL = 1.0K
C = .001

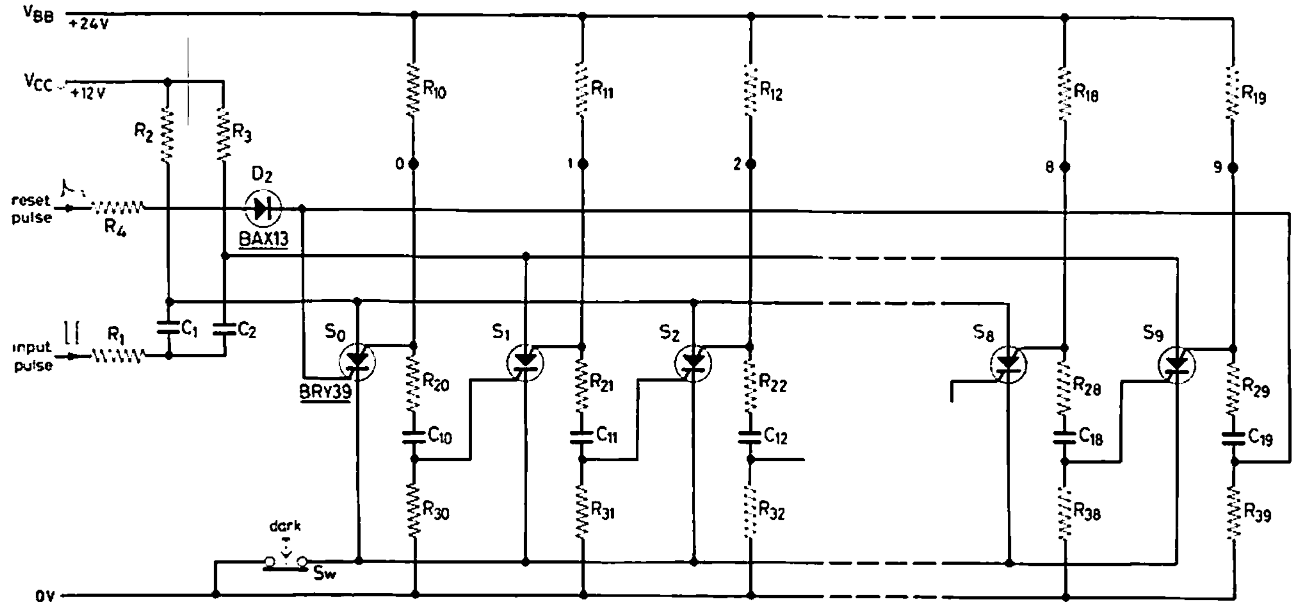
SUS RING WITH RATE-EFFECT RESISTOR—Uses resistor from supply to each gate lead to suppress rate effect. Will operate up to 10 kHz with type D13P1 sus and resistive loads such as lamps. Uses common-cathode connection. When supply voltage is applied, sus with lowest switching voltage comes on first, and succeeding pulses step count along.—W. R. Spofford, Jr., Applications of the New Silicon Bilateral Switch and the Silicon Unilateral Switch, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 7.


+
6V-
9 Vdc
R1
L
C2
R2
I1
I2
I3
IN
D1
C3
D3
C4
D5
C5
DM
CN
D2
D4
D6
DN
A
B
C
INPUT
SIGNAL
C1
Q
2N2195
RESET

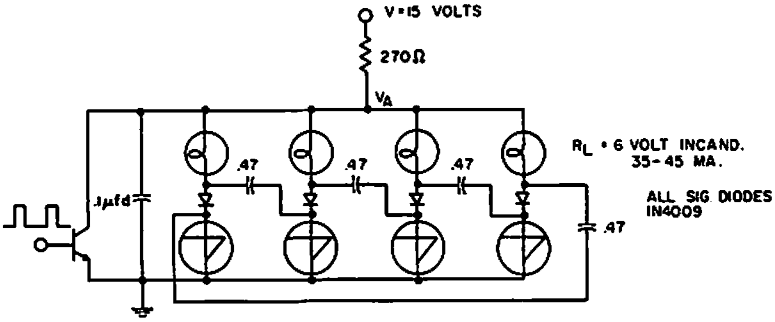
RING COUNTER WITH LAMPS—Sequentially transfers power to series of loads in response to pulse-train input signal. Any number of stages may be used. Output signals may be picked up as negative pulses at A or B, by current sensing at C, or by light sensing if lamps are used as loads. Input signal must be 6-mA negative current pulse lasting about 500 μs. Reset switch must be pressed and released after power is applied, to start operation.—J. Bliss and D. Zinder, 4-Layer and Current-Limiter Diodes Reduce Circuit Cost and Complexity, Motorola, Phoenix, Ariz., AN-221, 1966.

CIRCUIT VALUES

C_1 = 0.5 μF
C_2 = 0.02 μF
C_3 - C_N = 0.05 μF
L = 10 mH
$D_{1,3,5,M}$ = 1N4001
$D_{2,4,6,N}$ = M4L3050 SERIES
R_1 = 820 Ω
R_2 = 51 Ω
Q = 2N2195

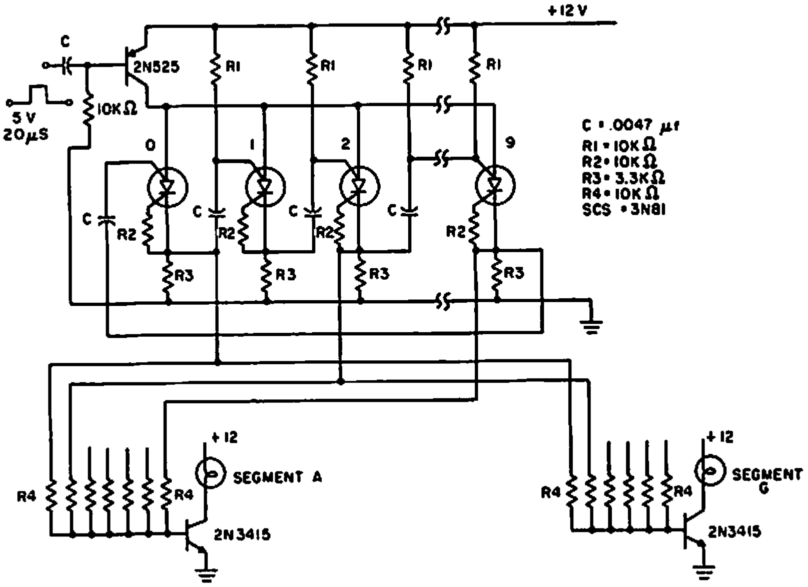

VBB
+24V
VCC
+12V
R2
R3
D2
BAX13
reset pulse
R4
input pulse
R1
C1
C2
R10
R11
R12
R18
R19
0
1
2
8
9
S0
S1
S2
S8
S9
BRY39
R20
R21
R22
R28
R29
C10
C11
C12
C18
C19
R30
R31
R32
R38
R39
dark
Sw
0V

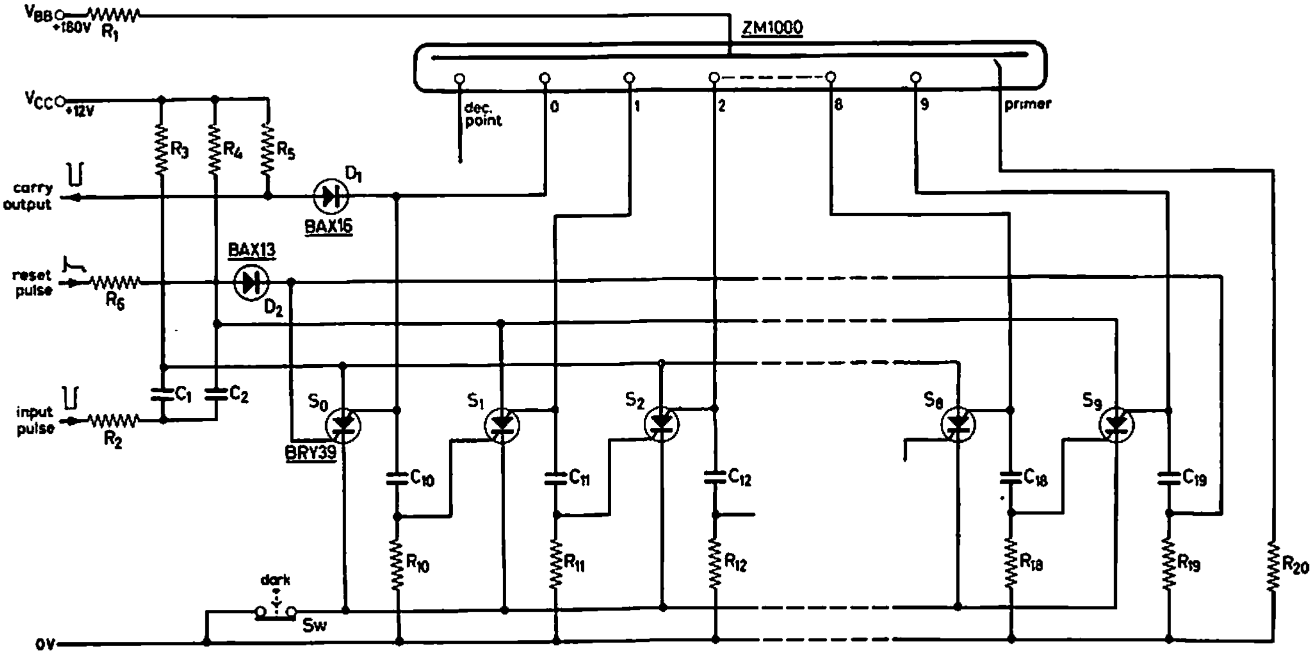
RING COUNTER WITHOUT DISPLAY—May be used to drive control circuit for numerical printout device, with negative-going output pulses taken from terminal points 0, 1, 2, . . ., 8, and 9. Values are: R1 820; R2, R3, 4.3K; R4, R10-R19 2.2K; R20-R29 3.9K; R30-R39 1K; C1, C2 5.6 nF; C10-C19 1 nF.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


V•15 VOLTS
270Ω
V_A
.47
.47
.47
.1μfd
R_L • 6 VOLT INCAND.
35-45 MA.
ALL SIG DIODES
1N4009
.47

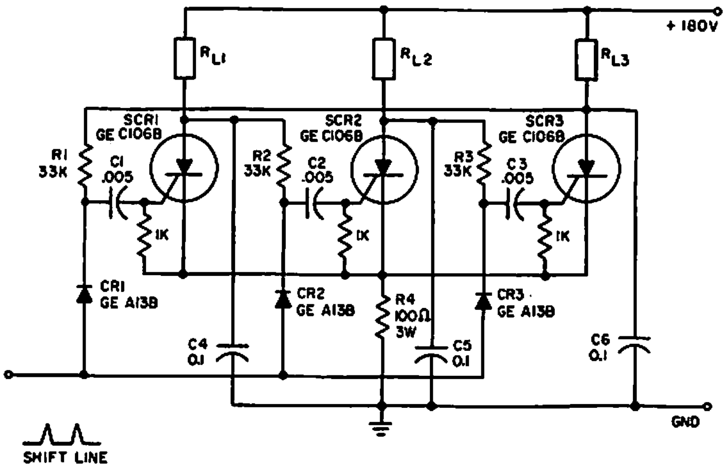
SUS LAMP-DRIVING RING COUNTER—Will operate up to 10 kHz. When supply voltage is applied, sus with lowest switching voltage comes on first. Succeeding count pulses applied to base of drive transistor step count along from stage to stage. Circuit is common-cathode type. Uses D13P1 sus.—W. R. Spofford, Jr., Applications of the New Silicon Bilateral Switch and the Silicon Unilateral Switch, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 7.

SEGMENT DECODING—Decoding circuit is OR gate formed by resistor group driving into transistor. This transistor provides threshold for gate and gain for driving lamp. Input to decoder is decimal-type signal from ring counter, portion of which is shown. Counter signal is referenced to ground, for compatibility with OR gates in decoding matrix.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 14.

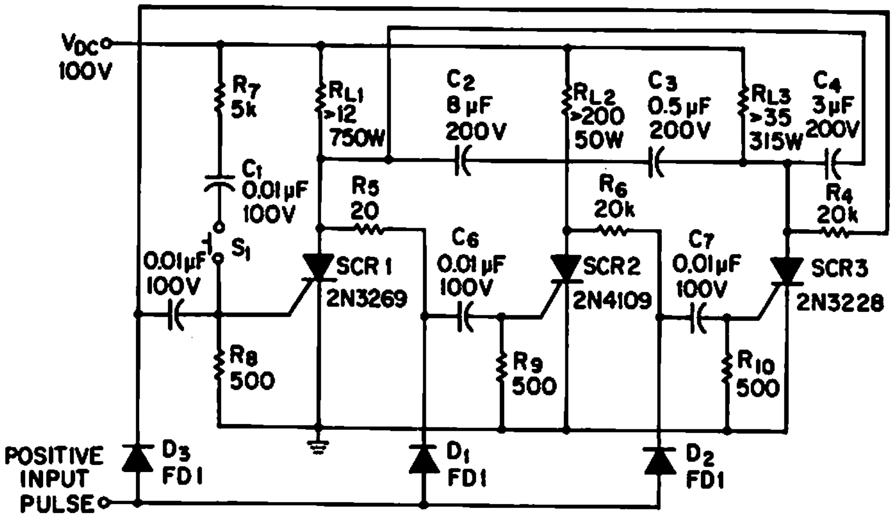

+12 V
C
2N525
R1
R1
R1
R1
5 V
20μS
10KΩ
0
1
2
9
C
R2
C
R2
C
R2
C
R2
R3
R3
R3
R3
C • .0047 μf
R1 • 10KΩ
R2 • 10KΩ
R3 • 3.3KΩ
R4 • 10KΩ
SCS • 3N81
+12
SEGMENT A
R4
R4
2N3415
+12
SEGMENT G
R4
R4
2N3415


V_{BB}
+180V
R_1
ZM1000
dec. point
0
1
2
8
9
primer
V_{CC}
+12V
R_3
R_4
R_5
D_1
carry output
BAX16
BAX13
reset pulse
R_6
D_2
input pulse
R_2
C_1
C_2
S_0
S_1
S_2
S_8
S_9
BRY39
C_{10}
C_{11}
C_{12}
C_{18}
C_{19}
R_{10}
R_{11}
R_{12}
R_{18}
R_{19}
R_{20}
dark
Sw
0V

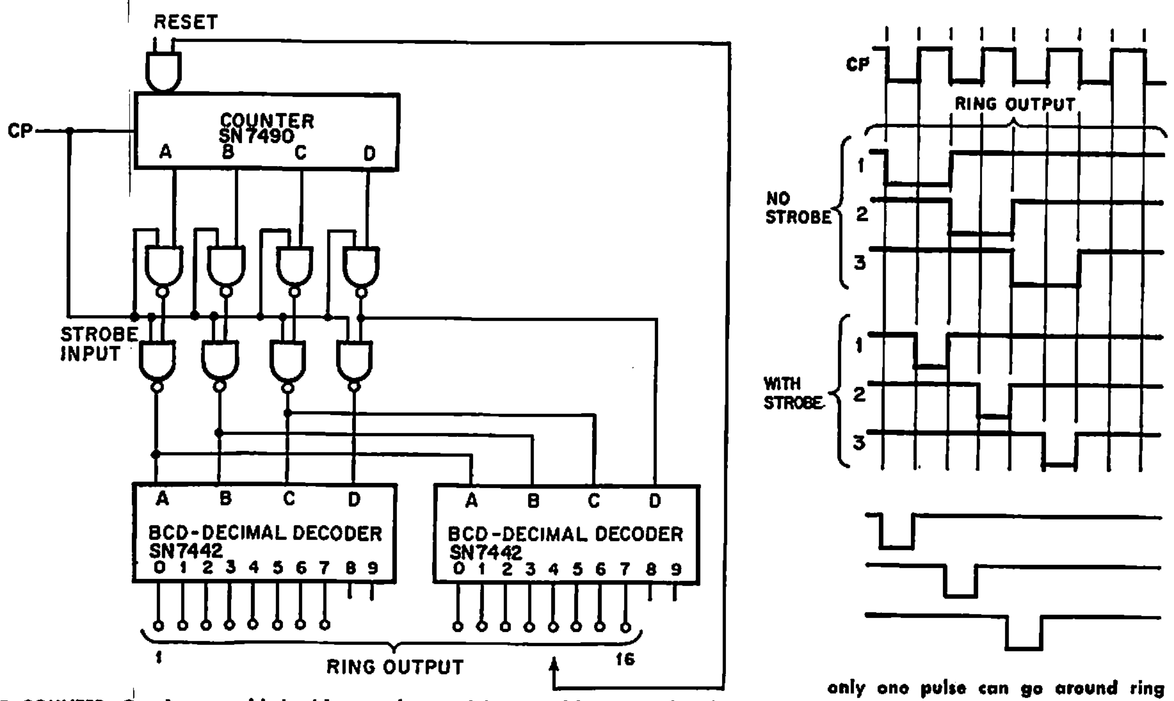
SCS RING COUNTER—Drives ZM1000 0-9 numerical indicator tube. Circuit design is simpler and less expensive than those using flip-flops. Input pulse amplitudes and durations are not critical, and can be about 12 V negative-going. Values are: R1 15K; R2, R10-R19 1K; R3-R4 5.1K; R5 10K; R6 2.2K; R20 10 meg; C1-C2 4.7 nF; C10-C19 390 pF.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


+180V
RL1
RL2
RL3
SCR1 GE C106B
SCR2 GE C106B
SCR3 GE C106B
R1 33K
C1 .005
R2 33K
C2 .005
R3 33K
C3 .005
1K
1K
1K
CR1 GE A13B
CR2 GE A13B
CR3 GE A13B
R4 100Ω 3W
C4 0.1
C5 0.1
C6 0.1
GND
SHIFT LINE

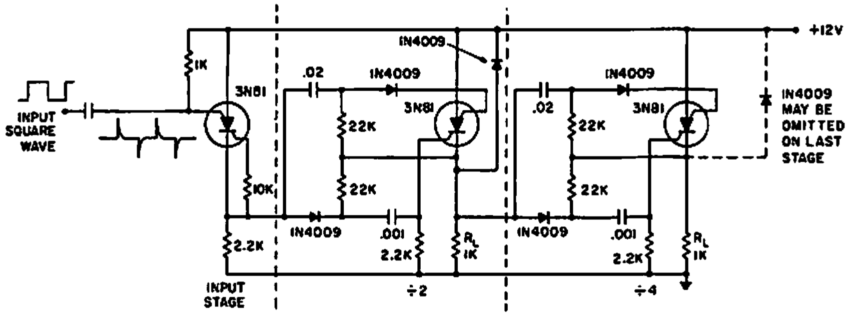
SCR RING COUNTER—Three-stage cathode-coupled ring counter can drive high-voltage loads up to 50 mA. Additional stages may be added. Useful in digital applications. Transfer along string always proceeds in same direction, with each transfer initiated by pulsing common input line. Gives undistorted square waves, free from commutation transients, across each load.—"SCR Manual," 4th Edition, General Electric, 1967, p 161–162.


VDC 100V
R7 5k
C1 0.01μF 100V
S1
0.01μF 100V
R8 500
RL1 >12 750W
R5 20
SCR1 2N3269
C2 8μF 200V
C6 0.01μF 100V
R9 500
RL2 >200 50W
R6 20k
SCR2 2N4109
C3 0.5μF 200V
C7 0.01μF 100V
R10 500
RL3 >35 315W
C4 3μF 200V
R4 20k
SCR3 2N3228
POSITIVE INPUT PULSE
D3 FD1
D1 FD1
D2 FD1

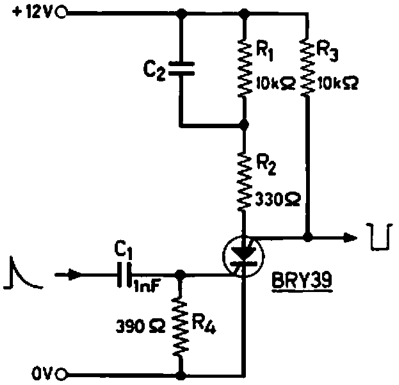
SCR HIGH-LEVEL SWITCHING—Scr's are both practical and economical for high-level switching within counting sequence in basic three-stage ring counter, despite popularity of IC modules for low-level switching. Article covers design procedure.—E. Kiburis, Sequential Control with Silicon Controlled Rectifiers, *EEE*, March 1970, p 100–103.


RESET
CP
COUNTER SN7490
A B C D
STROBE INPUT
A B C D
BCD-DECIMAL DECODER SN7442
0 1 2 3 4 5 6 7 8 9
A B C D
BCD-DECIMAL DECODER SN7442
0 1 2 3 4 5 6 7 8 9
1
RING OUTPUT
16
CP
RING OUTPUT
NO STROBE
1
2
3
WITH STROBE
1
2
3

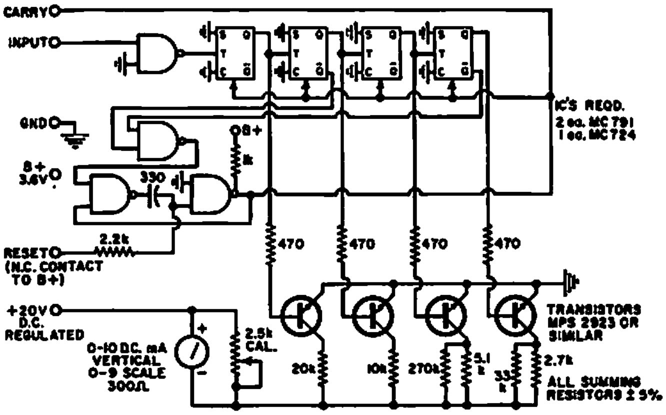
MSI RING COUNTER—Can be assembled with minimum number of IC connections. Straight-binary ripple-carry counter is driven by clock pulses and in turn drives two decoders, one for outputs 0 to 7 and the other for 8 to 15. Decoding networks allow only one output, so only one pulse can go around ring even if false triggering occurs.—W. Nadler, Build Ring Counters with Standard MSI, *Electronics*, June 8, 1970, p 96.


+12V
1K
INPUT SQUARE WAVE
3N81
.02
IN4009
3N81
22K
22K
10K
2.2K
IN4009
.001
2.2K
R_L 1K
INPUT STAGE
÷2
IN4009
.02
IN4009
3N81
22K
22K
IN4009
.001
2.2K
R_L 1K
÷4
IN4009 MAY BE OMITTED ON LAST STAGE

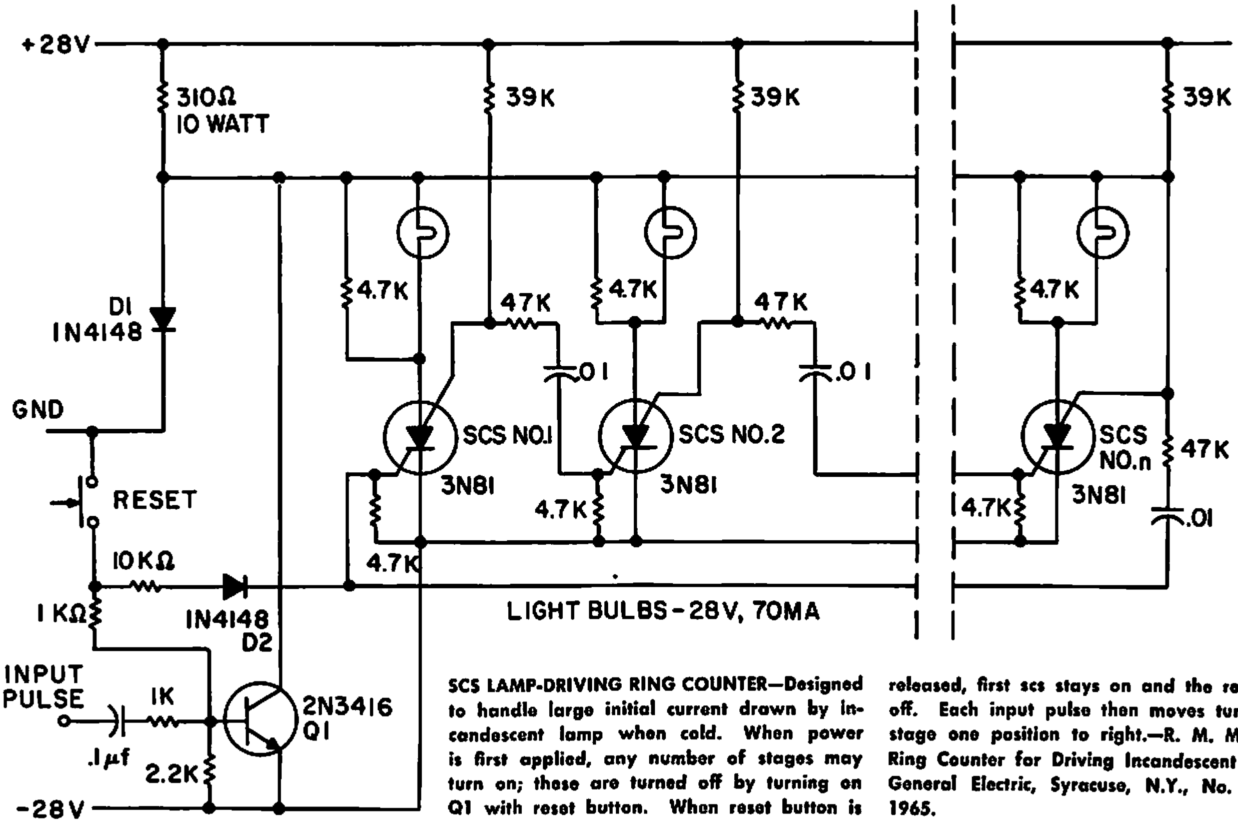
SCS BINARY—Stages are triggered by positive-going edge of input pulse, after sharpening by 3N81 scs input stage. Anode-cathode diode 1N4009 suppresses positive transients while scs is recovering. Each scs is turned on at cathode gate and turned off at anode gate.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


+12V
C_2
R_1 10kΩ
R_3 10kΩ
R_2 330Ω
C_1 1nF
BRY39
390Ω R_4
0V

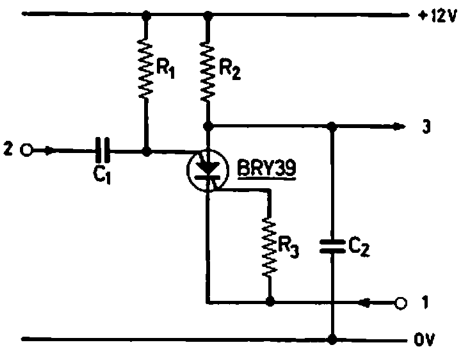
PULSE-SHAPING DRIVE—Supplies square-wave input signals to scs ring counter when positive-going pulses are fed to base of BRY39 scs.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


CARRY
INPUT
S Q T C Q̄
GND
B+
B+ 3.6V
330
1k
2.2k
RESET (N.C. CONTACT TO B+)
470
470
470
470
+20V D.C. REGULATED
0-10 DC. mA VERTICAL 0-9 SCALE 300Ω
2.5k CAL.
20k
10k
270k
5.1 k
33 k
2.7k
IC'S REQD. 2 ea. MC791 1 ea. MC724
TRANSISTORS MPS 2923 OR SIMILAR
ALL SUMMING RESISTORS ± 5%

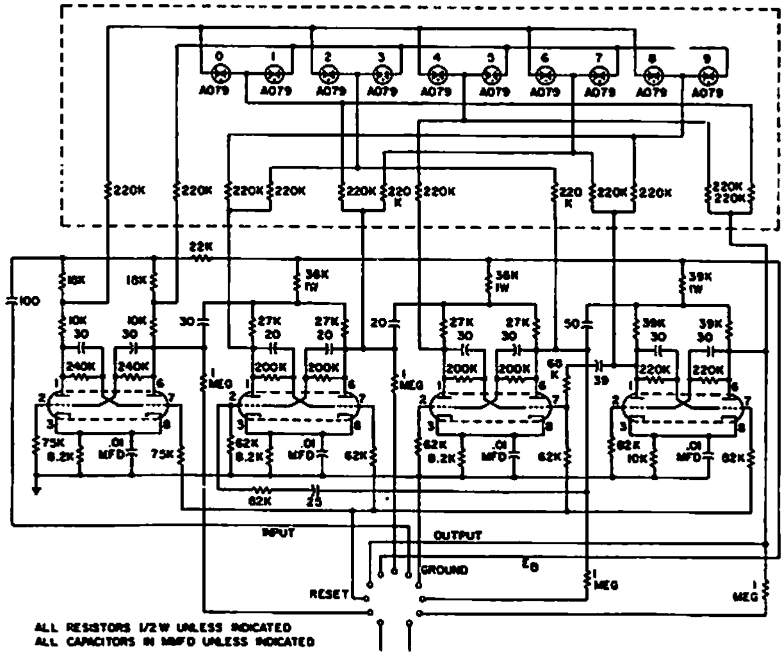
CURRENT SUMMING—Combines four integrated-circuit JK flip-flops in counter for use with meter or other analog readout. Sum of all currents will equal count stored with 1-2-4-8 counter. NAND gates at left are required for preclearing.—D. E. Lancaster, IC Decimal Counting Techniques, *Electronics World*, Sept. 1968, p 40–43 and 70.


+28V
310Ω 10 WATT
39K
39K
39K
D1 1N4148
GND
RESET
10KΩ
1N4148 D2
1 KΩ
INPUT PULSE
1K
.1µf
2.2K
2N3416 Q1
-28V
4.7K
47K
.01
SCS NO.1
3N81
4.7K
4.7K
47K
.01
SCS NO.2
3N81
4.7K
4.7K
SCS NO.n
3N81
47K
.01
4.7K
LIGHT BULBS - 28V, 70MA

SCS LAMP-DRIVING RING COUNTER—Designed to handle large initial current drawn by incandescent lamp when cold. When power is first applied, any number of stages may turn on; these are turned off by turning on Q1 with reset button. When reset button is released, first scs stays on and the rest stay off. Each input pulse then moves turned-on stage one position to right.—R. M. Muth, A Ring Counter for Driving Incandescent Bulbs, General Electric, Syracuse, N.Y., No. 90.24, 1965.

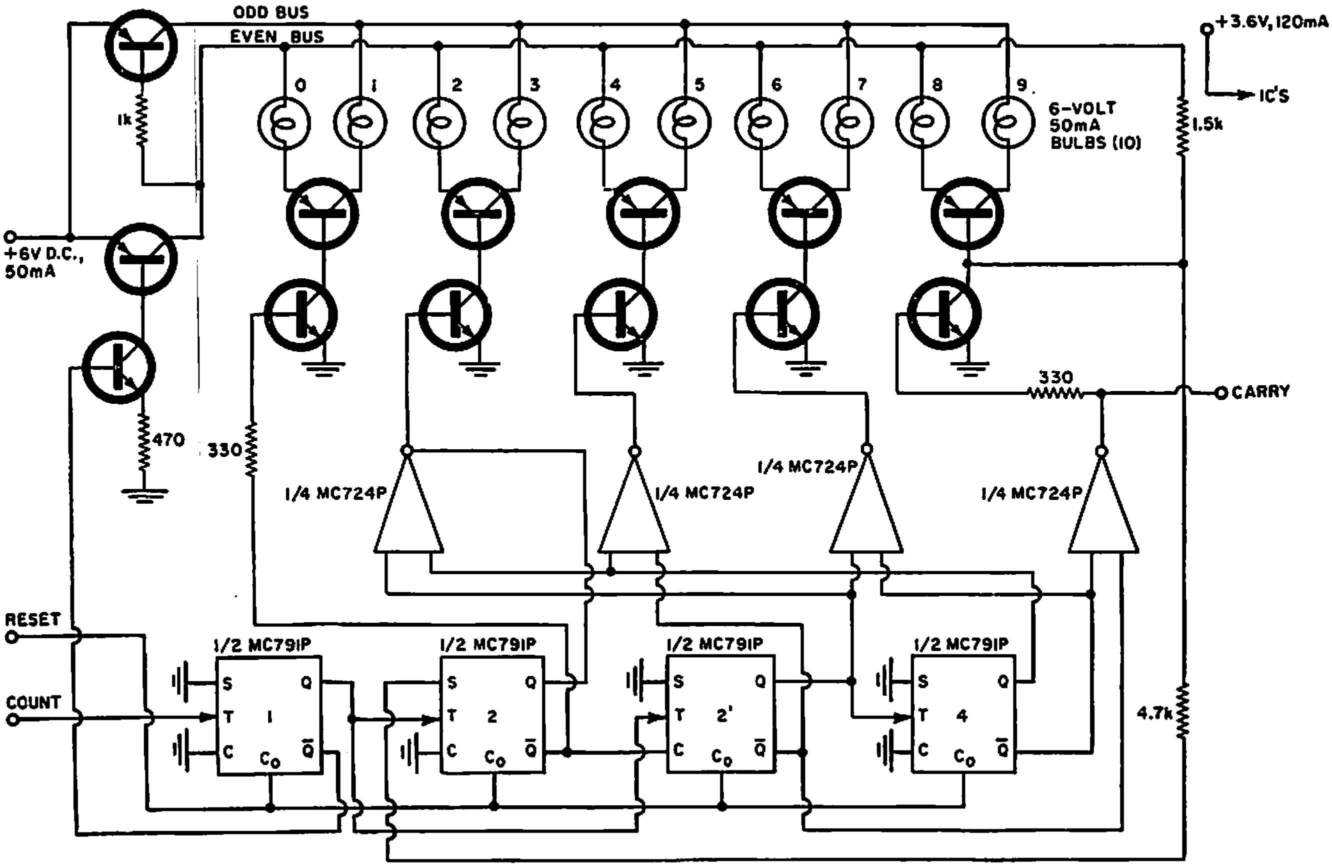

+12V
R1
R2
3
2
C1
BRY39
R3
C2
1
0V

SYNCHRONOUS AND GATE—Scs gate is used with scs ring counter to carry out switching and logic functions that are to be coordinated by a train of clock pulses. Gate responds only when negative-going clock pulse is applied to terminal 1 in synchronism with negative-going input pulse of about 12 V at terminal 2, and then produces negative-going square-wave output pulse at terminal 3 lasting for duration of clock pulse. This output is used for driving counter. Values: R1 10K; R2, R3 1K; C1, C2 180 pF.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


0
1
2
3
4
5
6
7
8
9
A079
220K
220 K
22K
18K
36K 1W
39K 1W
100
10K
30
20
50
39
27K
240K
200K
220K
1 MEG
75K
8.2K
62K
10K
.01 MFD
82K
25
INPUT
OUTPUT
GROUND
E0
RESET
1 MEG

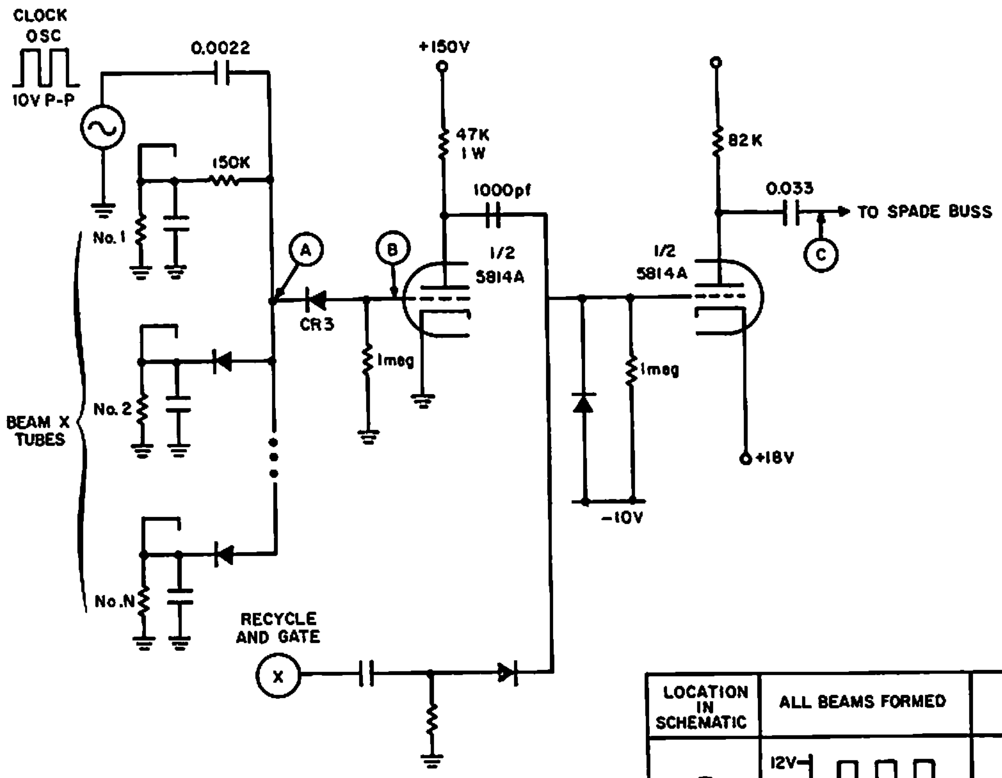
ALL RESISTORS 1/2 W UNLESS INDICATED
ALL CAPACITORS IN MFD UNLESS INDICATED

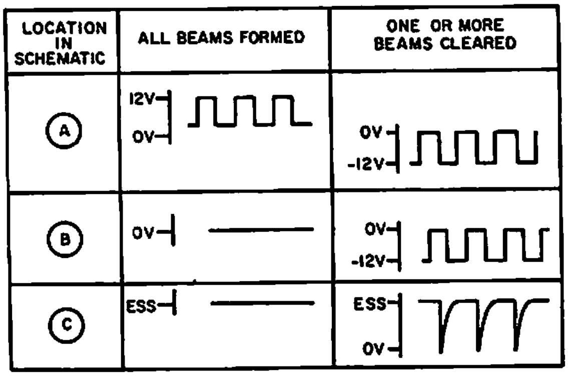
BINARY COUNTER—Neons provide high brightness and quick reaction time necessary for display. Good up to 1.2 MHz.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 141.


ODD BUS
EVEN BUS
0
1
2
3
4
5
6
7
8
9
6-VOLT 50mA BULBS (10)
+3.6V, 120mA
IC'S
1.5k
1k
+6V D.C., 50mA
470
330
330
CARRY
1/4 MC724P
1/4 MC724P
1/4 MC724P
1/4 MC724P
RESET
COUNT
1/2 MC791P
1/2 MC791P
1/2 MC791P
1/2 MC791P
S
Q
T
1
2
2'
4
C
C0
Q̄
4.7k

IC BIQUINARY—Low-cost design (about $11 per decade for parts) gives complete decimal counter, decoder, driver, and staggered 0-9 lamp readout operating from d-c to 8 MHz. Can also drive special biquinary Nixie indicator.—D. E. Lancaster, IC Decimal Counting Techniques, *Electronics World*, Sept. 1968, p 40–43 and 70.

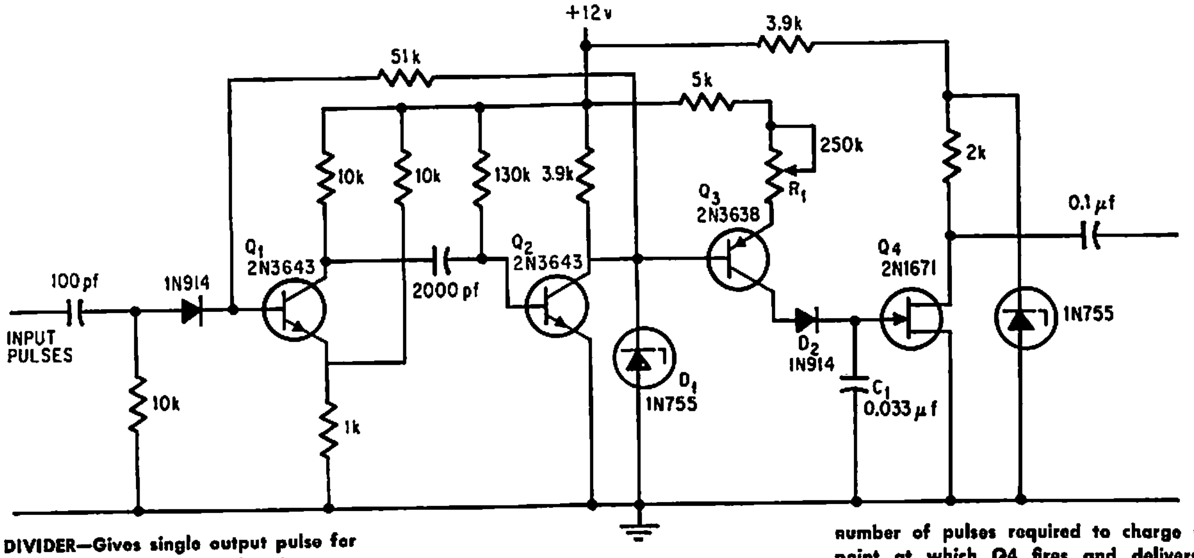
ALL n-p-n 2N5129 (6)
ALL p-n-p 2N5139 (7)


CLOCK OSC
10V P-P
0.0022
150K
No. 1
No. 2
No. N
BEAM X TUBES
A
B
CR3
1meg
+150V
47K 1W
1000pf
1/2 5814A
1/2 5814A
82K
0.033
TO SPADE BUSS
C
1meg
-10V
+18V
RECYCLE AND GATE
X

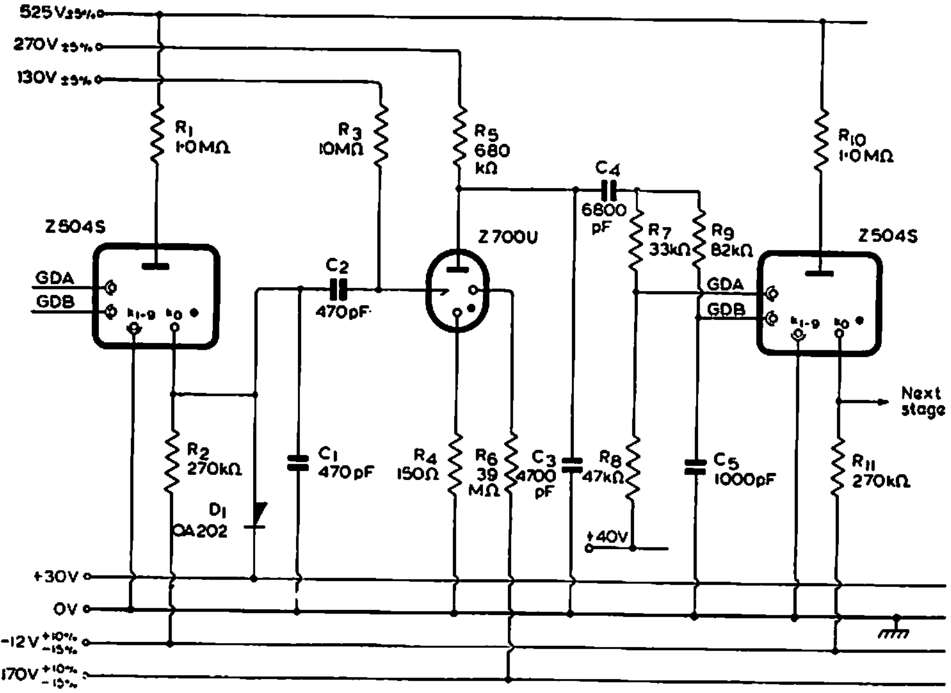


LOCATION IN SCHEMATIC	ALL BEAMS FORMED	ONE OR MORE BEAMS CLEARED
A	12V 0V	0V -12V
B	0V	0V -12V
C	ESS	ESS 0V

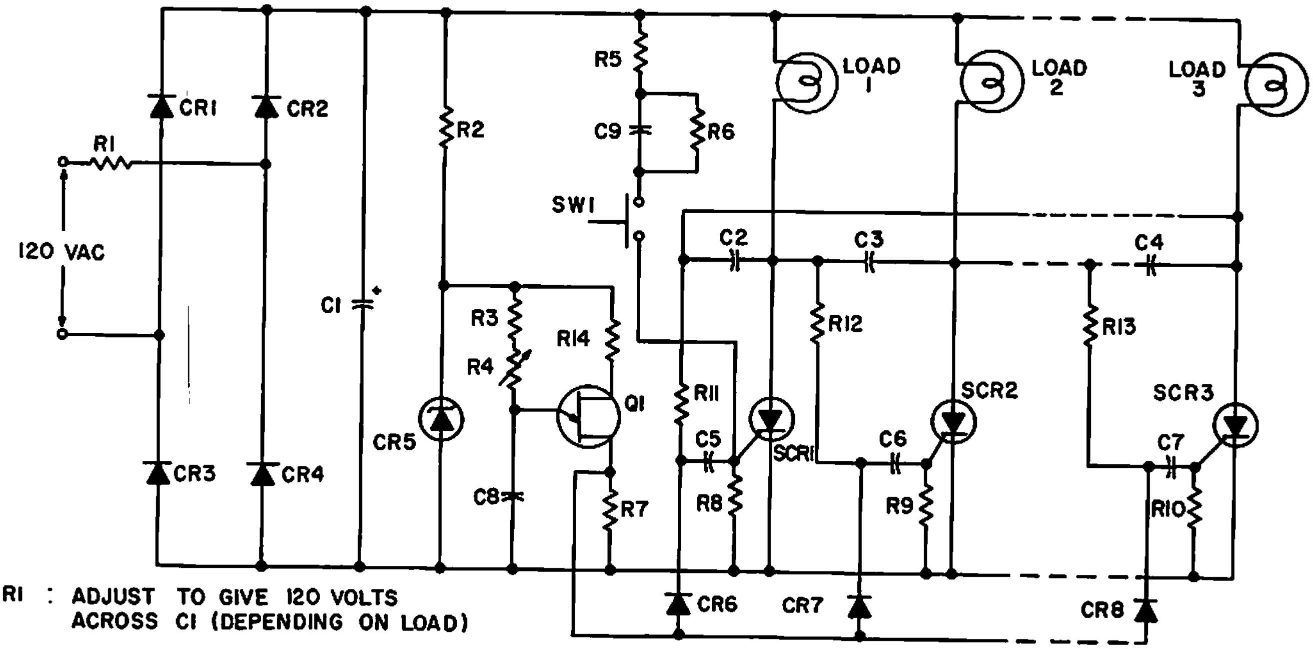
BEAM-SWITCHING COUNTER RESTARTER—If beam of Beam-x counter tube clears for any reason during operation, circuit shown will start tube again automatically. Circuit will operate on as little as 3 V from clock oscillator.—W. C. Whitworth, Simple Circuit Starts Beam Tubes Automatically, *Electronic Design*, Jan. 18, 1965, p 44 and 46.


+12v
3.9k
51k
5k
250k
10k
10k
130k
3.9k
Q3 2N3638
R1
2k
0.1μf
Q1 2N3643
Q2 2N3643
Q4 2N1671
100pf
1N914
2000 pf
INPUT PULSES
10k
1k
D1 1N755
D2 1N914
C1 0.033μf
1N755

PULSE DIVIDER—Gives single output pulse for any desired number of input pulses in range from 2 to 90, without binary counter or decoder. Input pulses trigger one-shot mvbr Q1-Q2, which delivers 150-μs pulse that is clamped at 6 V by D1 and applied to base of constant-current source Q3 for charging C1. Setting of 10-turn precision pot R1 determines number of pulses required to charge C1 to point at which Q4 fires and delivers one output pulse.—S. Domanski, Circuit Divides Pulses Without Binary Counters, *Electronics*, Sept. 30, 1968, p 81–82.


525V ±5%
270V ±5%
130V ±5%
R1 1·0MΩ
R3 10MΩ
R5 680 kΩ
C4 6800 pF
R7 33kΩ
R9 82kΩ
R10 1·0MΩ
Z504S
Z700U
Z504S
GDA
GDB
k1-9
k0
C2 470pF
GDA
GDB
k1-9
k0
Next stage
R2 270kΩ
D1 OA202
C1 470pF
R4 150Ω
R6 39 MΩ
C3 4700 pF
R8 47kΩ
+40V
C5 1000pF
R11 270kΩ
+30V
0V
-12V +10% -15%
-170V +10% -15%

40-HZ COLD-CATHODE COUPLING—Circuit shows method of using Z700U cold-cathode trigger tube in self-extinguishing circuit to provide economical and reliable coupling between gas-filled decade counter tubes in counter chain.—G. F. Joynes and S. Zilkha, Trigger Tube Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 16–25.


CR1
CR2
R1
120 VAC
C1
CR3
CR4
R2
CR5
R3
R4
R14
Q1
C8
R7
R5
C9
R6
SW1
LOAD 1
LOAD 2
LOAD 3
C2
C3
C4
R11
R12
R13
SCR1
SCR2
SCR3
C5
C6
C7
R8
R9
R10
CR6
CR7
CR8

R1 : ADJUST TO GIVE 120 VOLTS ACROSS C1 (DEPENDING ON LOAD)
R2 : 4.7K 2W
R3 : 10K 1/2 W
R4 : 500K LINEAR POT
R5 : 100Ω 1/2 W
R6 : 1 MEG 1/2 W
R7 : 47Ω 1/2 W
R8, R9, R10 : 1K 1/2 W
R11, R12, R13 : 33K 1/2 W
R14 : 330 , 1/2 W

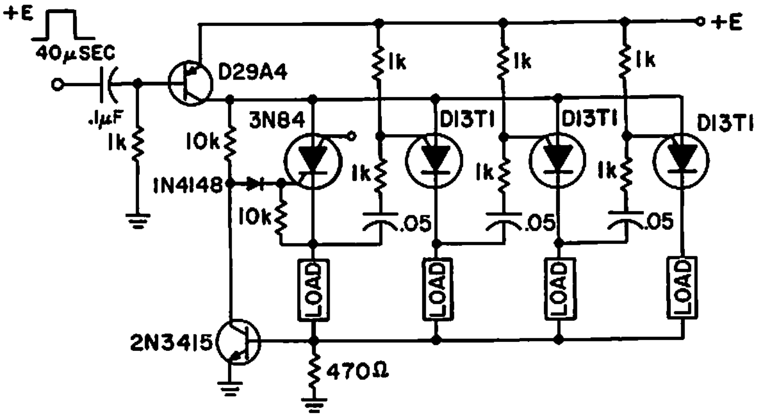
C1 : 100 μF, 200 V
C2, C3, C4 : 5 μF, 200 V
C5, C6, C7 : .01 μF
C8 : 1 μF, 25 V
C9 : .1 μF 200 V
CR1 - CR4 : GE A10B
CR5 : GE Z4XL18 ZENER
CR6 - CR8 : GE A13F

Q1 : GE 2N2646 UJT
SCR1, SCR2, SCR3 : GE C20B

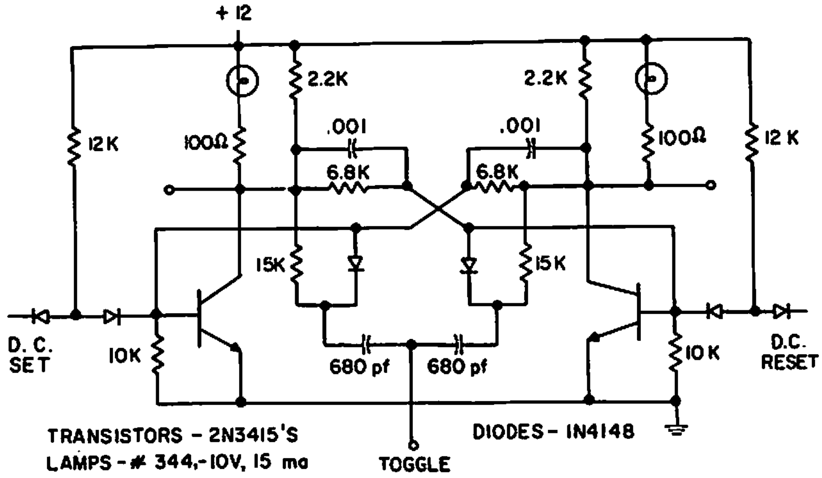
LOADS : 100 W

ADDITIONAL STAGES MAY BE ADDED BETWEEN DASHED LINES.

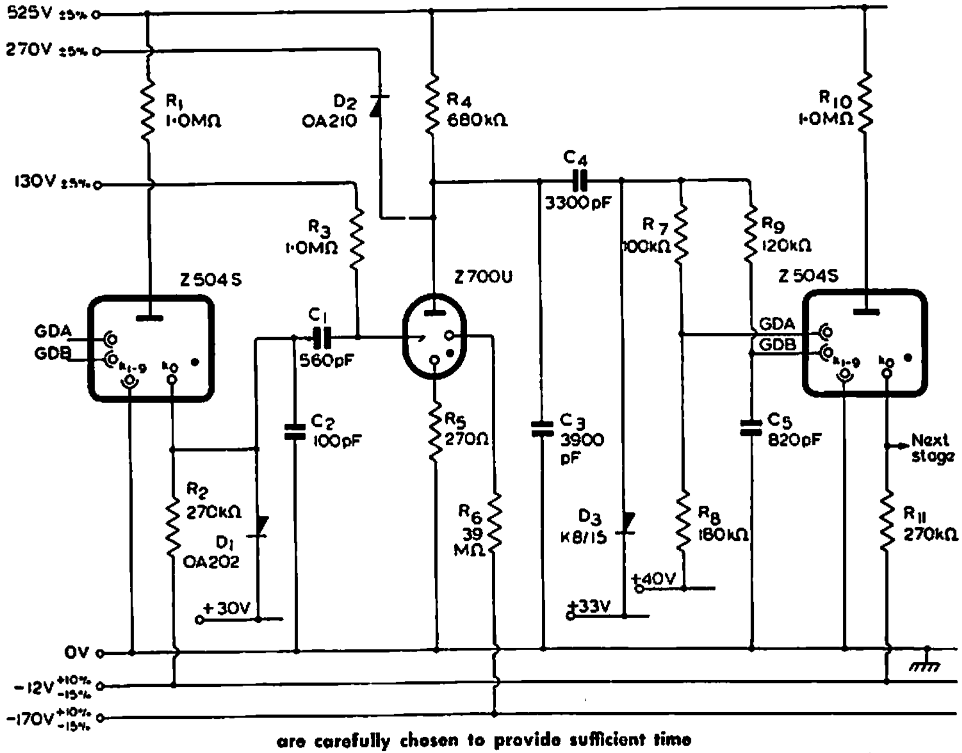
THREE-STAGE SCR RING COUNTER—Each stage can handle lamp or other resistive load up to 100 W. Developed for counting applications, but can be used also for turning on string of lights sequentially as for advertising signs.—A. A. Adem, Flashers, Ring Counters and Chasers, General Electric, Syracuse, N.Y., No. 200.48, 1966, p 5.


+E
40μSEC
.1μF
1k
D29A4
10k
3N84
IN4148
10k
2N3415
470Ω
+E
1k
1k
1k
D13T1
D13T1
D13T1
1k
1k
1k
.05
.05
.05
LOAD
LOAD
LOAD
LOAD

LOW-COST UJT RING COUNTER—Uses 3N84 scs ahead of D13T1 programmable ujt counting stages. When power is applied, only scs turns on. Next input pulse turns off D29A4 transistor momentarily, thereby turning off scs and turning on first D13T1 when power is restored after momentary interruption. Next pulse turns off first ujt and turns on next, with similar action.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 13.

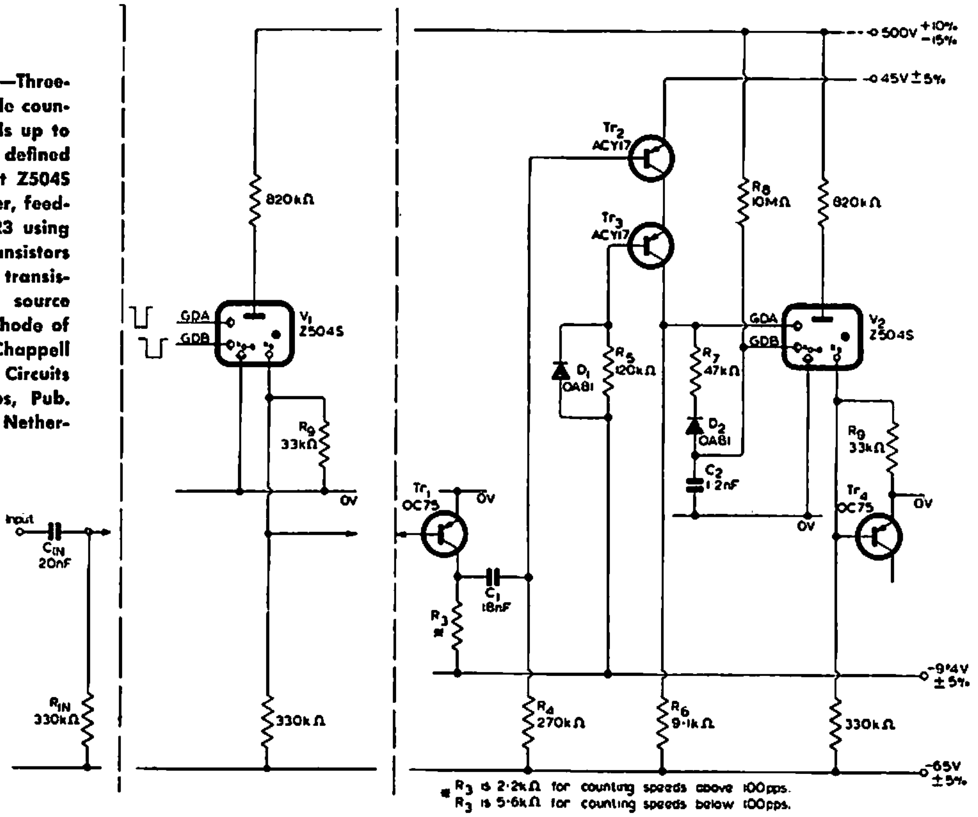

+ 12
12K
100Ω
2.2K
.001
6.8K
15K
D. C. SET
10K
680 pf
680 pf
TOGGLE
.001
2.2K
6.8K
15K
100Ω
12 K
10 K
D.C. RESET
TRANSISTORS - 2N3415'S
LAMPS - # 344,-10V, 15 ma
DIODES - IN4148

BINARY COUNTER WITH LAMP READOUT—High-gain transistors and low-current lamps eliminate need for separate driver stages. Continues to work when either or both lamps are burned out. Can drive other identical circuits to form binary counter chain.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 9.

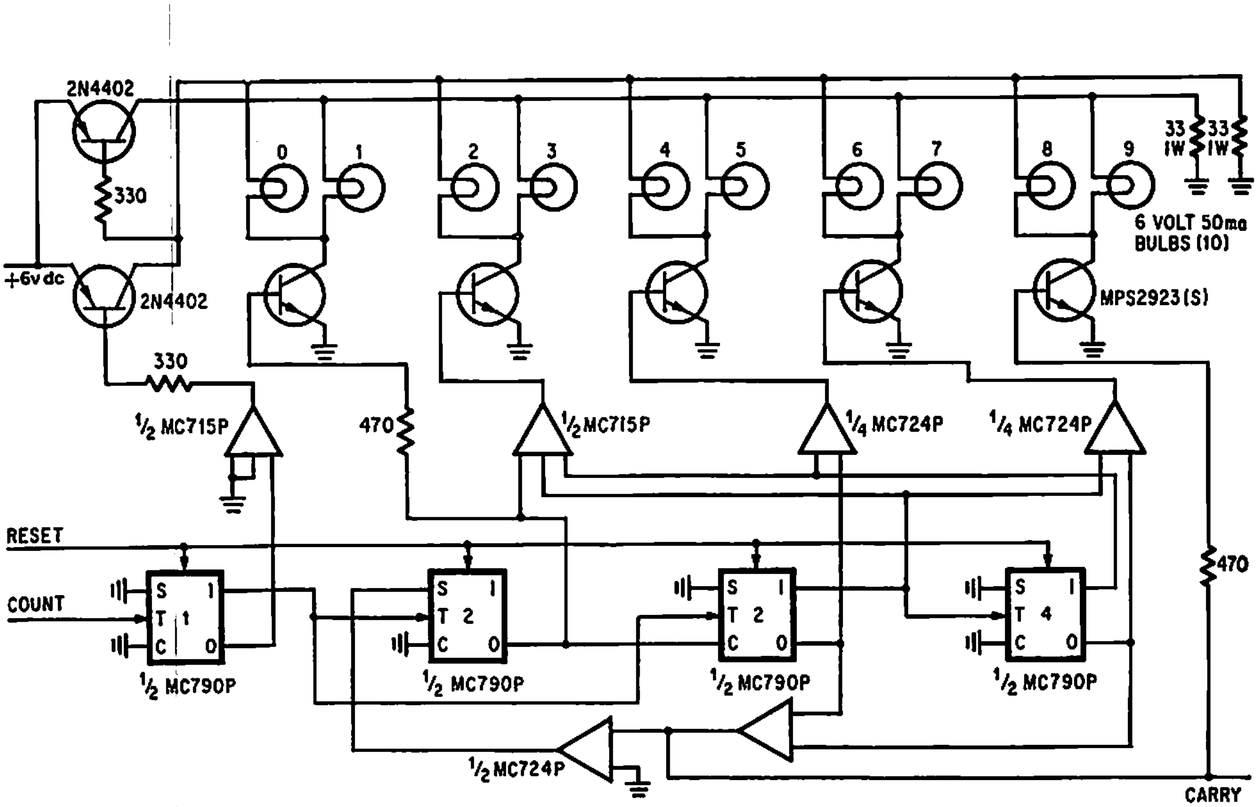

525V ±5%
270V ±5%
130V ±5%
R1 1·0MΩ
D2 OA210
R4 680kΩ
R10 1·0MΩ
C4 3300pF
R3 1·0MΩ
R7 100kΩ
R9 120kΩ
Z504S
Z700U
Z504S
GDA
GDB
C1 560pF
C2 100pF
R5 270Ω
C3 3900 pF
C5 820pF
GDA
GDB
Next stage
R2 270kΩ
D1 OA202
+30V
R6 39 MΩ
D3 K8/15
+33V
+40V
R8 180kΩ
R11 270kΩ
0V
-12V +10% -15%
-170V +10% -15%

400-HZ COLD-CATHODE COUPLING—Cold-cathode Z700U trigger tube provides reliable coupling between gas-filled decade counter tubes in counter chain. Circuit components are carefully chosen to provide sufficient time for recovery of trigger tube after firing, without false triggering. D-c restoring diode D3 ensures that C4 discharges completely after each pulse.—G. F. Joynes and S. Zilkha, Trigger Tube Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 16–25.

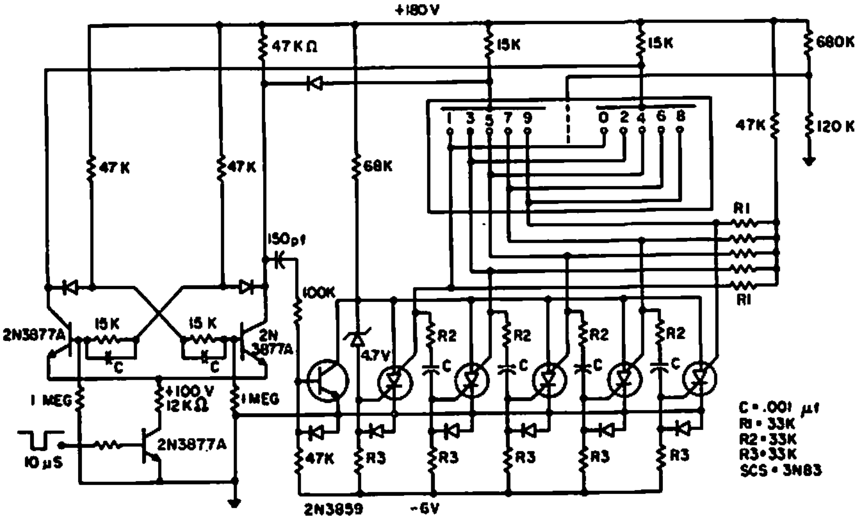
400-HZ PULSE-SHAPING COUPLER—Three-transistor coupling for gas-filled decade counter tubes will transfer pulses at speeds up to 400 Hz by producing new pulses of defined shape and amplitude for driving next Z504S stepping tube. TR1 is current amplifier, feeding cascode connection of TR2 and TR3 using inexpensive ACY17 low-voltage transistors instead of one high-cost high-voltage transistor. Input can be from external source through network CIN-RIN, or from cathode of previous stepping tube V1.—G. C. Chappell and G. F. Jeynes, Transistor Coupling Circuits for the Z540S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 26–38.


820kΩ
GDA
GDB
V1
Z504S
R9 33kΩ
0V
Input
CIN 20nF
RIN 330kΩ
330kΩ
Tr1 OC75
0V
C1 18nF
R3 *
Tr2 ACY17
Tr3 ACY17
D1 OA81
R5 120kΩ
R7 47kΩ
D2 OA81
C2 1·2nF
R8 10MΩ
820kΩ
GDA
GDB
V2 Z504S
R9 33kΩ
Tr4 OC75
0V
0V
500V +10% −15%
45V ±5%
−9·4V ±5%
−65V ±5%
R4 270kΩ
R6 9·1kΩ
330kΩ

* R3 is 2·2kΩ for counting speeds above 100pps.
R3 is 5·6kΩ for counting speeds below 100pps.

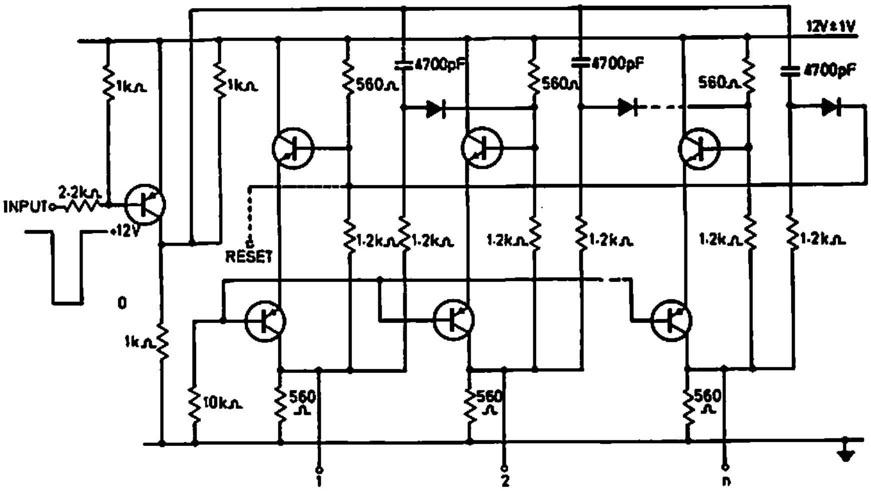

2N4402
330
+6vdc
2N4402
330
½ MC715P
470
½MC715P
¼ MC724P
¼ MC724P
0
1
2
3
4
5
6
7
8
9
33 1W
33 1W
6 VOLT 50ma BULBS (10)
MPS2923(S)
470
RESET
COUNT
S 1 T 1 C 0
S 1 T 2 C 0
S 1 T 2 C 0
S 1 T 4 C 0
½ MC790P
½ MC790P
½ MC790P
½ MC790P
½MC724P
CARRY

LOW-COST INCANDESCENT READOUT—Uses only seven switches to control ten bulbs. Sneak current paths keep all bulbs on all the time, but dimly. Effect is minimized by balancing resistors, to apply full supply voltage only to ON bulb, with one-third of supply voltage across OFF bulbs.—D. E. Lancaster, For Low Cost, Count on RTL, *Electronics*, Jan. 22, 1968, p 74–76.

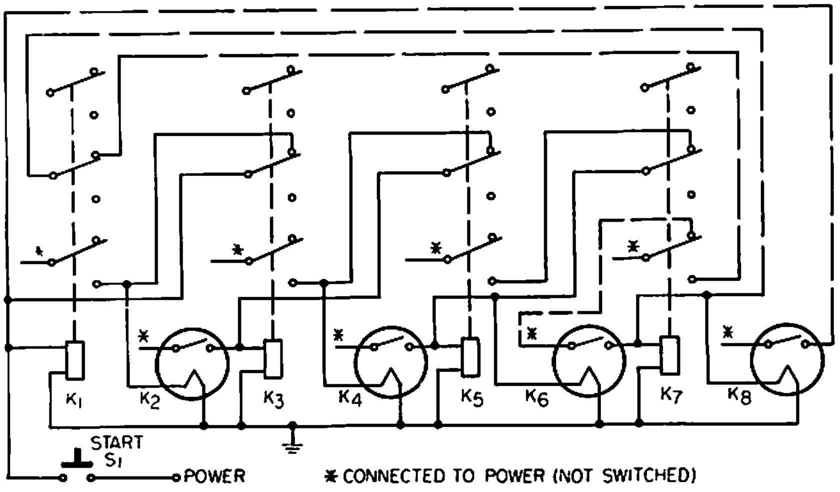

+180V
47KΩ
15K
15K
680K
1 3 5 7 9
0 2 4 6 8
47K
120K
47K
47K
68K
R1
R1
150pf
100K
2N3877A
15K
15 K
2N 3877A
C
C
4.7V
R2
R2
R2
R2
C
C
C
C
1 MEG
+100V
12KΩ
1 MEG
10 μS
2N3877A
47K
R3
R3
R3
R3
R3
2N3859
-6V
C = .001 μf
R1 = 33K
R2 = 33K
R3 = 33K
SCS = 3N83

BIQUINARY COUNTER WITH READOUT—Consists of binary flip-flop driving five-stage (quinary) counter. Two high-voltage transistors perform both memory and driving functions in binary stage. Automatic reset of ring counter is provided by 4.7-V zener. Operating limit is 5 kHz.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 14.

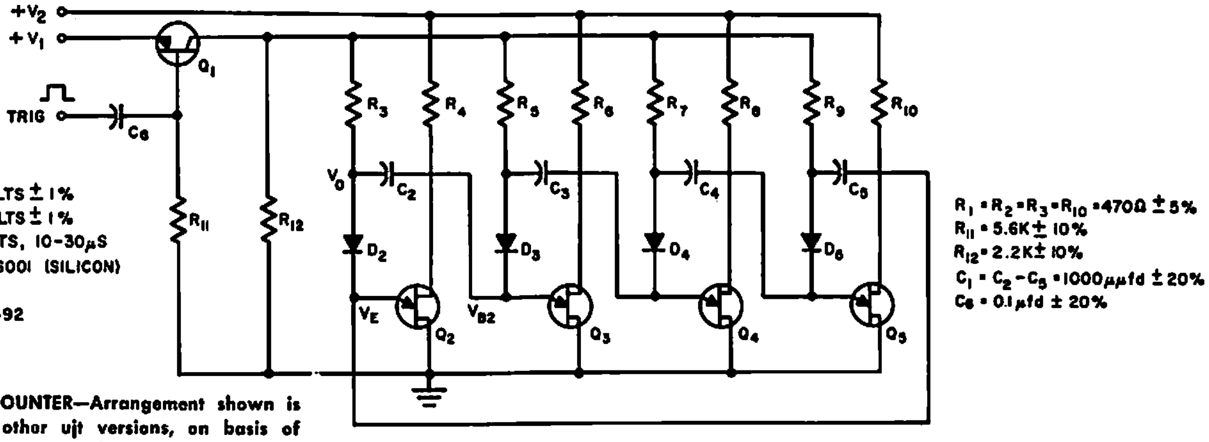
LAMP-DRIVING RING COUNTER—When source voltage is applied, one stage will be dominant and its transistor pair will turn on first. Click pulse turns off this stage and turns on next stage in ring. To obtain indication of state of counter, 560-ohm resistor may be replaced by 8-V 0.1-A lamp in series with 47-ohm resistor, or additional transistor may be driven from tap on 560-ohm resistor to control brighter 12-V 2.2-W lamp. With transistor drive, counter continues to operate if lamp fails.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 18.


12V±1V
1kΩ
1kΩ
560Ω
4700pF
560Ω
4700pF
560Ω
4700pF
2.2kΩ
INPUT
+12V
0
RESET
1.2kΩ
1.2kΩ
1.2kΩ
1.2kΩ
1.2kΩ
1.2kΩ
1kΩ
10kΩ
560 Ω
560 Ω
560 Ω
1
2
n

All n-p-n transistors, type ZTX300 (BCW10).
All p-n-p transistors, type ZTX500 (BCW11).
All diodes, type ZS140.

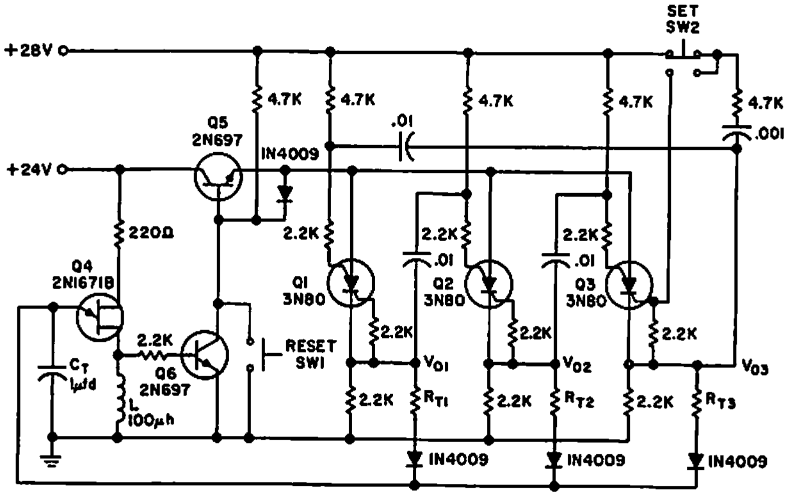

o
o
o
o
o
o
o
o
*
*
*
*
*
*
*
*
K1
K2
K3
K4
K5
K6
K7
K8
START
S1
POWER
* CONNECTED TO POWER (NOT SWITCHED)

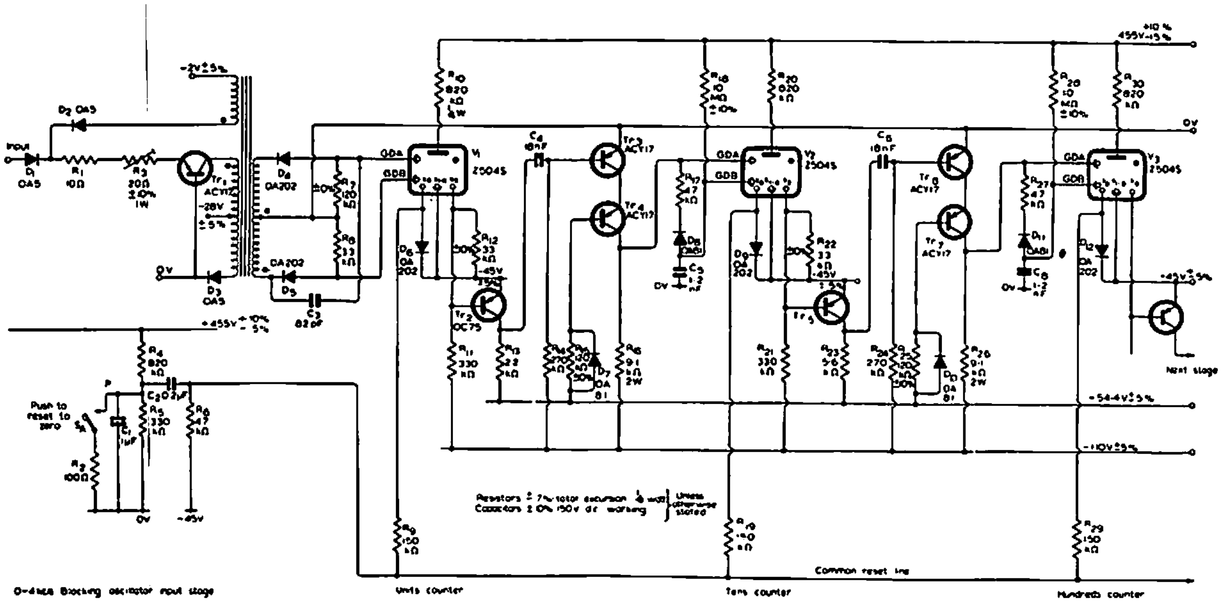
RING COUNTER WITH RELAYS—Low-cost combination of thermal delay relays gives adequate performance for low-speed counting applications, involving cycle times from 2 s to 3 min. If chain is closed, as indicated by dashed lines, counter runs continuously. Outputs are taken from third set of contacts on relays. If start switch is momentarily closed, circuit runs through one complete program and stops.—G. Richwell, Free-Running Ring Counter Uses Relays, *EEE*, Feb. 1967, p 144–145.


+V2
+V1
TRIG
C6
Q1
R3
R4
R5
R6
R7
R8
R9
R10
V0
C2
C3
C4
C5
D2
D3
D4
D5
VE
VB2
Q2
Q3
Q4
Q5
R11
R12
V1 = 10.0 VOLTS ± 1%
V2 = 20.5 VOLTS ± 1%
TRIG > 5 VOLTS, 10-30µS
D2-D5 = HD6001 (SILICON)
Q1 = 2N395
Q2-Q5 = 2N492
R1 = R2 = R3 = R10 = 470Ω ± 5%
R11 = 5.6K ± 10%
R12 = 2.2K ± 10%
C1 = C2-C5 = 1000µµfd ± 20%
C6 = 0.1µfd ± 20%

UJT RING COUNTER—Arrangement shown is superior to other ujt versions, on basis of design margins, flexibility, and overall performance. Any number of stages may be used. Each input trigger pulse advances "on" state one stage to right, then back from Q5 to Q2. Trigger width can vary over wide range.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 68.

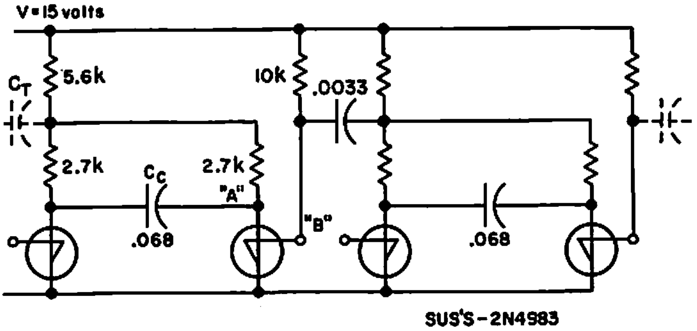
VARIABLE-TIMING SCS RING COUNTER—Will perform reliably over wide range of voltage, temperature, loading, and frequency. For telemetering, transducers can be used in place of timing resistors RT, so duration of output is indication of measured quantity. For visual indication, connect low-current lamp between each output (V) and ground. Additional stages can be added as desired.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 12.

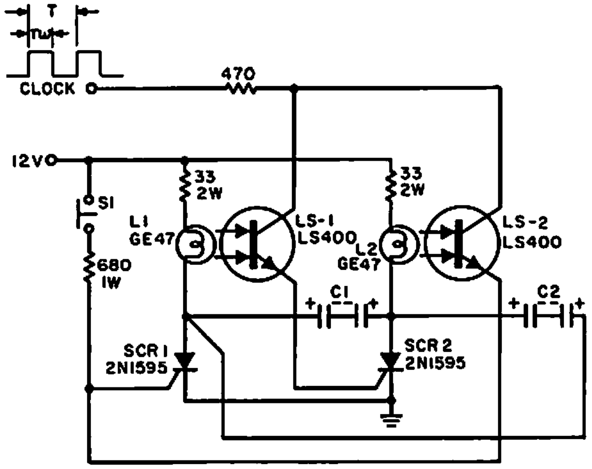

SET
SW2
+28V
+24V
4.7K
4.7K
4.7K
4.7K
4.7K
.01
.001
Q5
2N697
IN4009
220Ω
Q4
2N1671B
CT
1µfd
2.2K
Q6
2N697
L
100µh
RESET
SW1
2.2K
2.2K
2.2K
.01
.01
Q1
3N80
Q2
3N80
Q3
3N80
2.2K
2.2K
2.2K
VO1
VO2
VO3
2.2K
2.2K
2.2K
RT1
RT2
RT3
IN4009
IN4009
IN4009


+10%
455V -5%
0V
Input
D1
OA5
R1
10Ω
R3
20Ω
±10%
1W
D2 OA5
-2V±5%
Tr1
ACY17
-28V
±5%
0V
D3
OA5
D4
OA202
±10%
R7
120
kΩ
R8
33
kΩ
OA202
D5
C3
82pF
+455V +10% -5%
R4
820
kΩ
P
C2 0.2µF
Push to reset to zero
S1
C1
1µF
R5
330
kΩ
R6
47
kΩ
R2
100Ω
0V
-45V
R10
820
kΩ
¼W
GDA
GDB
V1
Z5045
C4
10nF
Tr3
ACY17
Tr4
ACY17
D6
OA
202
R12
33
kΩ
-45V
Tr2
OC75
R11
330
kΩ
R13
22
kΩ
D7
OA
81
R16
91
kΩ
2W
R17
47
kΩ
D8
C5
R18
10
MΩ
±10%
R20
820
kΩ
V2
Z5045
C6
10nF
Tr6
ACY17
Tr7
ACY17
D9
OA
202
R22
33
kΩ
-45V
Tr5
R21
330
kΩ
R23
56
kΩ
R24
270
kΩ
D10
OA
81
R26
91
kΩ
2W
R27
47
kΩ
D11
C8
R28
10
MΩ
±10%
R30
820
kΩ
V3
Z5045
D12
OA
202
-45V±5%
Next stage
-54.4V±5%
-110V±5%
Resistors ± 7% total excursion ¼ watt
Capacitors ± 10% 150V dc working
Unless otherwise stated
R9
150
kΩ
R19
150
kΩ
R29
150
kΩ
Common reset line
0-4kHz Blocking oscillator input stage
Units counter
Tens counter
Hundreds counter

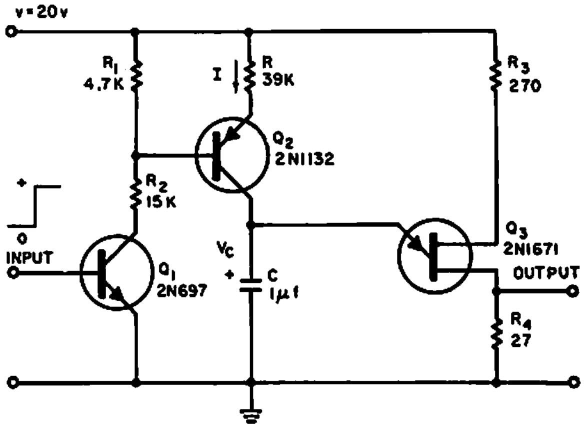
4-KHZ SIX-DECADE SCALER—Uses 4-kHz triggered blocking oscillator to drive first cold-cathode stepping tube in counter chain. Power supply is designed to handle up to three additional decade steppers with associated three-transistor pulse-shaping couplers. Includes reset circuit for setting all counters back to zero.—G. C. Chappell and G. F. Joynes, Transistor Coupling Circuits for the Z5045 Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 26–38.

SUS BINARY DIVIDER CHAIN—Silicon unilateral switch reduces number of components, as compared to transistor flip-flops. Output at point B is free from transients. 2N4987 sus may also be used.—Silicon Unilateral Switch 2N4983/2N4986, General Electric, Syracuse, N.Y., No. 65.25, 1967.


V=15 volts
C_T
5.6k
2.7k
C_C
.068
2.7k
"A"
10k
.0033
"B"
.068
SUS'S-2N4983

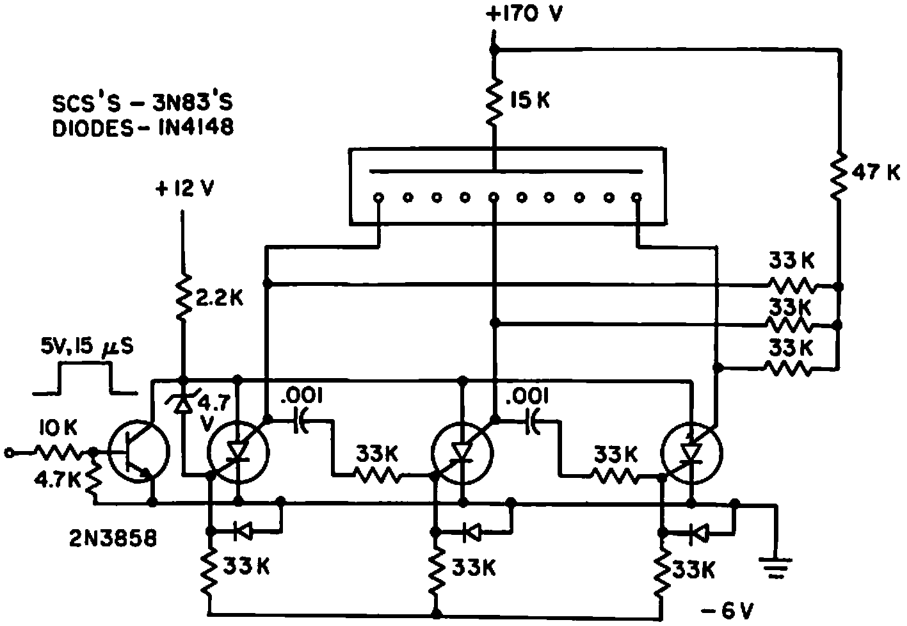

T
CLOCK
470
12V
33
2W
S1
L1
GE47
LS-1
LS400
L2
GE47
33
2W
LS-2
LS400
680
1W
C1
C2
SCR1
2N1595
SCR2
2N1595

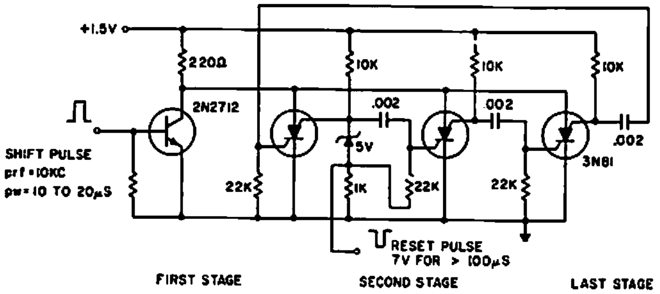
FOUR-STAGE RING—Time constant of lamps limits upper counting frequency to about 20 Hz in simple arrangement for counting clock pulses having widths between 2 and 10 ms. Count can be stopped mechanically by blocking light beam between lamp and corresponding light-sensitive silicon controlled rectifier.—R. Carvajal, Light-Sensing SCRs Make Simple Ring Counter, *Electronic Design*, Feb. 3, 1964, p 50–51.


v=20v
R_1
4.7K
I
R
39K
R_3
270
Q_2
2N1132
R_2
15K
0
INPUT
Q_1
2N697
V_C
C
1μf
Q_3
2N1671
OUTPUT
R_4
27

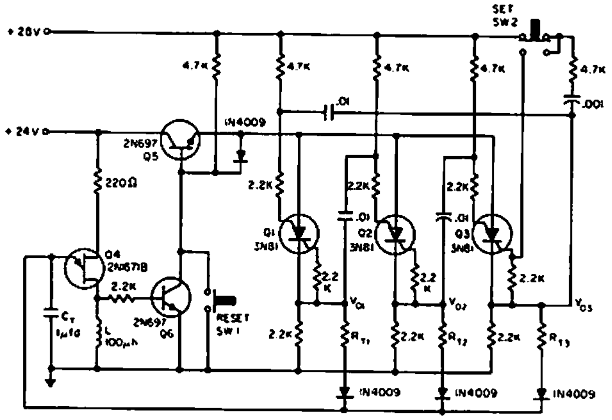
UJT COUNTER—Gives 100:1 count-down for 10-kHz input, to give one output pulse after 100 input pulses. Capacitor C charges through constant-current source Q2 each time Q1 is saturated by an input pulse. Circuit values are chosen from design equations given, so voltage across C will fire ujt Q3 and discharge C through R4 at 100th pulse. —R. A. Wilson, High-Ratio Pulse Counter Utilizes UJT Switch, *Electronic Design*, March 15, 1965, p 58–59.

NIXIE WITH AUTOMATIC RESET—Silicon controlled switches combine functions of memory element and high-voltage driver for ring counter. Feedback from last stage to first is accomplished by breakdown of 4.7-V zener, causing all stages to turn off. First stage comes on automatically when power is applied. If any other stage also comes on, it will be automatically cleared out by succeeding input pulses.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 13.

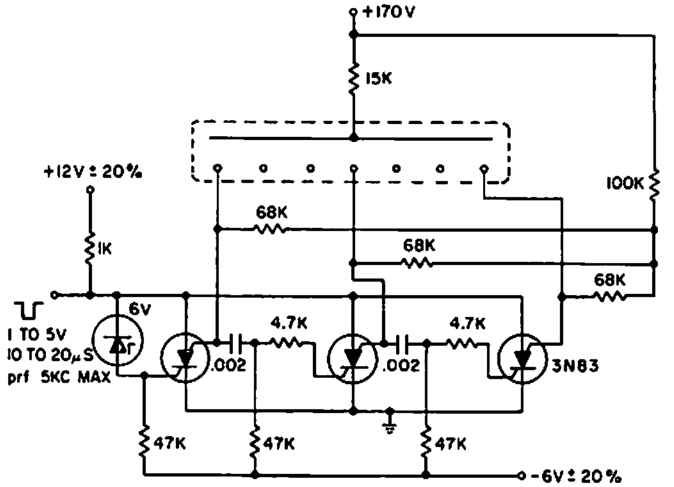

+170 V
SCS'S - 3N83'S
DIODES - IN4148
15 K
47 K
+12 V
33K
33K
33K
2.2K
5V, 15 μS
4.7 V
.001
.001
10 K
33K
33K
4.7K
2N3858
33K
33K
33K
-6V


+1.5V
220Ω
2N2712
10K
10K
10K
.002
.002
.002
5V
1K
22K
22K
22K
3N81
SHIFT PULSE
prf = 10KC
pw = 10 TO 20μS
RESET PULSE
7V FOR > 100μS
FIRST STAGE
SECOND STAGE
LAST STAGE

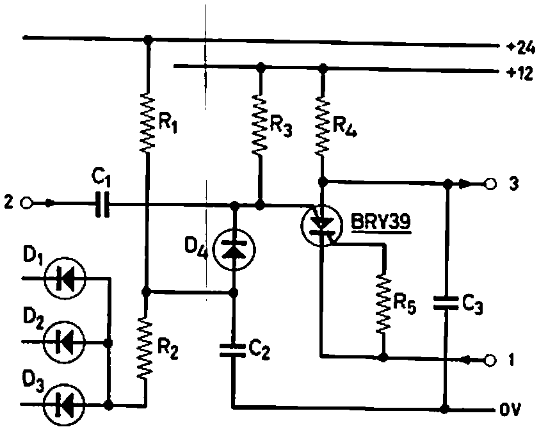
LOW-POWER RING—Requires only 6 mW at 1.5 V, with shift pulses of 1 to 6 V. Trailing edge of reset pulse turns on first stage. Maximum shift pulse width increases with voltage, approaching 70 μs for 6-V supply.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


+28V
+24V
SET SW2
4.7K
4.7K
4.7K
4.7K
4.7K
.01
.001
1N4009
2N697 Q5
220Ω
2.2K
2.2K
2.2K
.01
.01
Q1 3N81
Q2 3N81
Q3 3N81
Q4 2N6718
2.2K
2N697 Q6
2.2 K
2.2 K
2.2K
V_{O1}
V_{O2}
V_{O3}
C_T 1μfd
L 100μh
RESET SW1
2.2K
2.2K
2.2K
R_{T1}
R_{T2}
R_{T3}
1N4009
1N4009
1N4009

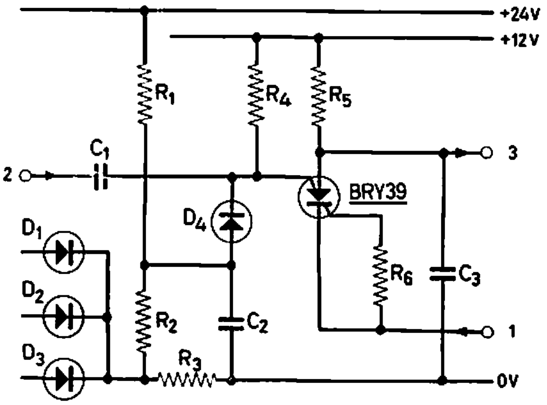
VARIABLE-TIMING RING—Intervals between ujt-generated shift pulses are controlled by values of RT and CT, which can be different for each stage.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


+170V
15K
+12V ± 20%
1K
100K
68K
68K
68K
6V
1 TO 5V
10 TO 20μS
prf 5KC MAX
4.7K
4.7K
.002
.002
3N83
47K
47K
47K
-6V ± 20%

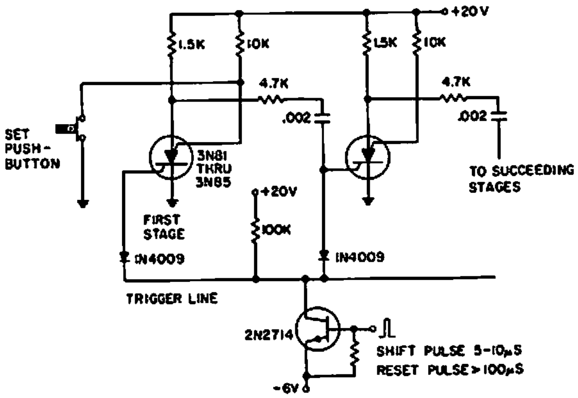
PLANAR PNPN SWITCHES DRIVE NIXIE—Uses one 3N83 switch for each Nixie electrode. Chief advantage is freedom from triggering by line transients.—Planar Neon Driver Silicon Controlled Switch 3N83, General Electric, Syracuse, N.Y., No. 65.17, 1964.


+24V
+12V
R_1
R_3
R_4
C_1
2
3
BRY39
D_1
D_2
D_3
D_4
R_5
C_3
R_2
C_2
1
0V

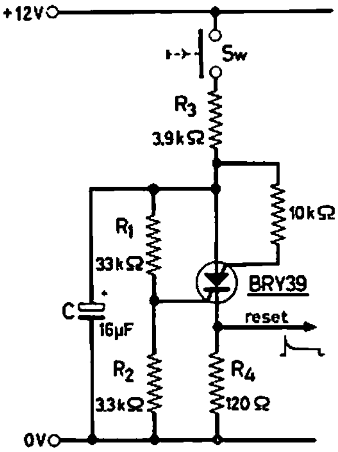
AND GATE WITH DELAYED OR—Used with scs ring counter to carry out switching and logic functions in synchronism with clock pulses applied to terminal 1. Negative-going 12-V input pulse at terminal 2 produces square-wave output pulse for as long as clock pulse is on 1, provided at least one of D1-D2-D3 OR inputs is at zero level. If all OR diodes are at positive 12 V level, input pulse has no effect. R2-C2 introduces delay to insure that change of d-c level has no effect until next clock pulse arrives. Values: R1 22K; R2 6.8K; R3 10K; R4, R5 1K; C1, C3 180 pF; C2 1 nF.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


+24V
+12V
R_1
R_4
R_5
C_1
2
3
BRY39
D_4
D_1
D_2
D_3
R_6
C_3
R_2
C_2
R_3
1
0V

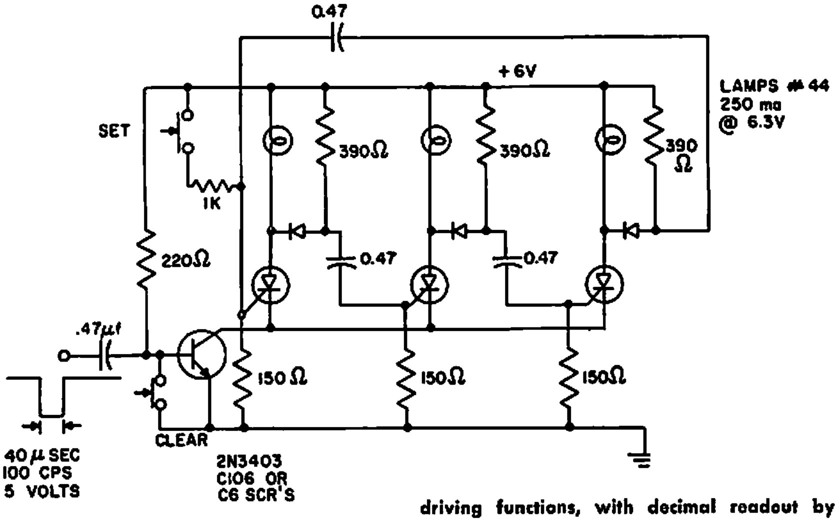
GATE WITH TWO DELAYS—Used with scs ring counter to carry out switching, logic, and delay functions as controlled by clock pulses. Diodes D1, D2, and D3 provide AND function, wherein negative-going input pulses at terminal 2 initiate square-wave output only if all d-c inputs to diodes have zero potential and no input is at +12 V or higher. Values: R1 22K; R2 6.8K; R3, R4, 10K; R5, R6 1K; C1, C3 180 pF; C2 1 nF.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


+20V
1.5K
10K
1.5K
10K
4.7K
4.7K
.002
.002
SET PUSH-BUTTON
3N81 THRU 3N85
FIRST STAGE
+20V
100K
1N4009
1N4009
TO SUCCEEDING STAGES
TRIGGER LINE
2N2714
SHIFT PULSE 5-10µS
RESET PULSE > 100µS
-6V

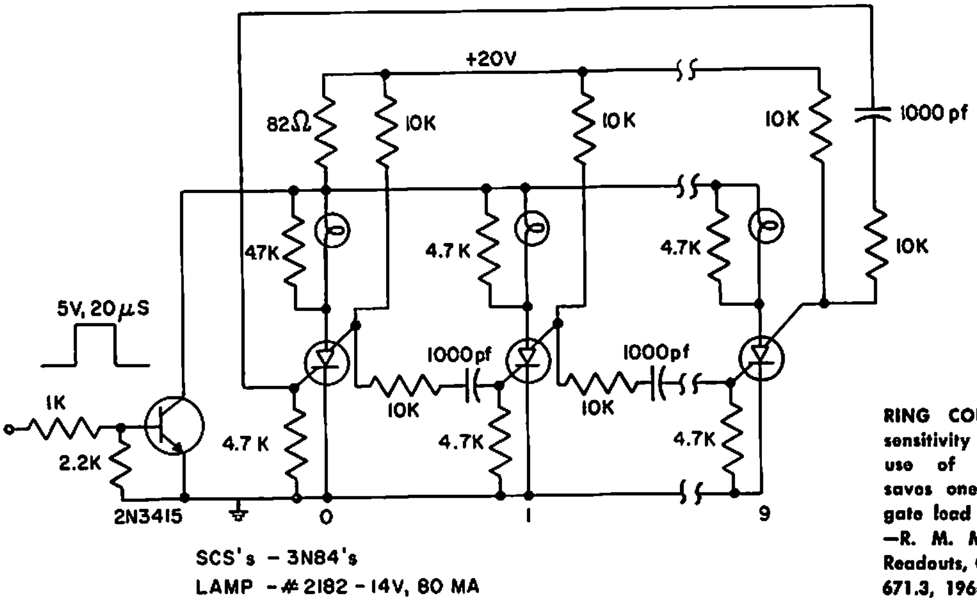
20-KHZ SCS RING—Shift pulse turns off conducting scs by reverse-biasing cathode gate. Charge stored on coupling capacitor then triggers next stage. Long shift pulse is used to turn off all stages by charging all capacitors. Grounding anode gate of stage will set it.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


+12V
Sw
R3
3.9kΩ
10kΩ
R1
33kΩ
C
16µF
BRY39
reset
R2
3.3kΩ
R4
120Ω
0V

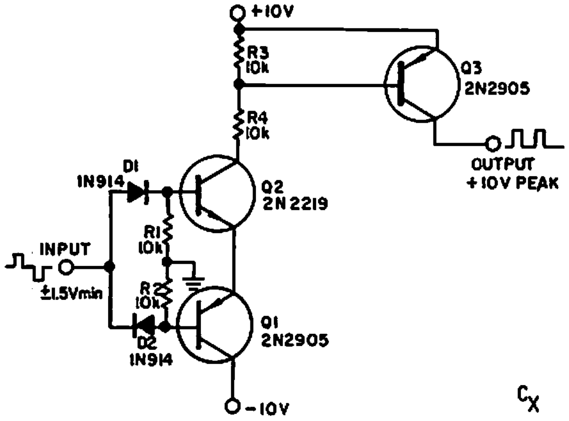
RESET PULSE GENERATOR—Closing of switch produces single pulse for simultaneously resetting scs ring counter to zero after numerical indicator tube has been darkened.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


0.47
+6V
LAMPS #44
250 ma
@ 6.3V
SET
1K
390Ω
390Ω
390 Ω
0.47
0.47
220Ω
.47µf
150Ω
150Ω
150Ω
CLEAR
40µSEC
100 CPS
5 VOLTS
2N3403
C106 OR
C6 SCR'S

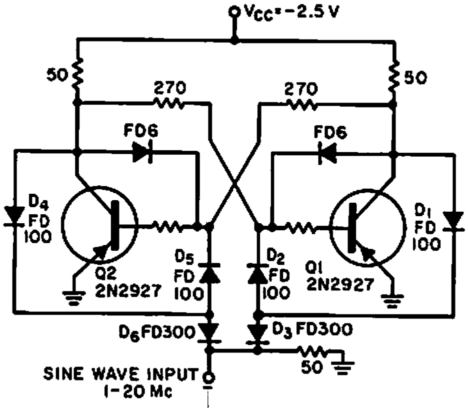
HIGH-CURRENT RING COUNTER—Operates at up to 2 kHz and will count either with or without lamps. Combines both memory and driving functions, with decimal readout by lamps.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 12.

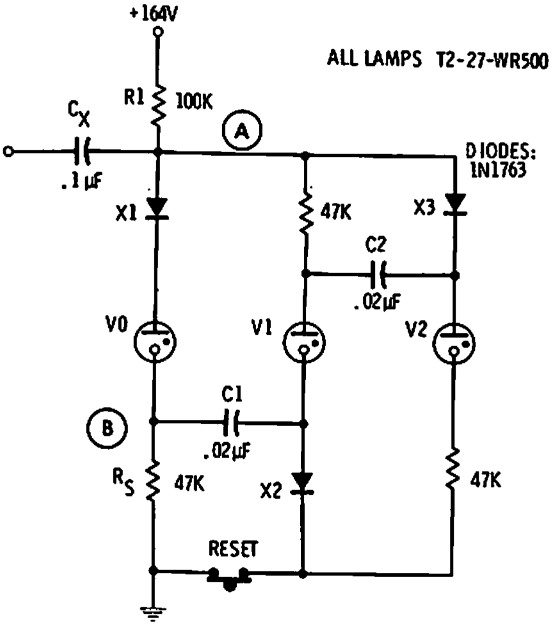

+20V
82Ω
10K
10K
10K
1000 pf
47K
4.7 K
4.7K
10K
5V, 20µS
1000pf
1000pf
10K
10K
1K
2.2K
4.7 K
4.7K
4.7K
2N3415
0
1
9
SCS's - 3N84's
LAMP - #2182 - 14V, 80 MA

RING COUNTER FOR SMALL LAMPS—High sensitivity of silicon controlled switch permits use of smaller capacitors. Arrangement saves one diode per stage because anode gate load prevents triggering by rate effect. —R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 13.


+10V
R3 10k
R4 10k
Q3 2N2905
OUTPUT +10V PEAK
D1
1N914
Q2 2N2219
R1 10k
INPUT
±1.5Vmin
R2 10k
D2 1N914
Q1 2N2905
-10V

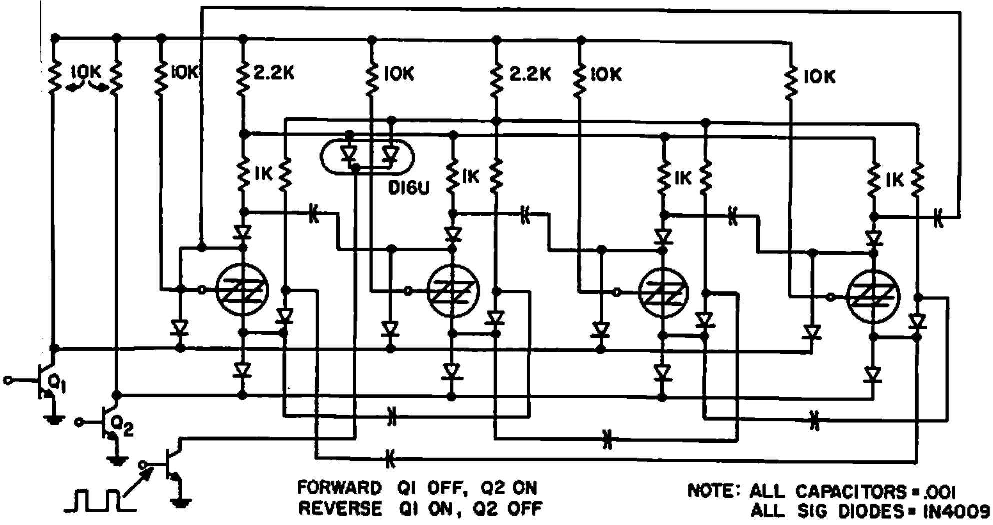
BIPOLAR PULSE COUNTER—Either polarity of input pulse makes Q3 deliver positive output pulse for driving counter.—R. L. Billon, Find the Absolute Value of Bipolar Pulses, *Electronic Design*, Feb. 15, 1970, p 84.


Vcc=-2.5 V
50
270
270
50
FD6
FD6
D4 FD 100
D1 FD 100
Q2 2N2927
D5 FD 100
D2 FD 100
Q1 2N2927
D6FD300
D3FD300
50
SINE WAVE INPUT
1-20 Mc


+164V
ALL LAMPS T2-27-WR500
R1
100K
Cx
.1µF
A
DIODES: 1N1763
X1
47K
X3
C2
.02µF
V0
V1
V2
C1
.02µF
B
Rs
47K
X2
47K
RESET

COUNTING PULSES AT 1 TO 20 MHZ—Flip-flop uses additional fast diodes to provide switching times under 10 ns. FD100's are for pulse steering, FD6's prevent collector saturation, and long-storage FD300's complete triggering action.—20 MC Counter Flip Flop, *Electronic Design*, March 2, 1964, p 58.

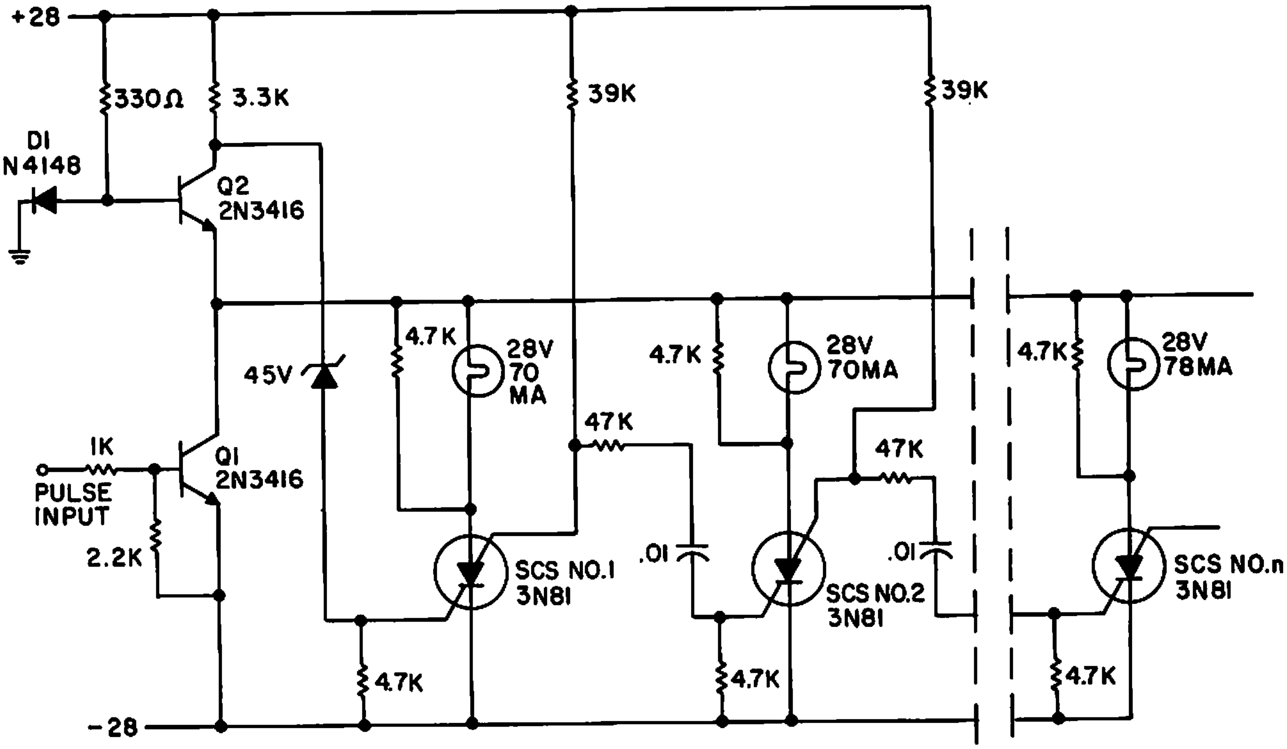
DECIMAL RING COUNTER—Can count up to 999 without need for buffer amplifier, at rates up to 500 Hz. Each stage has neon glow lamp, which can be used for visual readout (circuit shows only first three stages of decade). Pressing reset button fires V0 to indicate count of zero. First input pulse turns off V0 and turns on V1, with count advancing one stage for each succeeding pulse. Resistor and supply values are not critical. Known as Manley-Buckley ring counter.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 55.


10K
10K
10K
2.2K
10K
2.2K
10K
10K
1K
D16U
1K
1K
1K
Q1
Q2

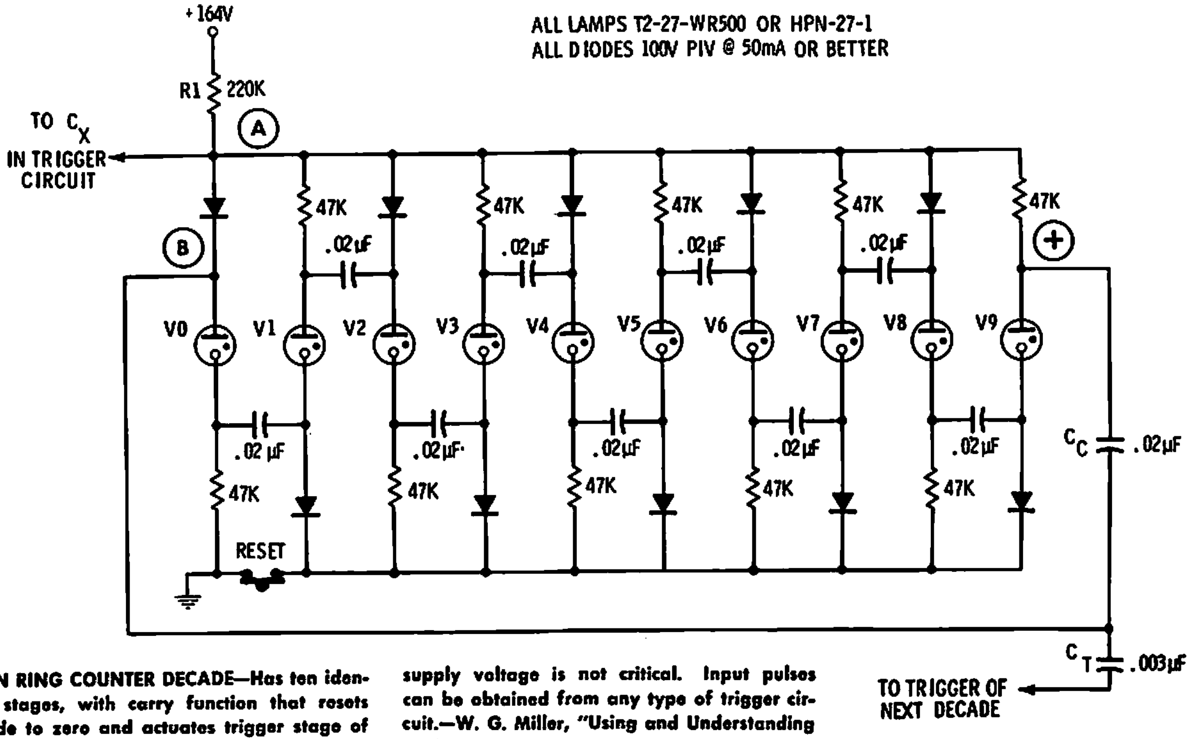
FORWARD Q1 OFF, Q2 ON
REVERSE Q1 ON, Q2 OFF

NOTE: ALL CAPACITORS = .001
ALL SIG DIODES = IN4009

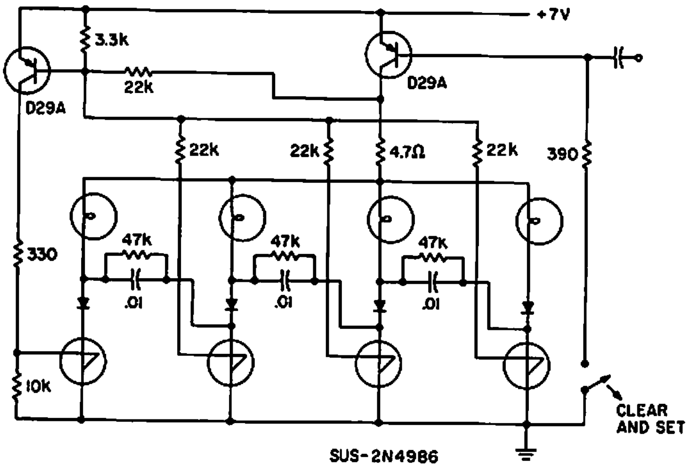
SBS REVERSIBLE RING COUNTER—Type D13Q1 silicon bilateral switches permit changing direction of stepping of stages simply by switching states of transistors Q1 and Q2. Operation can be about 10 kHz. During switch from forward to reverse count, stored charge in bottom p-n region of sbs serves to remember which stage was on.—W. R. Spofford, Jr., Applications of the New Silicon Bilateral Switch and the Silicon Unilateral Switch, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 8.


+28
330Ω
3.3K
39K
39K
D1
1N4148
Q2
2N3416
4.7K
28V
70
MA
4.7K
28V
70MA
4.7K
28V
78MA
45V
47K
47K
1K
PULSE
INPUT
Q1
2N3416
2.2K
.01
.01
SCS NO.1
3N81
SCS NO.2
3N81
SCS NO.n
3N81
4.7K
4.7K
4.7K
-28

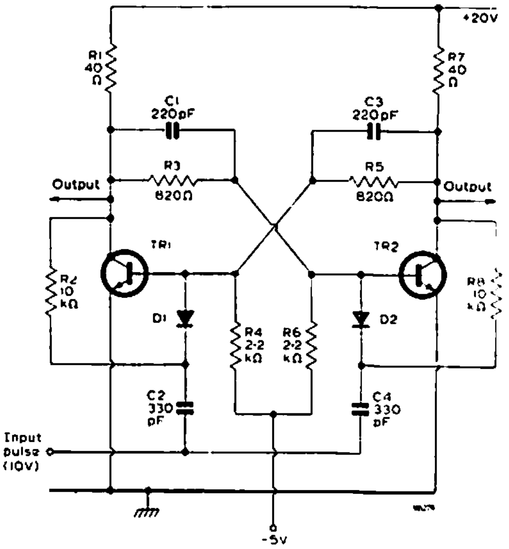
AUTOMATIC RESET—In this variation of lamp-driving scs ring counter, breakdown diode is used to couple last stage to first. First stage then turns on only if all other stages are off. —R. M. Muth, A Ring Counter for Driving Incandescent Bulbs, General Electric, Syracuse, N.Y., No. 90.24, 1965.


+164V
ALL LAMPS T2-27-WR500 OR HPN-27-1
ALL DIODES 100V PIV @ 50mA OR BETTER
R1
220K
A
TO C_X
IN TRIGGER
CIRCUIT
B
47K
.02µF
V0
V1
V2
V3
V4
V5
V6
V7
V8
V9
+
.02 µF
47K
RESET
C_C
.02µF
C_T
.003µF
TO TRIGGER OF
NEXT DECADE

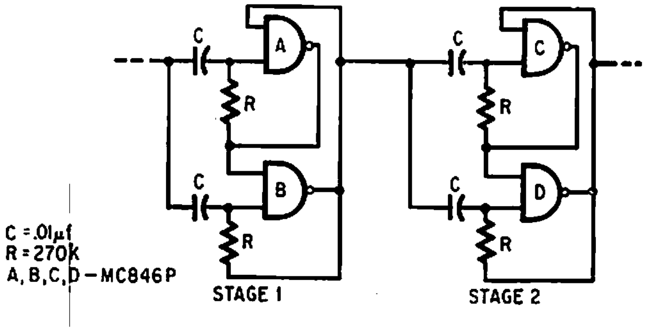
NEON RING COUNTER DECADE—Has ten identical stages, with carry function that resets decade to zero and actuates trigger stage of next decade. Power supply can be two Z82R10 miniature neon regulators in series; supply voltage is not critical. Input pulses can be obtained from any type of trigger circuit.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 58.


+7V
3.3k
22k
D29A
D29A
22k
22k
4.7Ω
22k
390
330
47k
.01
47k
.01
47k
.01
10K
CLEAR
AND SET
SUS-2N4986

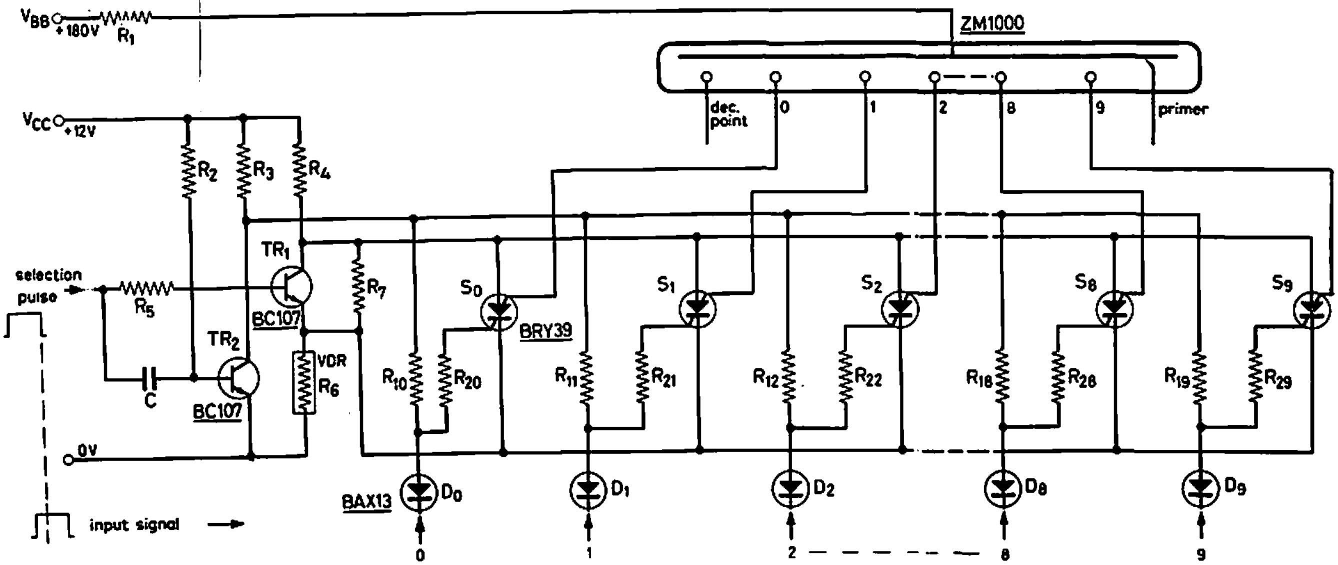
LAMP-DRIVING RING COUNTER—Uses 2N4986 (or 2N4990) silicon unilateral switches to drive incandescent lamps of ring counter.—Silicon Unilateral Switch 2N4983/2N4986, General Electric, Syracuse, N.Y., No. 65.25, 1967.


+20V
R1
40
Ω
R7
40
Ω
C1
220pF
C3
220pF
R3
820Ω
R5
820Ω
Output
Output
TR1
TR2
R2
10
kΩ
R8
10
kΩ
D1
D2
R4
2·2
kΩ
R6
2·2
kΩ
C2
330
pF
C4
330
pF
Input
pulse
(10V)
-5V

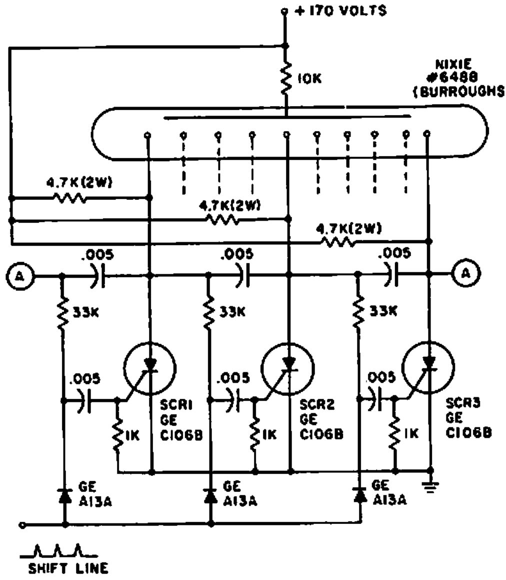
100-KHZ HIGH-CURRENT ECCLES-JORDAN—Transistors are BFY50 and diodes AAZ12. Input trigger pulses are negative.—Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


C
A
R
C
B
R
C
C
R
C
D
R
C = .01µf
R = 270k
A, B, C, D – MC846P
STAGE 1
STAGE 2

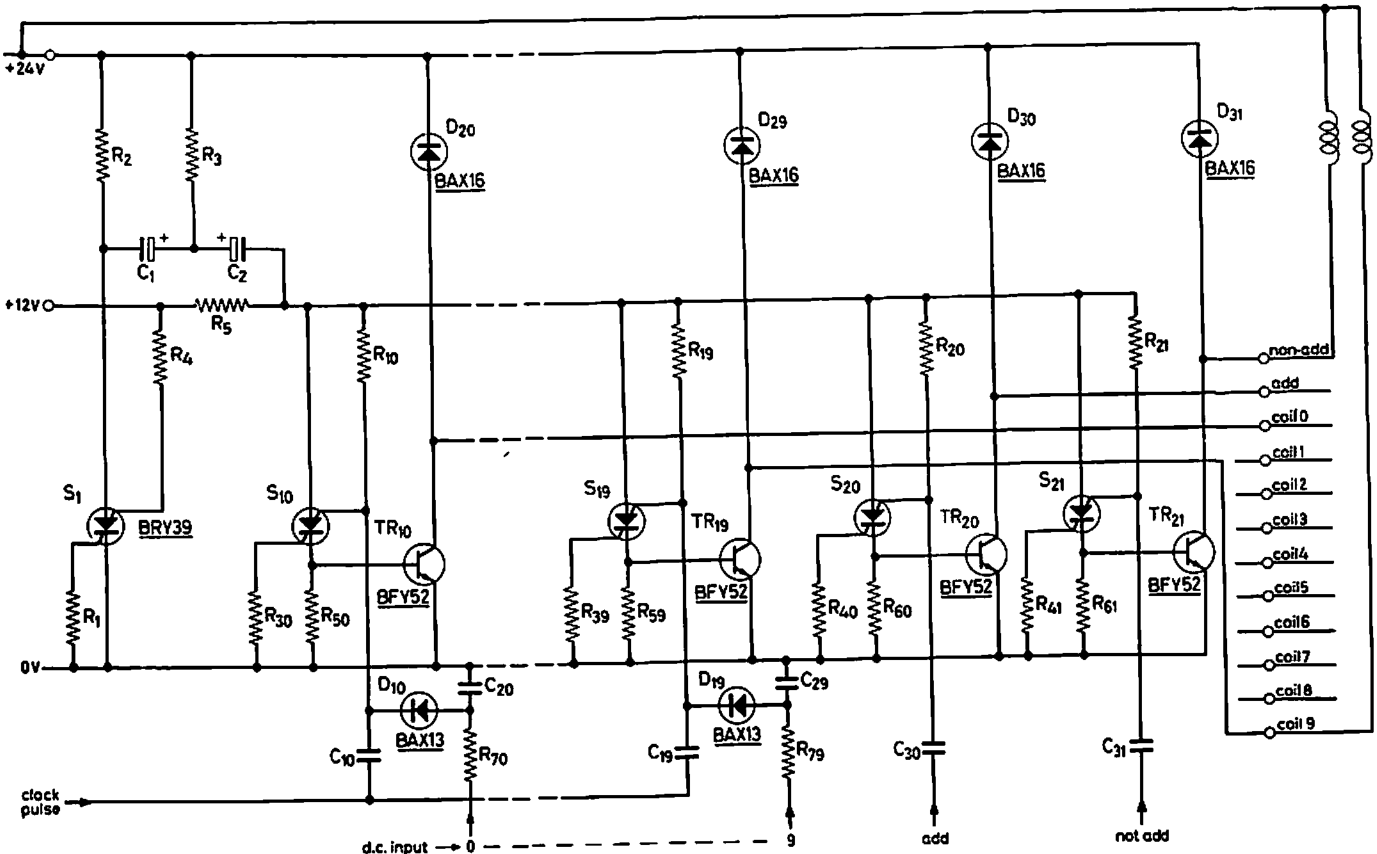
RIPPLE COUNTER—Two 0.01-µF capacitors and two 270K resistors added to MC846P NAND gate make low-cost ripple counter for applications where high speed is not important.—S. Kass, NAND Gate Counter is Cheaper to Make, *Electronics*, Jan. 20, 1969, p 87.


VBB
+180V
R1
ZM1000
dec.
point
0
1
2
8
9
primer
VCC
+12V
R2
R3
R4
TR1
selection
pulse
R5
R7
S0
S1
S2
S8
S9
BC107
BRY39
TR2
VDR
R6
C
BC107
R10
R20
R11
R21
R12
R22
R18
R28
R19
R29
0V
BAX13
D0
D1
D2
D8
D9
input signal
0
1
2 — — — — — 8
9

NUMERICAL DISPLAY WITH MEMORY—Used for controlling one numerical indicator tube in bank of such tubes used for displaying parallel digits representing information from computer or calculator. Scs associated with each digit acts as switch and memory, with digit remaining lit after input signal that selected it has ceased. Article describes operation in detail.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.


+170 VOLTS
10K
NIXIE
#6488
(BURROUGHS)
4.7K(2W)
4.7K(2W)
4.7K(2W)
.005
.005
.005
A
A
33K
33K
33K
.005
.005
.005
SCR1
GE
C106B
SCR2
GE
C106B
SCR3
GE
C106B
1K
1K
1K
GE
A13A
GE
A13A
GE
A13A
SHIFT LINE

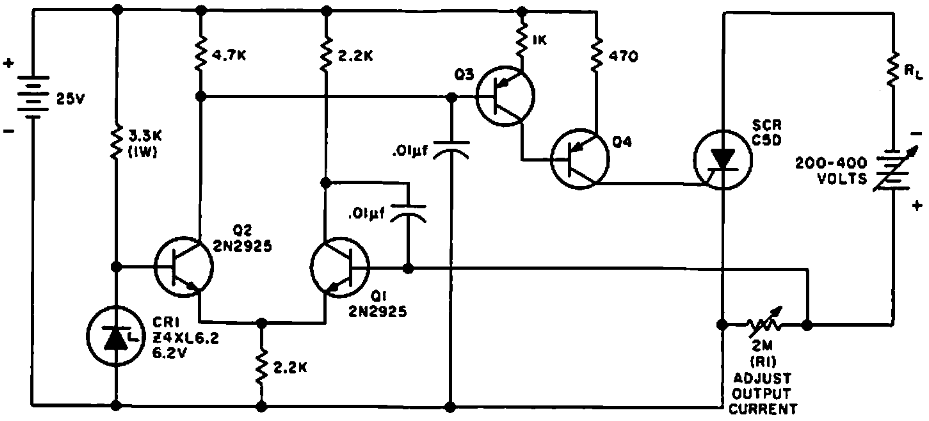
ANODE-COUPLED SCR RING COUNTER—Modification of basic cathode-coupled scr ring counter, as required for driving Nixie decade readout tube.—"SCR Manual," 4th Edition, General Electric, 1967, p 162.


+24V
R2
R3
C1
C2
+12V
R5
R4
S1
BRY39
R1
S10
TR10
R10
R30
R50
D20
BAX16
BFY52
D10
BAX13
C20
C10
R70
clock pulse
d.c. input → 0
D29
BAX16
R19
S19
TR19
BFY52
R39
R59
D19
BAX13
C29
C19
R79
9
D30
BAX16
R20
S20
TR20
BFY52
R40
R60
C30
add
D31
BAX16
R21
S21
TR21
BFY52
R41
R61
C31
not add
0V
non-add
add
coil 0
coil 1
coil 2
coil 3
coil 4
coil 5
coil 6
coil 7
coil 8
coil 9

DRIVING NUMERICAL PRINTOUT—First and last stages for energizing coils of printout device are shown. Operation is similar to that of monostable mvbr, with normally-on scr S1 controlling period. Circuit produces 35-ms output pulses up to 300 mA. Article tells how to modify circuit for driving faster printout devices. Values are: R1 5.6K; R2 3.9K; R3 100K; R4, R10-R21, R30-R41, R50-R61 1K; R5 390; R70-R79 10K; C1-C2 10 μF; C10-C19, C30-C31, 180 pF; C20-C29 1 nF.—D. J. G. Janssen, Circuit Logic with Silicon Controlled Switches, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 1–11.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

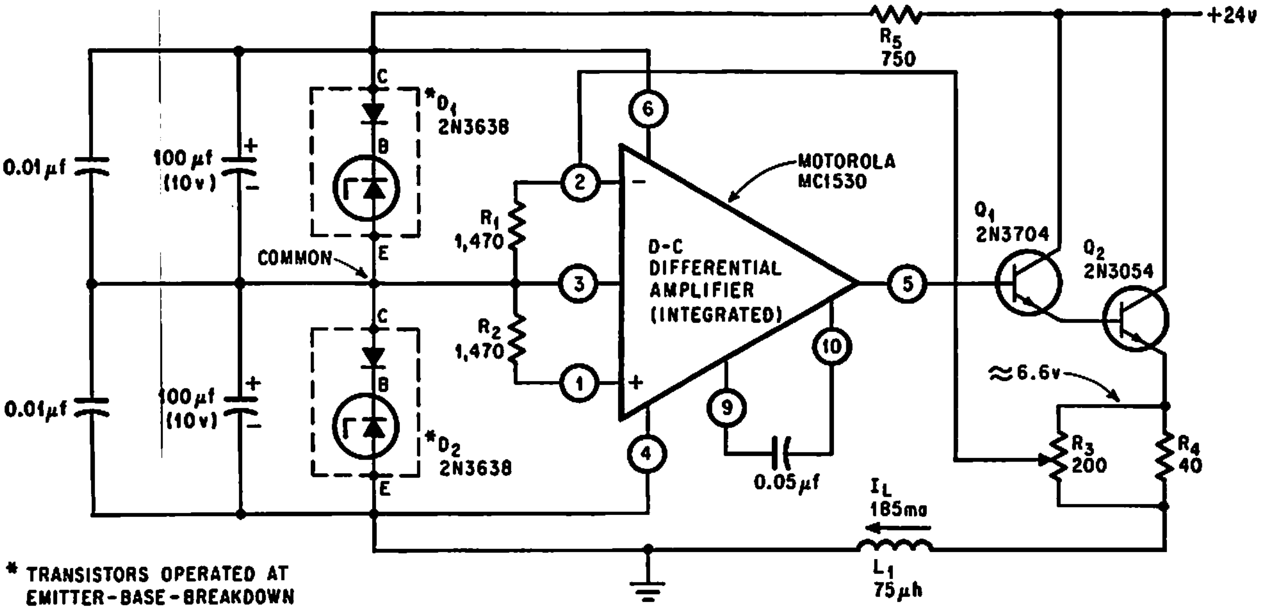
CHAPTER 21
Current Control Circuits



+
25V
-
3.3K (1W)
4.7K
2.2K
IK
470
Q3
Q4
.01µf
.01µf
Q2 2N2925
Q1 2N2925
CR1 Z4XL6.2 6.2V
2.2K
SCR C5D
RL
200-400 VOLTS
-
+
2M (R1) ADJUST OUTPUT CURRENT

Q3, Q4, •GE D29A4

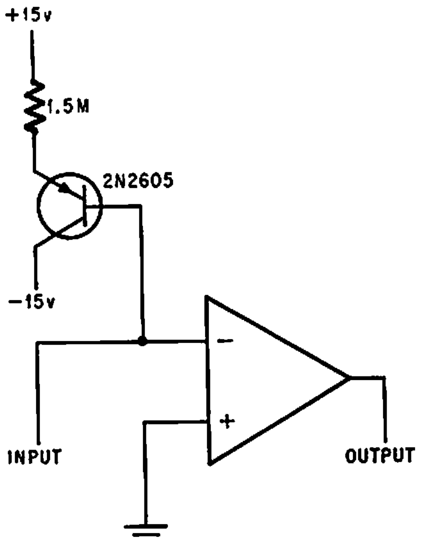
ADJUSTABLE CONSTANT-CURRENT SUPPLY—R1 gives range of 50 µA to 1 mA for output current of scr regulated supply. At 500 µA current is held constant within 0.1% when d-c supply voltage (at right) varies from 200—400 V. Load current is sensed by R1 and differential amplifier Q1-Q2. Zener CR1 provides reference input. Output error signal is applied to scr gate after amplification by Q3-Q4.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 40.



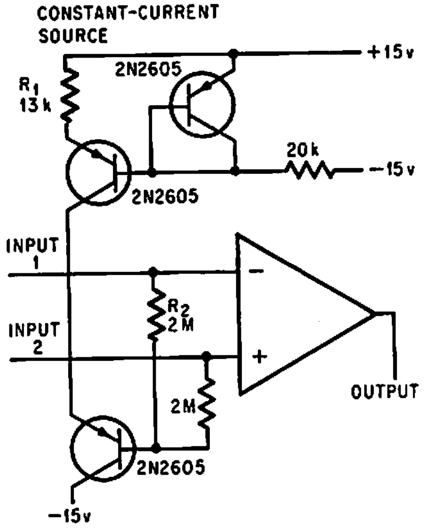
0.01µf
100 µf (10v)
+
C
B
E
*D1 2N3638
COMMON
C
B
E
*D2 2N3638
0.01µf
100µf (10v)
+
R1 1,470
R2 1,470
2
3
1
6
4
9
10
5
-
+
MOTOROLA MC1530
D-C DIFFERENTIAL AMPLIFIER (INTEGRATED)
0.05µf
R5 750
+24v
Q1 2N3704
Q2 2N3054
≈6.6v
R3 200
R4 40
IL 185ma
L1 75µh

*** TRANSISTORS OPERATED AT EMITTER-BASE-BREAKDOWN**

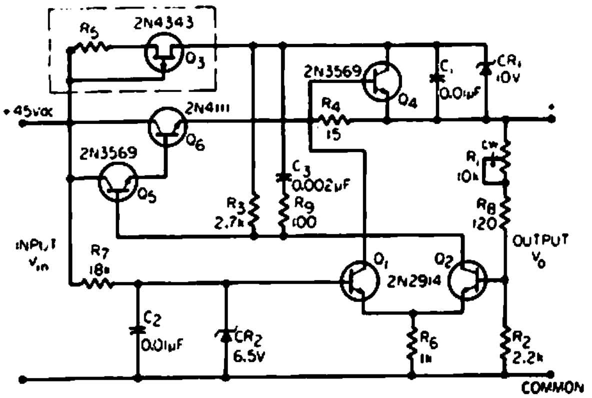
185-MA CURRENT STANDARD WITH IC—Can be built for about $40, has excellent regulation, and can serve as laboratory standard for calibrating magnetometers. Can generate several amperes of constant current if appropriate output transistors are added. Feedback loop goes from pin 2 of IC to R3. Passive components outside feedback loop must have low temperature coefficients.—C. S. Pepper, IC Amplifier Serves as Stable Current Source, *Electronics*, March 6, 1967, p 131—132.


+15v
1.5M
2N2605
−15v
−
+
INPUT
OUTPUT

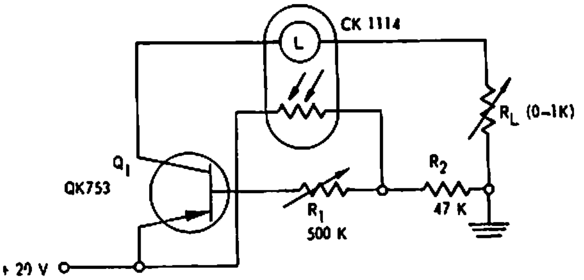
COMPENSATION NETWORK FOR SUMMING—Pnp transistor and 1.5-meg resistor compensate for bias current drift, independently of source impedance, for summing amplifier. Circuit is effective only over narrow range of positive supply voltages. Amount of temperature drift depends on how closely betas of IC and external transistors track.—R. J. Widlar, Linear IC's: Compensating For Drift, *Electronics*, Feb. 5, 1968, p 90–93.


CONSTANT-CURRENT SOURCE
R1 13k
2N2605
+15v
20k
−15v
2N2605
INPUT 1
INPUT 2
R2 2M
2M
−
+
OUTPUT
2N2605
−15v

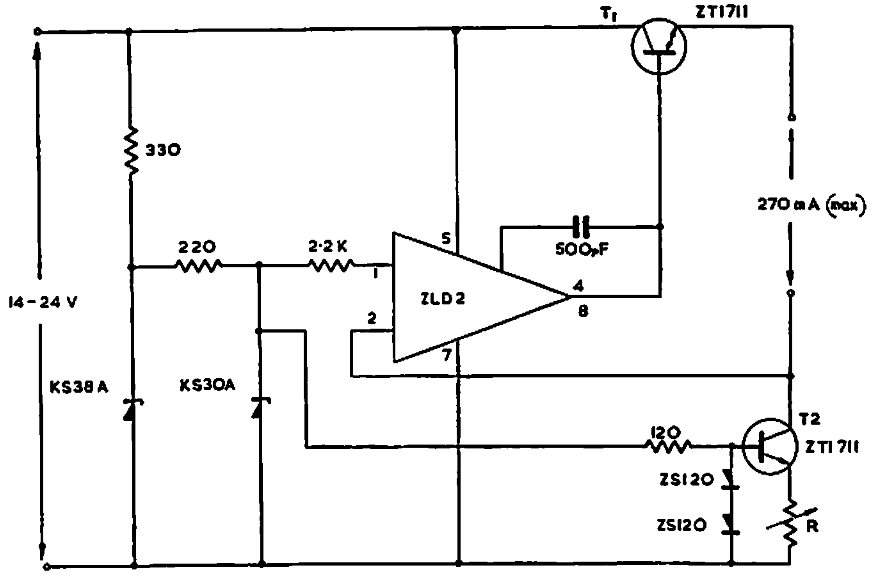
DRIFT-FREE DIFFERENTIAL INPUT—Three transistors and selected resistors R1 and R2 provide bias current compensation for differential-input IC amplifier, independently of source impedance for both inputs over entire common mode range.—R. J. Widlar, Linear IC's: Compensating For Drift, *Electronics*, Feb. 5, 1968, p 90–93.


R5
2N4343
Q3
+45vdc
2N4111
Q6
2N3569
Q5
2N3569
Q4
C1 0.01μF
CR1 10V
R4 15
C3 0.002μF
R3 2.7k
R9 100
R1 10k
cw
R8 120
OUTPUT Vo
INPUT Vin
R7 18k
Q1
Q2
2N2914
C2 0.01μF
CR2 6.5V
R6 1k
R2 2.2k
COMMON

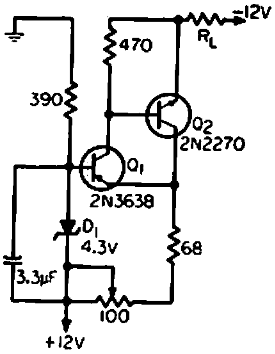
FET CONSTANT-CURRENT SOURCE—Q3 and R5 are added to conventional voltage regulator to improve regulation by making current through zener CR1 less dependent on input voltage and load current. Circuit also provides automatic current limiting. Choose value of R5 to bias fet at 4.5 mA drain current.—J. McPhail, FET Improves Voltage Regulation and Allows Current Limiting, *EEE*, July 1968, p 97–98.


CK 1114
L
RL (0-1K)
Q1
QK753
R2
47 K
R1
500 K
+ 20 V

OPTOELECTRONIC CURRENT REGULATOR—Lamp of Raysistor senses current changes, and photocell in feedback circuit initiates compensation for change. R1 is set for desired load current. Regulation is within 10% for load range of 0 to 1,000 ohms.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 23.

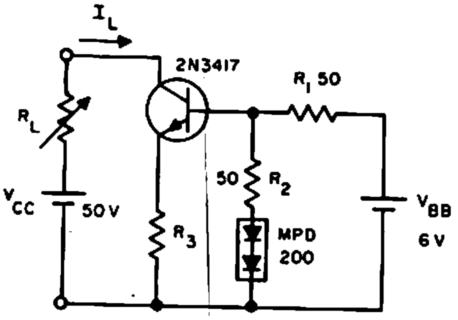

T1
ZT1711
330
270 mA (max)
220
2·2 K
5
500pF
1
ZLD2
4
8
2
7
14−24 V
KS38A
KS30A
120
T2
ZT1 711
ZS120
ZS120
R

STABILIZED DIRECT CURRENT SUPPLY—Uses Ferranti ZLD2 as error signal amplifier, with d-c error signal being proportional to stabilized output current of d-c supply. Output current changes only about 0.03% per volt of change in d-c input voltage.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 15.



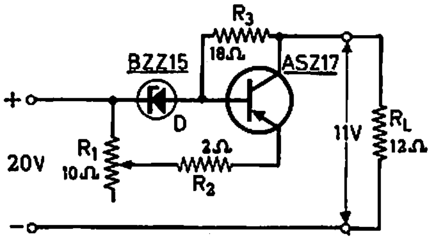
+12V
470
R_L
390
Q2
2N2270
Q1
2N3638
D1
4.3V
68
3.3μF
100
+12V

CONSTANT-CURRENT SOURCE—Addition of Q2 to conventional current source and careful adjustment of circuit values minimizes temperature drift and overcomes dissipation problem in Q1 when handling emitter currents above a few mA. With values shown, load current changes less than 0.5% over ambient temperature range of 0 to 70 C. Applications include differential amplifiers, timing generators, and fet stabilizers.—W. G. Jung, Temperature-Stabilized Constant-Current Source, *EEE*, Oct. 1968, p 126–127.



I_L
2N3417
R_1 50
R_L
V_CC
50V
R_3
50
R_2
MPD
200
V_BB
6V

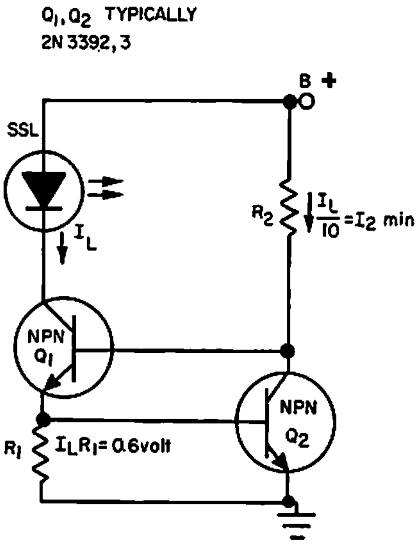
TEMPERATURE COMPENSATION WITH DIODE—Two-pellet diode in constant-current source compensates for variations in transistor base-emitter voltage due to temperature changes.—Silicon Multi-Pellet Diodes MPD200/MPD-300/MPD400, General Electric, Syracuse, N.Y., No. 75.42, 1966.



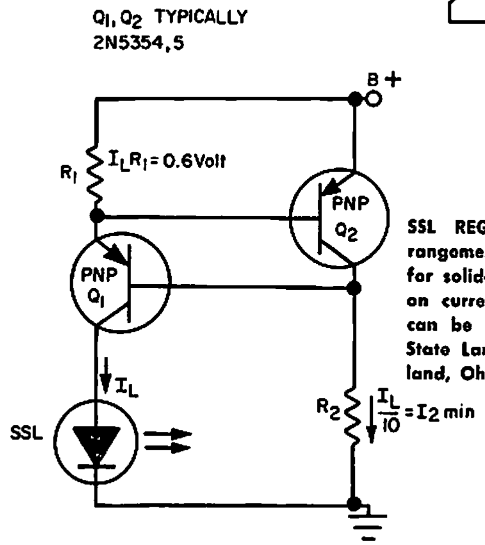
R3
18Ω
BZZ15
ASZ17
+
D
20V
R1
10Ω
2Ω
R2
11V
RL
12Ω
−

11-V CONSTANT-CURRENT SUPPLY—Any change in current through R3 modifies bias of power transistor, changing its differential impedance in such a way as to bring current through R3 and load back to original value. Uses power zener.—Zener Diodes and Their Applications, Philips, Publications Dept., Elcoma Division, Eindhoven, The Netherlands, Technical Information 17, 1966.

SSL REGULATOR—Two-transistor sink arrangement provides 4% current regulation for variations in supply voltage and 0.3% per deg C for thermal variations, for current-sensitive devices such as solid-state lamps. Suggested value for R2 is IL/10. Supply voltage can be as low as 3 V, with maximum value limited by transistor ratings.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 27.

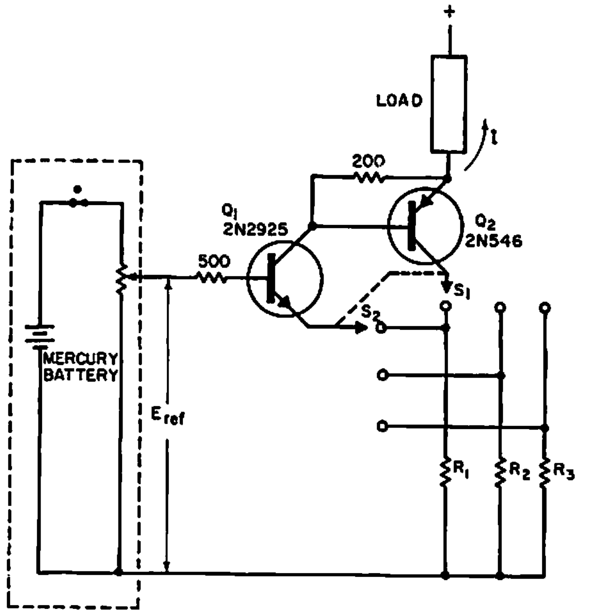


Q1,Q2 TYPICALLY
2N 3392,3
B +
SSL
I_L
R2
I_L/10 = I2 min
NPN
Q1
NPN
Q2
R1
I_L R1 = 0.6volt



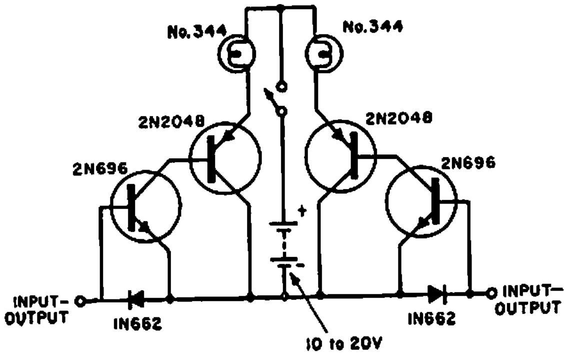
Q1,Q2 TYPICALLY
2N5354,5
B+
R1
I_L R1 = 0.6Volt
PNP
Q2
PNP
Q1
I_L
SSL
R2
I_L/10 = I2 min

SSL REGULATOR—Two-transistor source arrangement provides 4% current regulation for solid-state lamp. Resistor values depend on current rating of lamp. Supply voltage can be as low as 3 V.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 27.



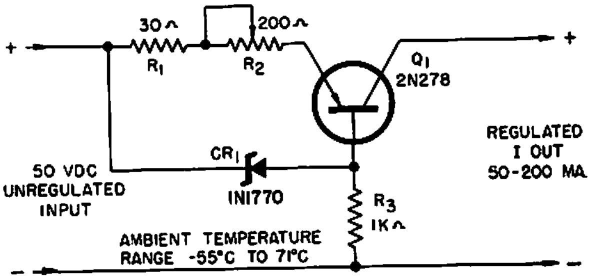
+
LOAD
I
200
Q1
2N2925
Q2
2N546
500
S1
S2
MERCURY BATTERY
E_ref
R1
R2
R3

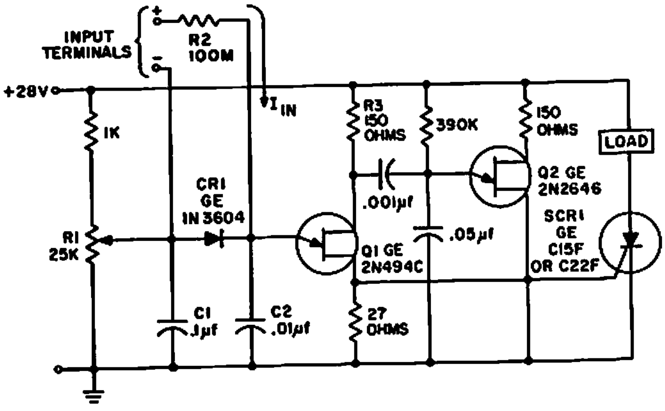
WIDE-RANGE CURRENT CONTROL—Uses variable reference voltage, obtained from mercury battery, with complementary-transistor power amplifier, to change current through load.—D. L. Boos, Complementary Transistors Expand Current Supply Range, *Electronic Design*, June 8, 1964, p 72–73.


No.344
No.344
2N2048
2N2048
2N696
2N696
+
INPUT-OUTPUT
INPUT-OUTPUT
IN662
IN662
10 to 20V

BIPOLAR CURRENT-LEVEL DETECTOR—Direct-coupled two-stage amplifiers drive two lamps to indicate when current between input-output terminals exceeds about 10 μA, with appropriate lamp lighting to indicate direction of current flow.—R. Gerdes, Sensitive Current Detector Indicates Direction of Flow, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 150.

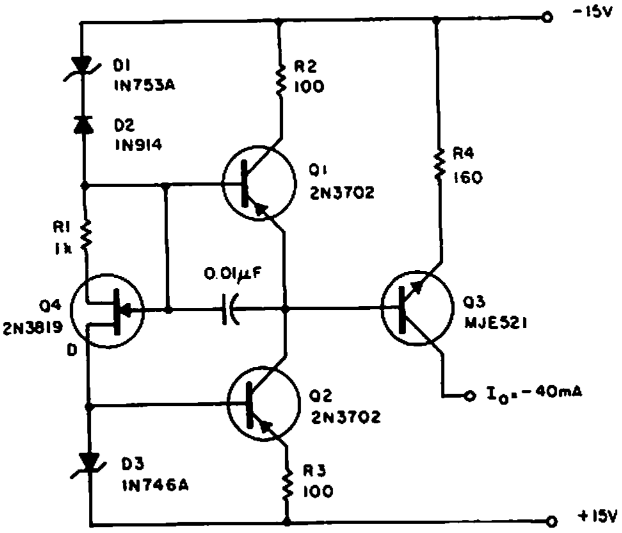
CURRENT REGULATOR—Circuit is basically grounded-base, with collector and emitter currents essentially equal because of high current gain of transistor. R3 must draw enough current through reference diode so its voltage drop will remain at 8 V as current regulator is loaded. Load current remains essentially constant until load resistance is increased to point where voltage drops across load and R3 become equal.—Current Regulator, Delco Radio, Kokomo, Ind., No. 4-B, May 1965.

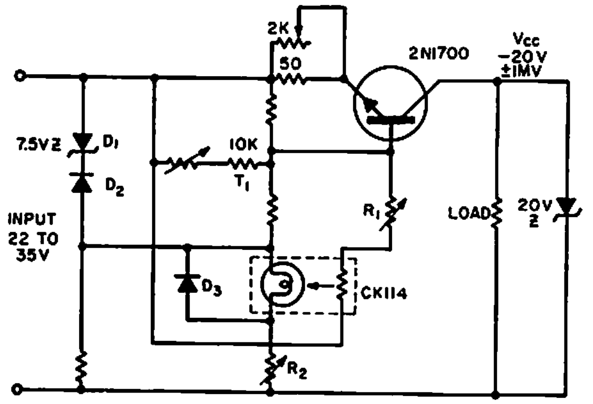

+
30Ω
R1
200Ω
R2
Q1
2N278
+
REGULATED I OUT 50-200 MA
CR1
IN1770
50 VDC UNREGULATED INPUT
R3
1KΩ
AMBIENT TEMPERATURE RANGE -55°C TO 71°C
−
−


INPUT TERMINALS
+
−
R2
100M
+28V
IK
I IN
R3
150 OHMS
390K
150 OHMS
LOAD
CR1
GE
IN3604
R1
25K
.001μf
Q2 GE
2N2646
.05μf
SCR1
GE
C15F
OR C22F
Q1 GE
2N494C
C1
.1μf
C2
.01μf
27 OHMS

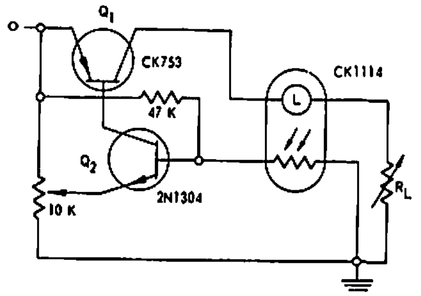
NANOAMPERE SENSING—May be used as sensitive current detector, or as voltage detector having high input impedance. Sampling technique gives input current sensitivity below 35 nA and input impedance above 100 meg. R1 is adjusted so circuit will not fire in absence of current input signal. Input signal then charges C2 through R2 toward emitter firing voltage of Q1. Relaxation oscillator Q2 supplies series of 0.75-V negative pulses to base 2 of Q1 to drop its firing voltage momentarily and permit firing even though R2 cannot furnish required peak point firing current of 2 μA.—"SCR Manual," 4th Edition, General Electric, 1967, p 166–167.

CONSTANT 40 MA WITH 0.1% REGULATION—Operates over wide range of supply voltages, temperatures, and loads yet cost of parts is only $5. Basic reference voltage, provided by zener D1 driven by constant current, is buffered by emitter-follower Q1 driven by constant-current source Q2.—R. C. Gordes, Constant-Current Source is Stable and Inexpensive, *Electronic Design*, March 15, 1969, p 254.

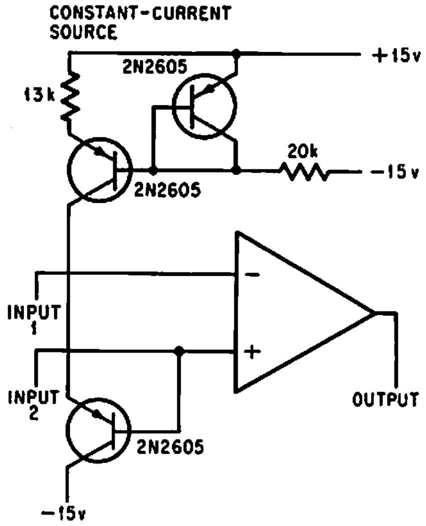

-15V
D1
IN753A
R2
100
D2
IN914
R4
160
Q1
2N3702
R1
1k
0.01μF
Q4
2N3819
D
Q3
MJE521
I0 = -40mA
Q2
2N3702
D3
IN746A
R3
100
+15V


2K
50
2N1700
Vcc
-20V
±1MV
7.5VZ
D1
D2
10K
T1
INPUT
22 TO
35V
R1
LOAD
20V
Z
D3
CK114
R2

RAYSISTOR CONTROL OF 30 MA AT 20 V—Combination photoresistor and lamp (CK-114) provides electrically isolated compensation for input voltage changes from 22 to 35 V in constant-current generator. D3 simply protects lamp and helps offset positive temperature coefficient; type is not critical.—K. Myers, Raysistor Compensates Current Generator, *Electronic Design*, April 13, 1964, p 75–77.


Q1
CK753
CK1114
47 K
Q2
L
2N1304
10 K
RL

OPTOELECTRONIC REGULATOR—Additional transistor Q2 increases loop gain of optoelectronic constant-current regulator to provide improved regulation.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 24.

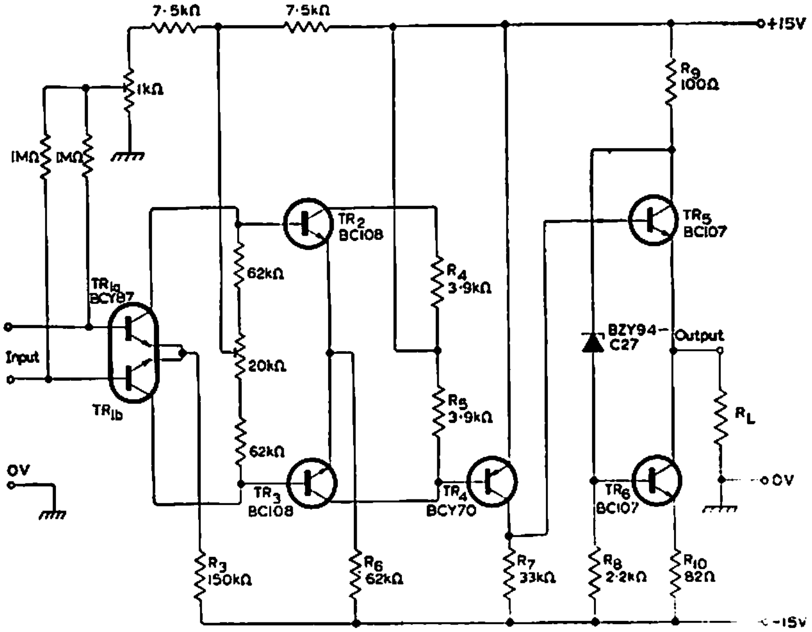

CONSTANT-CURRENT
SOURCE
+15v
2N2605
13k
20k
-15v
2N2605
INPUT
1
-
+
INPUT
2
OUTPUT
2N2605
-15v

CONSTANT-CURRENT SOURCE—Three pnp transistors and selected 13K transistor serve as bias-current compensation network for noninverting IC amplifier requiring large common mode ranges. Circuit provides tight drift control but over limited temperature range. Feedback resistance of IC must be kept low.—R. J. Widlar, Linear IC's: Compensating For Drift, *Electronics*, Feb. 5, 1968, p 90–93.

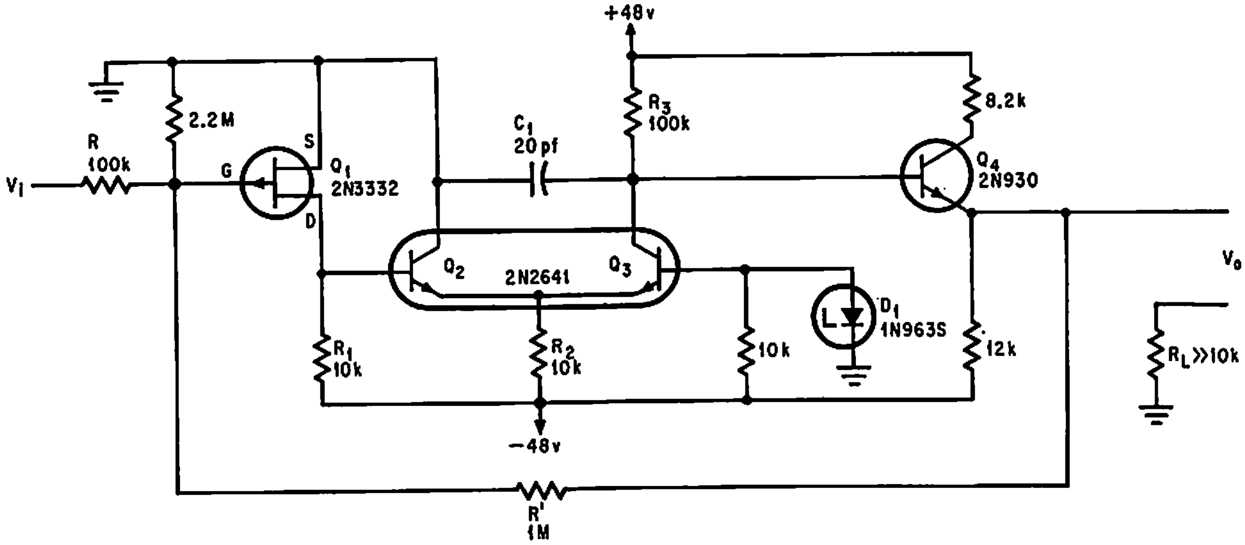
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 22

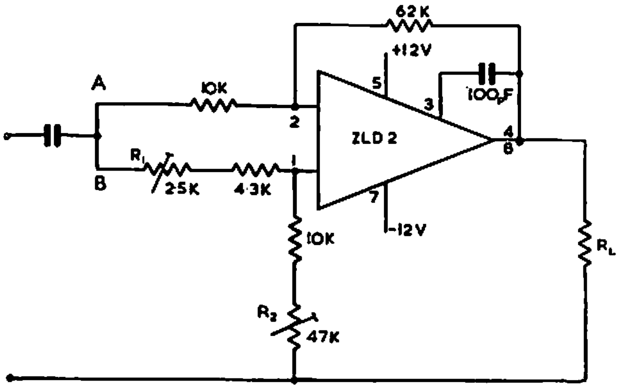
D-C Amplifier Circuits


7·5kΩ
7·5kΩ
+15V
1kΩ
R9
100Ω
1MΩ
1MΩ
TR2
BC108
TR5
BC107
TR1a
BCY87
62kΩ
R4
3·9kΩ
BZY94-C27
Output
Input
20kΩ
R5
3·9kΩ
RL
TR1b
62kΩ
0V
TR3
BC108
TR4
BCY70
TR6
BC107
0V
R3
150kΩ
R6
62kΩ
R7
33kΩ
R8
2·2kΩ
R10
82Ω
−15V

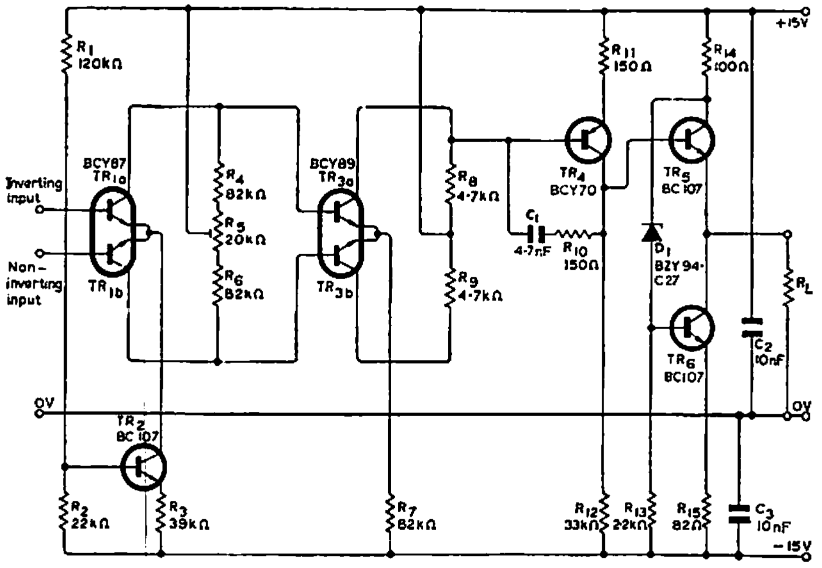
VOLTAGE GAIN 150,000—Input resistance is 240K and output resistance 10 ohms. Provides single-ended output of 10 V with either polarity at up to 20 mA. Output voltage is 0 V for zero input. Uses two differential amplifiers at input to keep differential voltage drift at required value of less than 12 μV per deg C.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 11.


+48v
R3
100k
8.2k
C1
20pf
R
100k
VI
2.2M
G
S
Q1
2N3332
D
Q4
2N930
Q2
2N2641
Q3
V0
R1
10k
R2
10k
10k
D1
1N963S
12k
RL>>10k
−48v
R'
1M

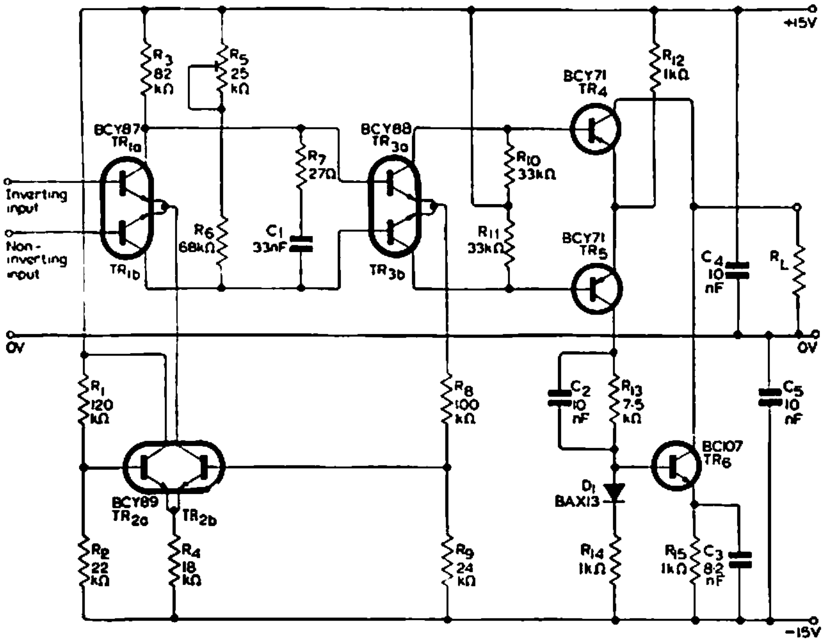
FET STABILIZATION—Addition of fet Q1 to d-c amplifier improves stability for wide range of temperatures and supply voltages, and gives high open-loop input impedance for operational amplifier applications. Article gives gain equations.—N. C. Voulgaris, FET Boosts Impedance of D-C Feedback Amplifier, *Electronics*, Oct. 16, 1967, p 98.


62K
+12V
A
10K
100μF
2
3
5
ZLD 2
4
8
R1
B
25K
4·3K
1
7
10K
-12V
RL
R2
47K

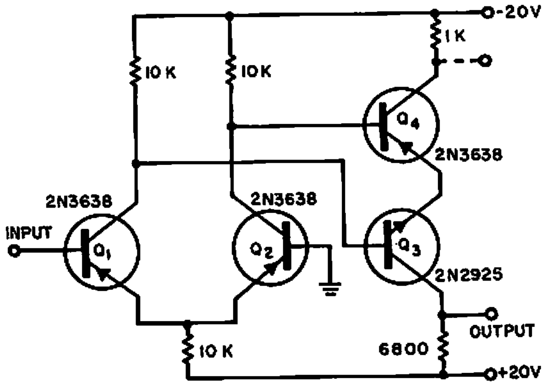
DIFFERENTIAL-INPUT IC WITH 90-DB CMR— Uses Ferranti ZLD2 IC low-power d-c amplifier having high common mode rejection, common mode range within 2 V of either supply voltage, and large output voltage swing.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 4.


R1
120kΩ
Inverting input
Non-inverting input
BCY87
TR1a
TR1b
R4
82kΩ
R5
20kΩ
R6
82kΩ
BCY89
TR3a
TR3b
R8
4·7kΩ
R9
4·7kΩ
C1
4·7nF
R10
150Ω
R11
150Ω
TR4
BCY70
R14
100Ω
TR5
BC107
D1
BZY94-C27
TR6
BC107
C2
10nF
RL
+15V
0V
0V
TR2
BC107
R2
22kΩ
R3
39kΩ
R7
82kΩ
R12
33kΩ
R13
22kΩ
R15
82Ω
C3
10nF
-15V

VOLTAGE GAIN 70,000— Four-stage d-c amplifier has differential input stage and single-ended output. Combined emitter currents of first stage are stabilized by constant-current source TR2. Nominal output voltage is 10 V at either polarity for up to 10 mA. Common-mode rejection ratio is 600. Differential voltage drift is 6 μV per deg C. Frequency response drops almost linearly from 96 dB at 10 Hz to 0 dB at 700 kHZ.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 20.

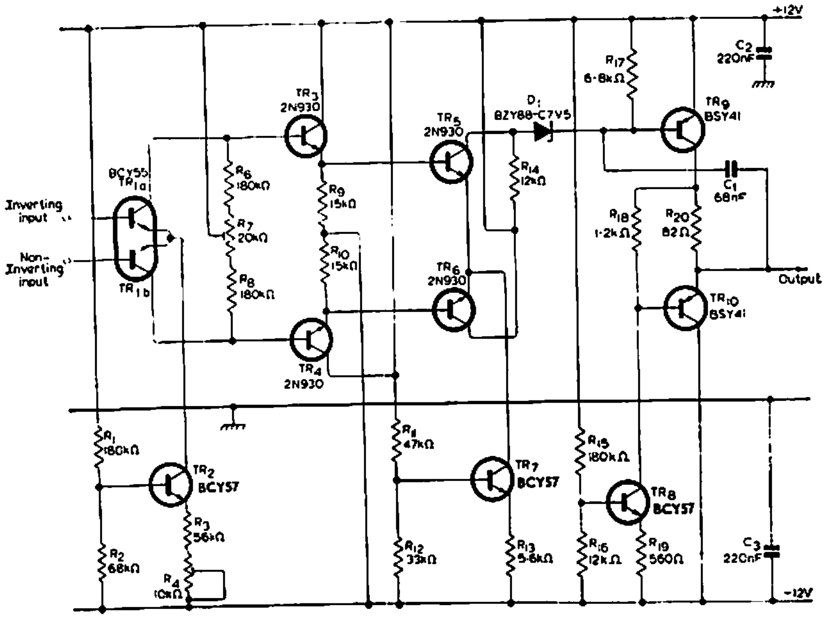

+15V
R3
82
kΩ
R5
25
kΩ
BCY87
TR1a
TR1b
Inverting input
Non-inverting input
R7
270Ω
R6
68kΩ
C1
33nF
BCY88
TR3a
TR3b
R10
33kΩ
R11
33kΩ
BCY71
TR4
BCY71
TR5
R12
1kΩ
C4
10
nF
RL
0V
0V
R1
120
kΩ
BCY89
TR2a
TR2b
R2
22
kΩ
R4
18
kΩ
R8
100
kΩ
R9
24
kΩ
C2
10
nF
R13
7·5
kΩ
D1
BAX13
R14
1kΩ
BC107
TR6
R15
1kΩ
C3
8·2
nF
C5
10
nF
-15V

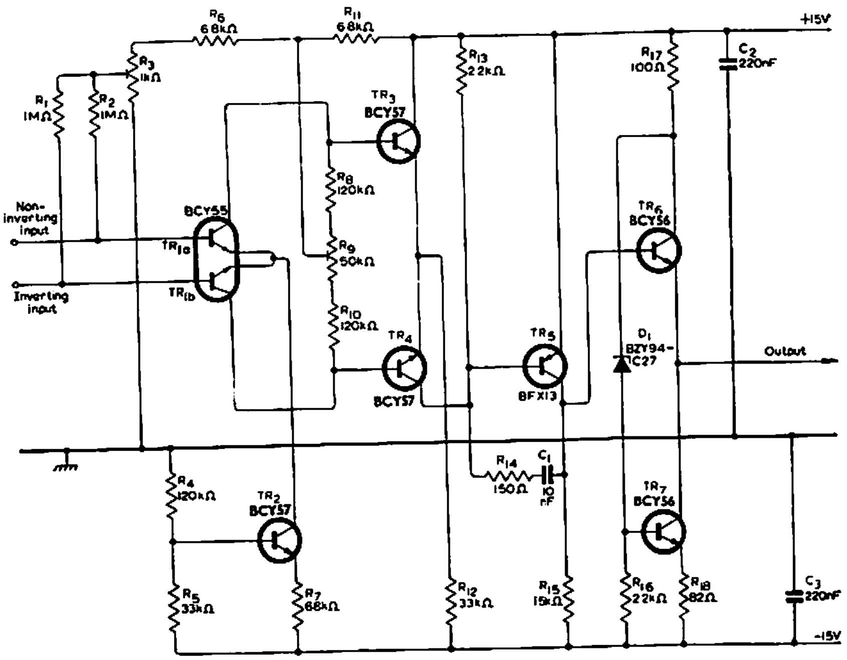
VOLTAGE GAIN 100,000— Uses three differential stages and single-ended output, with TR2 serving as constant-current source for holding input stage emitter currents constant. Output stage uses long-tailed pair TR4-TR5 to drive TR6. Frequency response falls about 6 dB per octave from 100 dB voltage gain at 100 Hz down to 0 at 10 MHz. Output voltage is 10 V of either polarity at up to 2.5 mA. Differential voltage drift is 3 μV per deg C.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 22.


-20V
1 K
10 K
10 K
Q4
2N3638
2N3638
2N3638
INPUT
Q1
Q2
Q3
2N2925
OUTPUT
10 K
6800
+20V

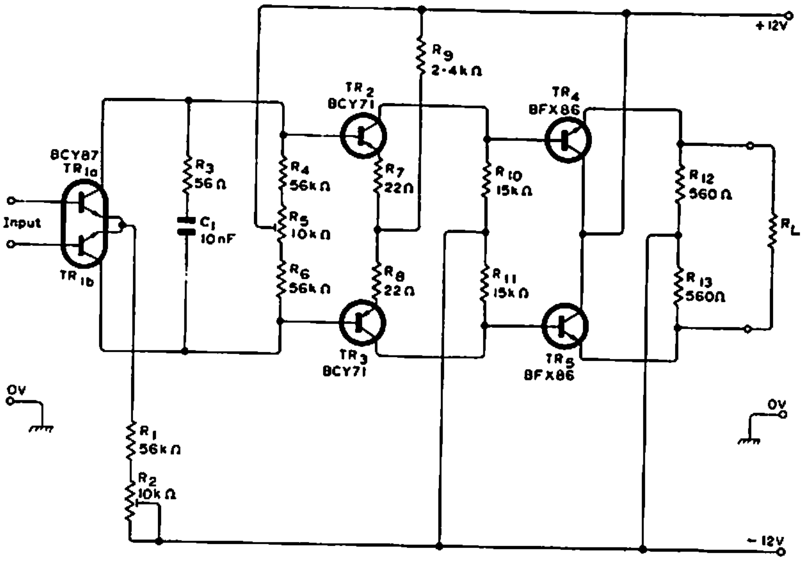
DUAL OUTPUT—Modified version of differential amplifier provides dual output along with higher gain and higher efficiency than conventional differential output stage. Dashed line indicates second output phase that is available, but d-c voltage excursion available is less desirable. Lowered current requirement makes this circuit highly desirable in analog systems using many amplifiers.—S. G. Freshour, Differential Amplifier Offers Efficient, Dual Outputs, *Electronic Design*, July 19, 1965, p 37–38.

VOLTAGE GAIN 1,500,000—Single-ended output delivers 10 V of either polarity up to 10 mA. Frequency response drops essentially linearly from 115 dB at 10 Hz to 0 dB at 1 MHz. Intended for use as operational amplifier, being stable with over-all voltage gains down to unity.—"Directly Coupled Amplifiers," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 40.

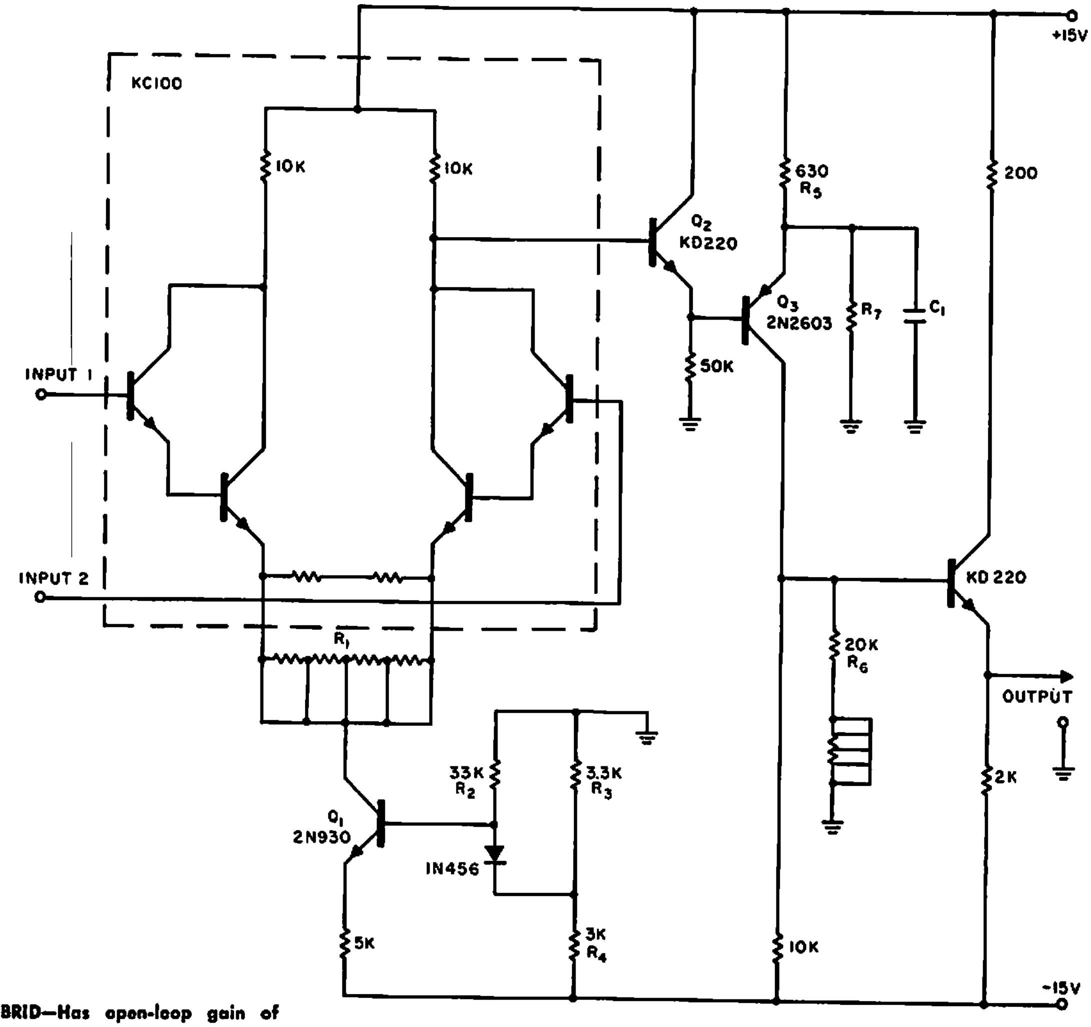

+12V
TR3
2N930
TR5
2N930
D1
BZY88-C7V5
R17
6·8kΩ
C2
220nF
TR9
BSY41
BCY55
TR1a
R6
180kΩ
R14
12kΩ
C1
68nF
Inverting input
R9
15kΩ
R18
1·2kΩ
R20
82Ω
Non-Inverting input
R7
20kΩ
R10
15kΩ
TR6
2N930
Output
TR1b
R8
180kΩ
TR10
BSY41
TR4
2N930
R1
180kΩ
R11
47kΩ
R15
180kΩ
TR2
BCY57
TR7
BCY57
TR8
BCY57
R3
56kΩ
R2
68kΩ
R4
10kΩ
R12
33kΩ
R13
5·6kΩ
R16
12kΩ
R19
560Ω
C3
220nF
-12V


R6
68kΩ
R11
68kΩ
+15V
R3
1kΩ
R13
22kΩ
R17
100Ω
C2
220nF
R1
1MΩ
R2
1MΩ
TR3
BCY57
R8
120kΩ
TR6
BCY56
Non-inverting input
BCY55
TR1a
R9
50kΩ
Inverting input
TR1b
R10
120kΩ
TR4
BCY57
TR5
BFX13
D1
BZY94-C27
Output
R14
150Ω
C1
10nF
R4
120kΩ
TR2
BCY57
TR7
BCY56
R5
33kΩ
R7
68kΩ
R12
33kΩ
R15
15kΩ
R16
22kΩ
R18
82Ω
C3
220nF
-15V

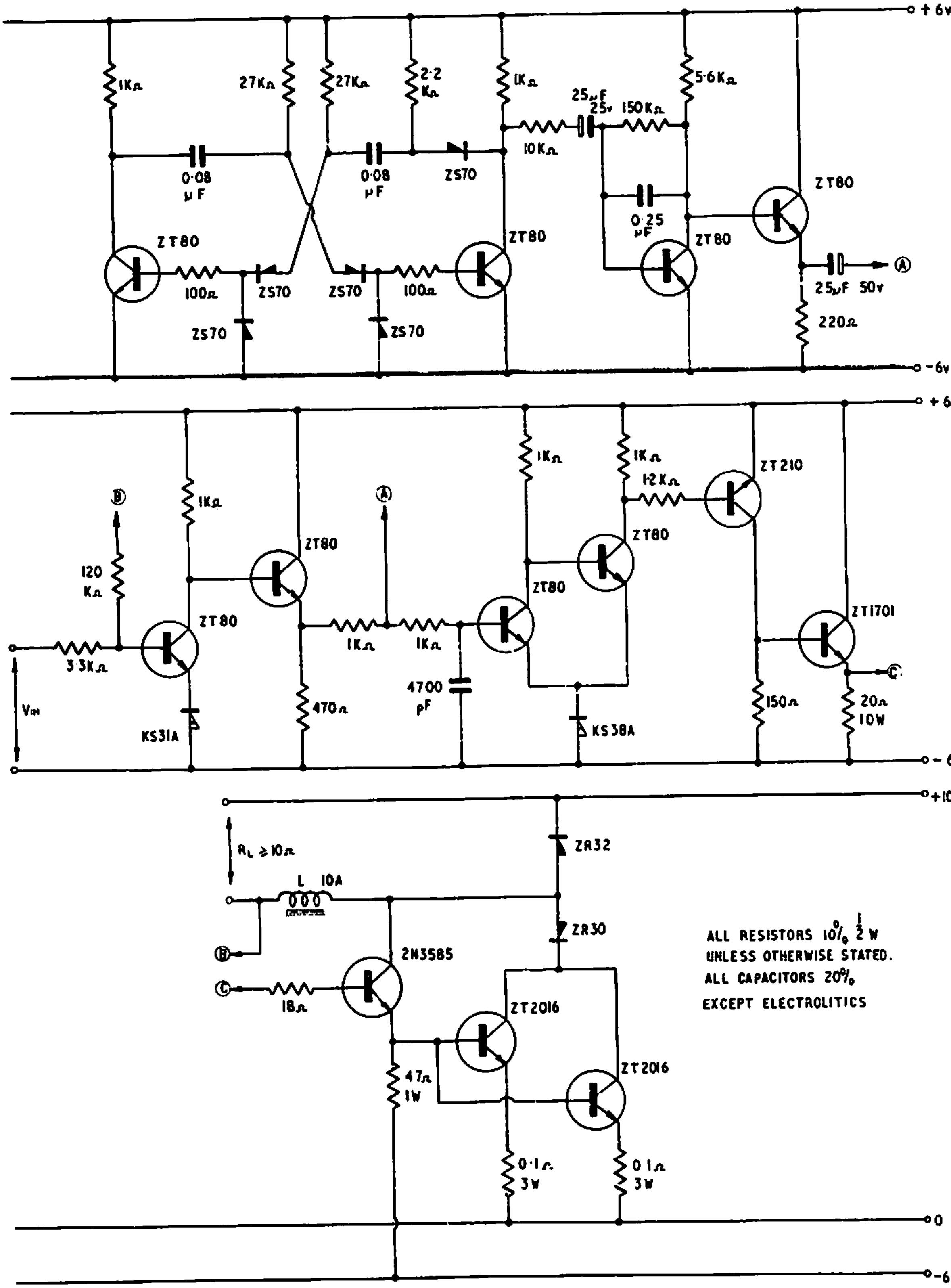
VOLTAGE GAIN 40,000—Differential input stage uses low-drift transistor pair, with constant-current source TR2 fixing combined emitter currents. Output is single-ended, delivering 10 V of either polarity at up to 20 mA. Frequency response drops about 6 dB per octave from 93 dB at 10 Hz to 0 dB at 2 MHz.—"Directly Coupled Amplifiers," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 34.


+12V
R_9 2·4kΩ
TR_2 BCY71
TR_4 BFX86
BCY87 TR_{1a}
Input
TR_{1b}
R_3 56Ω
C_1 10nF
R_4 56kΩ
R_5 10kΩ
R_6 56kΩ
R_7 22Ω
R_8 22Ω
R_{10} 15kΩ
R_{11} 15kΩ
R_{12} 560Ω
R_{13} 560Ω
R_L
TR_3 BCY71
TR_5 BFX86
0V
0V
R_1 56kΩ
R_2 10kΩ
−12V

VOLTAGE GAIN 6,500—All three stages are push-pull. Differential-input first stage uses transistor pair, and second stage is long-tailed pair. Output is zero when there is no input signal, permitting use of over-all negative feedback without altering d-c conditions. Frequency response is intentionally shaped to fall about 6 dB per octave between 1 kHz and 10 MHz, from voltage gain of 76 dB below 1 kHz. Output voltage is 10 V of either polarity at 10 mA.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 18.

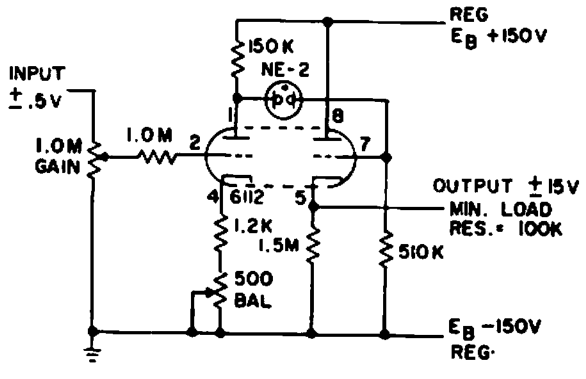

+15V
KC100
10K
10K
Q_2 KD220
630 R_5
200
Q_3 2N2603
R_7
C_1
50K
INPUT 1
INPUT 2
R_1
KD 220
20K R_6
OUTPUT
33K R_2
3.3K R_3
Q_1 2N930
IN456
2K
5K
3K R_4
10K
-15V

THIN-FILM HYBRID—Has open-loop gain of 500 and zero drift below 10 μV. With output capacitor, can be used as a-c amplifier for any gain between 1 and 500. Differential-pair input stage has 1-meg input resistance. Shorting bars on R1 are cut as required to correct for d-c unbalance, and on R6 to set open-loop gain. Dashed lines enclose IC which uses techniques described in article for reducing surface-area requirements of components.—A. Tuszynski, Skirting Thin-Film Design Problems, *Electronic Design*, Aug. 30, 1965, p 38–43.

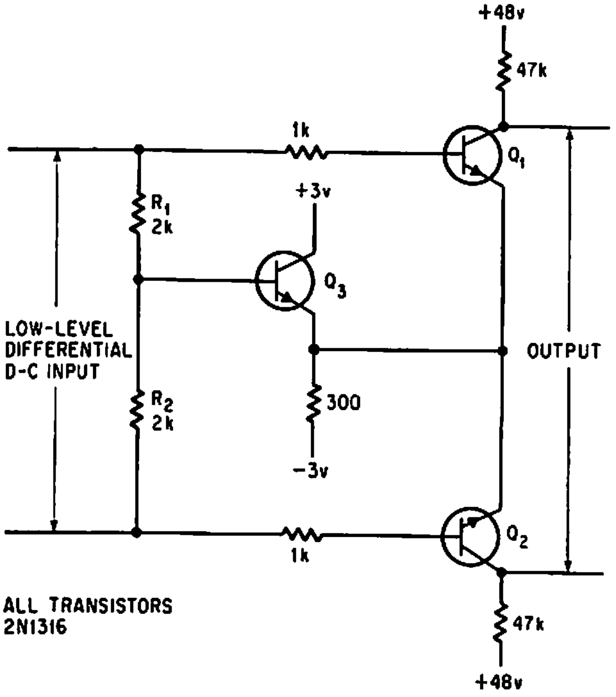

+6v
1KΩ
27KΩ
27KΩ
2·2 KΩ
1KΩ
25μF 25v
150KΩ
5·6KΩ
10KΩ
0·08 μF
0·08 μF
ZS70
ZT80
0·25 μF
ZT80
ZT80
ZT80
Ⓐ
25μF 50v
220Ω
100Ω
ZS70
ZS70
100Ω
ZS70
ZS70
-6v
+6v
Ⓑ
1KΩ
Ⓐ
1KΩ
1KΩ
1·2KΩ
ZT210
120 KΩ
ZT80
ZT80
ZT80
ZT80
ZT1701
3·3KΩ
1KΩ
1KΩ
Ⓒ
Vin
4700 pF
470Ω
150Ω
20Ω 10W
KS31A
KS38A
-6v
+100v
RL ≥ 10Ω
ZR32
L 10A
ZR30
Ⓑ
2N3585
Ⓒ
18Ω
ZT2016
ZT2016
47Ω 1W
0·1Ω 3W
0·1Ω 3W
0
-6v

ALL RESISTORS 10% ½ W UNLESS OTHERWISE STATED.
ALL CAPACITORS 20% EXCEPT ELECTROLITICS

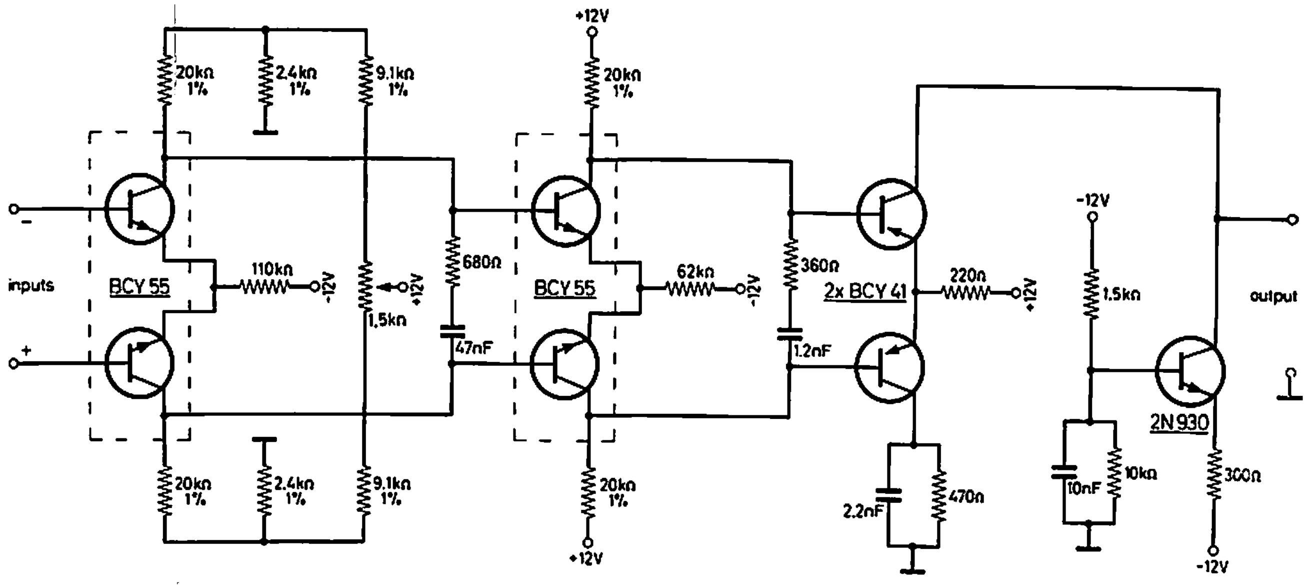
1-KW D-C AMPLIFIER FOR 10-OHM LOAD—Uses pulse-width modulation technique, with inductive filter in series with load to attenuate carrier. Output of 300-Hz mvbr is integrated to give linear sawtooth for adding to amplified d-c signal level to give constant-voltage sawtooth waveform whose level above zero is proportional to d-c input voltage. This is applied to Schmitt trigger that delivers rectangular pulses having mark-space ratio proportional to d-c level, for use in switching power transistor in series with filter and load. Output stage contains two 10-A 130-V ZT2016 transistors in parallel, driven by 2N3585. Input of 4 V gives full output, corresponding to power gain of 54 dB.—1-kW D.C. Amplifier, Ferranti, Oldham, Lancs., England, No. 32, 1966.


REG
E_B +150V
150K
NE-2
INPUT
±.5V
1.0M
GAIN
1.0M
2
1
8
7
4
6112
5
1.2K
1.5M
510K
500
BAL
OUTPUT ±15V
MIN. LOAD
RES. = 100K
E_B −150V
REG

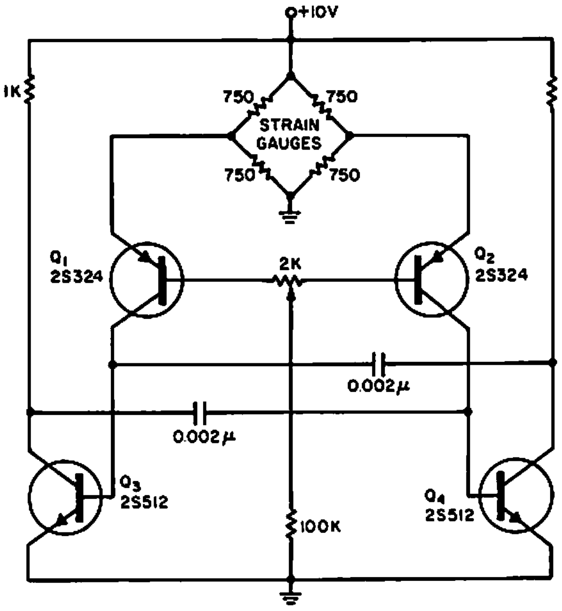
COUPLING BY MEMORY SWITCH—For d-c amplifiers, neon provides offset voltage to permit input and output voltages to operate about ground potential. Bottom of gain pot could be returned to output terminal for increased long-term stability.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 75.


+48v
47k
1k
Q_1
R_1
2k
+3v
Q_3
LOW-LEVEL
DIFFERENTIAL
D-C INPUT
OUTPUT
R_2
2k
300
−3v
1k
Q_2
47k
+48v
ALL TRANSISTORS
2N1316

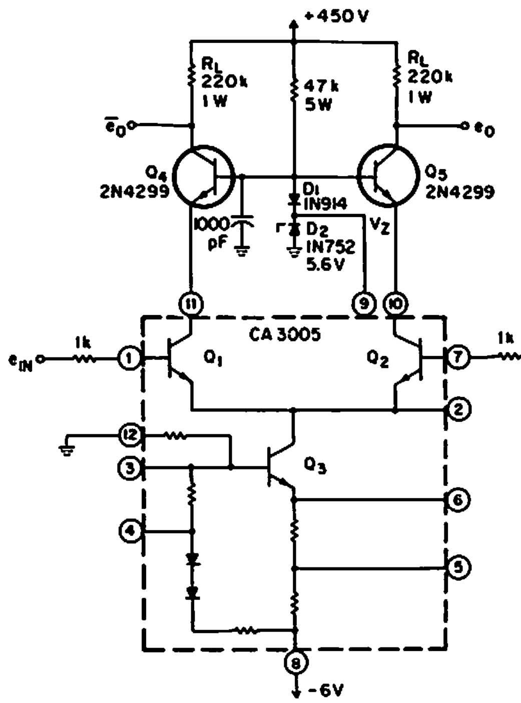
STABILIZED AT 2,000 GAIN—Common-mode noise and thermal drift are canceled in d-c differential amplifier by feeding input signal forward instead of using feedback. Technique gives gain of 2,000 with excellent stability, for delivering up to 2.5 A to servomotor in IBM 2310 disk storage drive. Circuit also provides locked-in temperature compensation, to prevent spurious triggering pulses from destroying bridge by turning on both sides at once.—F. J. Sordello, Forward Feed Stabilizes D-C Differential Amplifier, *Electronics*, Nov. 28, 1966, p 84.


20kΩ 1%
2.4kΩ 1%
9.1kΩ 1%
+12V
20kΩ 1%
inputs
−
+
BCY 55
110kΩ
−12V
+12V
1.5kΩ
680Ω
47nF
BCY 55
62kΩ
−12V
360Ω
1.2nF
2x BCY 41
220Ω
+12V
−12V
1.5kΩ
2N930
output
10kΩ
10nF
300Ω
−12V
470Ω
2.2nF
20kΩ 1%
2.4kΩ 1%
9.1kΩ 1%
20kΩ 1%
+12V

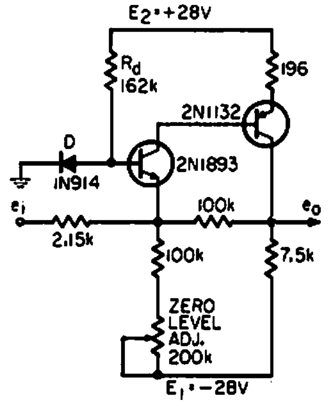
DIFFERENTIAL-TRANSISTOR AMPLIFIER—Use of silicon planar transistors encapsulated together and connected as differential pair gives highly stable opamp with open-loop gain of 60,000 and gain-bandwidth product of 10 MHz. Stability is better than 3 μV and 1 nA per deg C. Report gives circuit design procedure.—K. Hart, The Differential Transistor Pair BCY55 Employed in a D. C. Amplifier Having High Stability and Low Drift, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 322, 1966.


+10V
1K
1K
750
750
750
750
STRAIN GAUGES
Q1 2S324
Q2 2S324
2K
0.002μ
0.002μ
Q3 2S512
Q4 2S512
100K

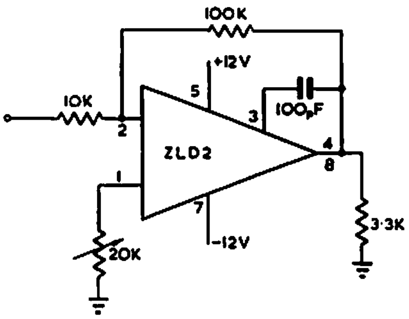
PULSE OUTPUT FROM STRAIN GAGE—Four transistors transform output signals of strain gage into modulated pulses. Q1 and Q2 form differential amplifier for amount of unbalance in strain-gage quad, and control mark-space output ratio of saturated-mode mvbr Q3-Q4. Resulting output may be measured by average-reading voltmeter connected between collectors of Q3 and Q4.—Strain Gage Output Amplifier Produces Modulated Pulse Signal, *Electronic Design*, May 24, 1965, p 52.


+450V
RL 220k 1W
47k 5W
RL 220k 1W
$\bar{e}_0$
e_0
Q4 2N4299
Q5 2N4299
D1 IN914
D2 IN752 5.6V
Vz
1000 pF
11
9
10
CA 3005
e_{IN}
1k
1
Q1
Q2
7
1k
$\bar{e}_{IN}$
2
12
3
Q3
6
4
5
8
-6V

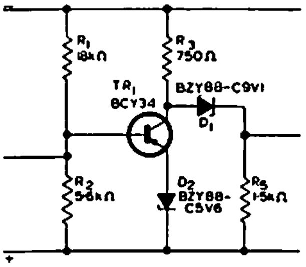
BOOSTING OUTPUT AND SPEED—Two-transistor circuit added to CA3005 IC differential amplifier permits operation from 450-V supply, as required for improving performance. —W. E. Peterson, Higher Speed, Gain, Output from IC Diff Amp, *EEE*, Jan. 1970, p 128.


E_2=+28V
Rd 162k
196
2N1132
D IN914
2N1893
e_i
2.15k
100k
e_0
100k
7.5k
ZERO LEVEL ADJ. 200k
E_1=-28V

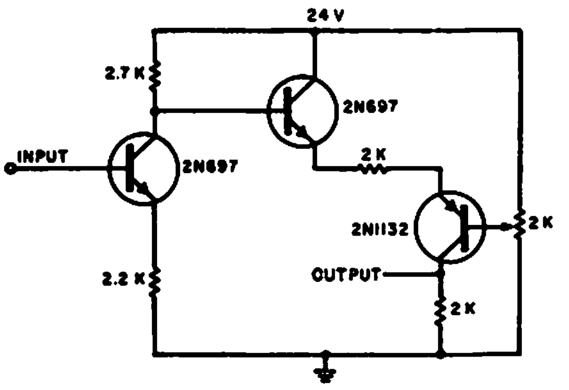
INVERTING WITH GAIN OF −30—Diode D brings input voltage close to zero to minimize dependence of output voltage on supply voltage. Article gives detailed design procedure.—T. Mollinga, Designing D-C Amplifiers, *EEE*, Feb. 1969, p 46–51.


100K
+12V
10K
5
3
100pF
2
ZLD2
4
8
1
7
-12V
20K
3·3K

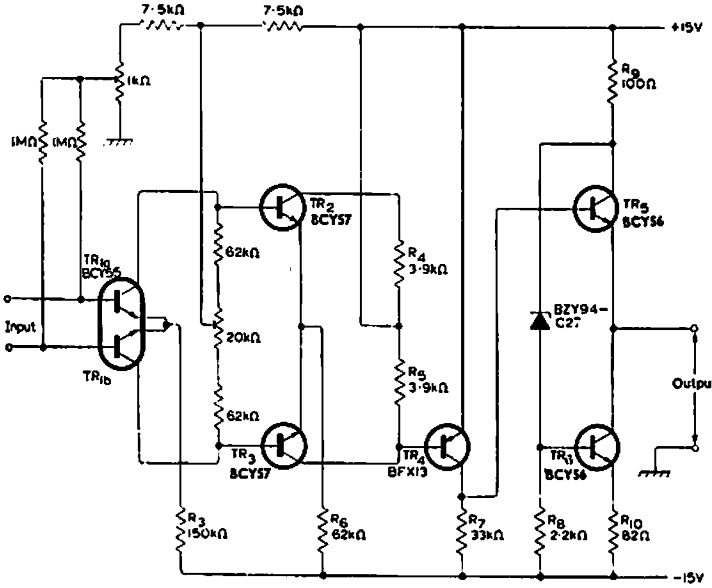
CANCELLING AMPLIFIER OFFSET VOLTAGE—Use of potentiometer as one of source resistances permits adjusting resistance value until differential voltage produced cancels out offset voltage of IC inverting d-c amplifier. Drawback of method is tendency to increase offset temperature drift.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 11.


−
+
R1 18kΩ
R3 750Ω
TR1 BCY34
BZY88-C9V1
D1
R2 5·6kΩ
D2 BZY88-C5V6
R5 1·5kΩ

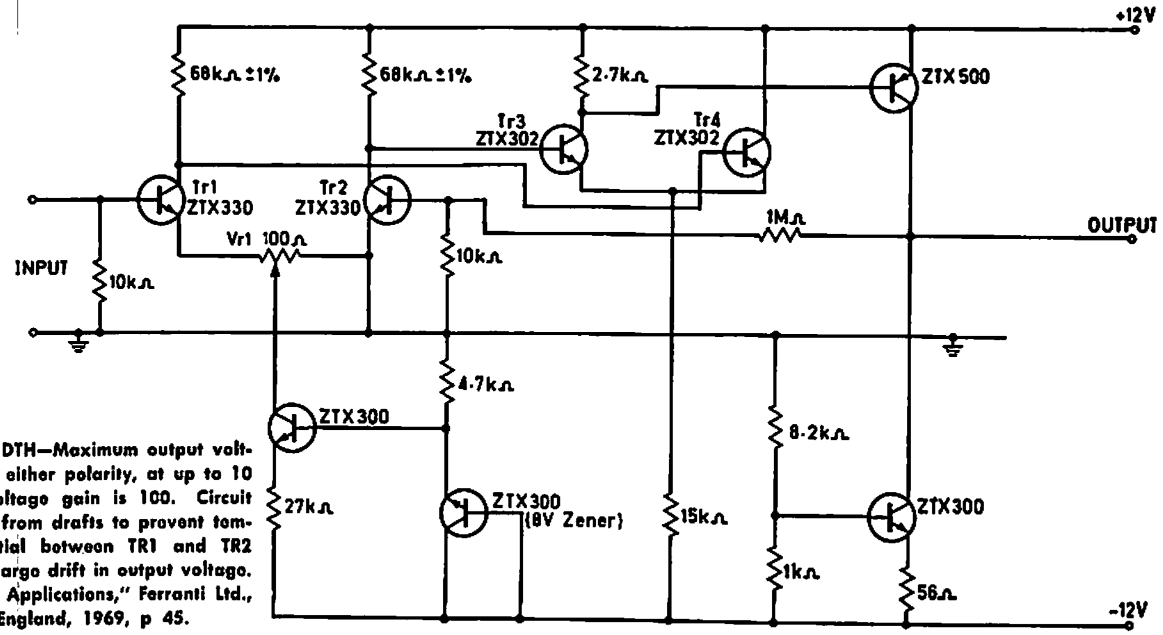
35 DB GAIN—Developed for use with 24-V d-c supply. Book gives design procedure for determining value of each component.—"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 53.


24 V
2.7 K
2N697
INPUT
2N697
2 K
2N1132
2 K
2.2 K
OUTPUT
2 K

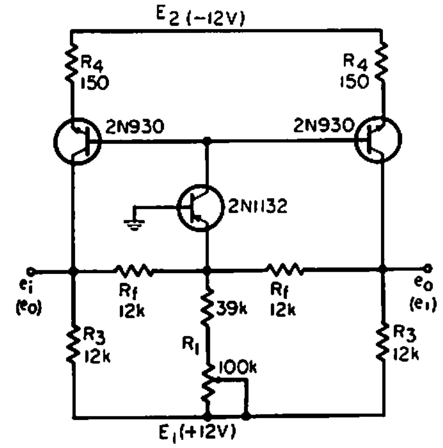
1:1 LEVEL CHANGER—With input of 0–9 V, output is 9–0 V with highly linear relationship. Temperature stability is good.—R. S. Hughes, Stable DC Amplifier Makes Good Level Changer, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 19.


7·5kΩ
7·5kΩ
+15V
1kΩ
1MΩ
1MΩ
R_9 100Ω
TR_2 BCY57
TR_5 BCY56
62kΩ
R_4 3·9kΩ
TR_{1a} BCY55
BZY94-C27
Input
20kΩ
TR_{1b}
R_5 3·9kΩ
Output
62kΩ
TR_3 BCY57
TR_4 BFX13
TR_{11} BCY56
R_3 150kΩ
R_6 62kΩ
R_7 33kΩ
R_8 2·2kΩ
R_{10} 82Ω
-15V

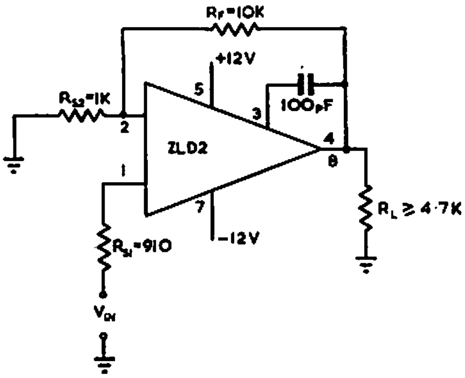
VOLTAGE GAIN 150,000—Low-drift transistor pair is used in differential input having resistance above 200K. Output voltage is 10 V with either polarity at up to 20 mA and output resistance is 20 ohms.—"Directly Coupled Amplifiers," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 31.


+12V
68kΩ ±1%
68kΩ ±1%
2·7kΩ
ZTX500
Tr3 ZTX302
Tr4 ZTX302
Tr1 ZTX330
Tr2 ZTX330
1MΩ
OUTPUT
Vr1 100Ω
INPUT
10kΩ
10kΩ
4·7kΩ
ZTX300
8·2kΩ
27kΩ
ZTX300 (8V Zener)
15kΩ
ZTX300
1kΩ
56Ω
-12V

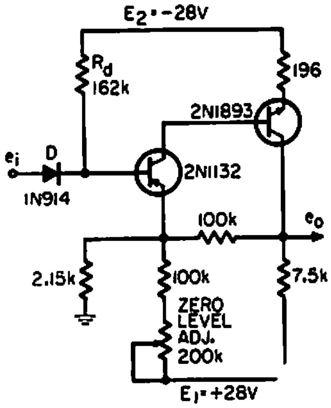
800-KHZ BANDWIDTH—Maximum output voltage is 11 V with either polarity, at up to 10 mA. Nominal voltage gain is 100. Circuit must be shielded from drafts to prevent temperature differential between TR1 and TR2 that could cause large drift in output voltage. "E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 45.


E2 (−12V)
R4
150
R4
150
2N930
2N930
2N1132
ei
(eo)
Rf
12k
39k
Rf
12k
eo
(ei)
R3
12k
R1
100k
R3
12k
E1(+12V)

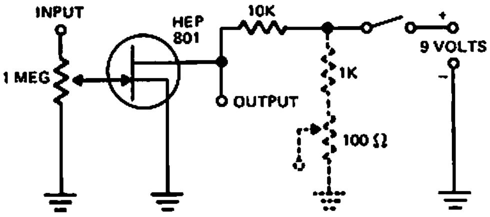
TWO-WAY INVERTING—Circuit is symmetrical, with output stage repeated at input side. Voltage gain is slightly less than unity. Article gives design equations.—T. Mollinga, Designing D-C Amplifiers, *EEE*, Feb. 1969, p 46–51.


Rf=10K
+12V
RS2=1K
5
3
100pF
2
ZLD2
4
8
1
7
RL ≥ 4.7K
RS1=910
−12V
VDI

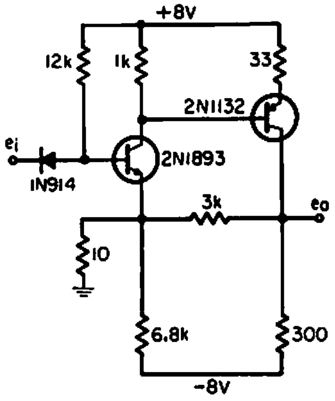
NONINVERTING D-C AMPLIFIER—Applying input between ground and terminal 1 of Ferranti ZLD2 IC differential-input d-c amplifier gives noninverting amplification of d-c input signal. Voltage gain is 10.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 11.


E2=−28V
Rd
162k
196
2N1893
ei
D
2N1132
IN914
100k
eo
2.15k
100k
7.5k
ZERO LEVEL ADJ.
200k
E1=+28V

NONINVERTING WITH GAIN OF 30—Diode D brings input voltage close to zero, to minimize dependence of output voltage on +28 V supply voltage. Article gives detailed design procedure.—T. Mollinga, Designing D-C Amplifiers, *EEE*, Feb. 1969, p 46–51.


INPUT
HEP
801
10K
+
9 VOLTS
−
1 MEG
1K
OUTPUT
100 Ω

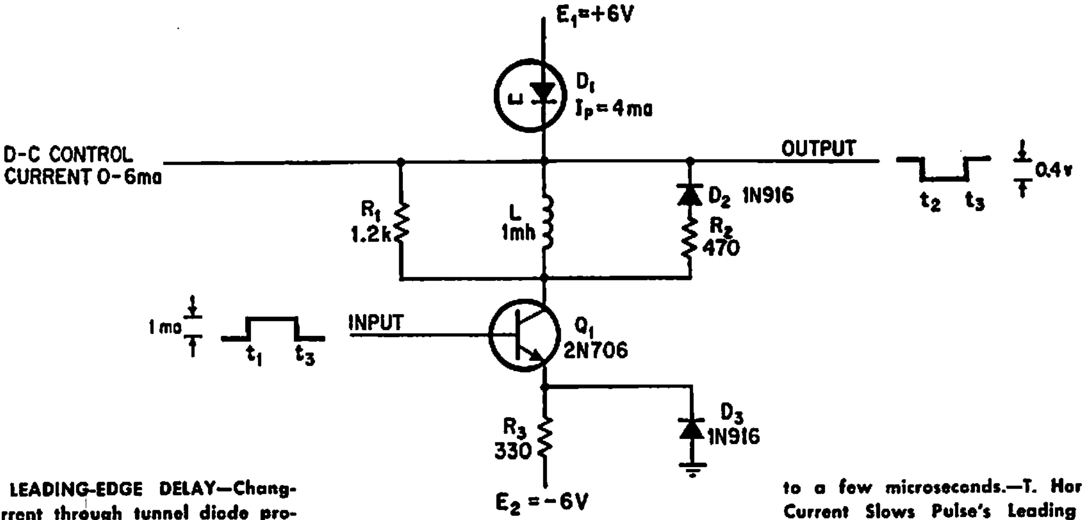
LOW-LEVEL FET—Gives output of 0.4 to 9 V on input of 0 to −1.5 V for scopes, vtvm, or as relay amplifier. To get output down to zero, add dashed circuit and use its terminal as ground for output. Adjust 100-ohm rheostat for zero output with input grounded.—"Tips on Using FET's," Motorola, Phoenix, Ariz., HMA-33, 1969.


+8V
12k
1k
33
2N1132
ei
2N1893
IN914
3k
eo
10
6.8k
300
−8V

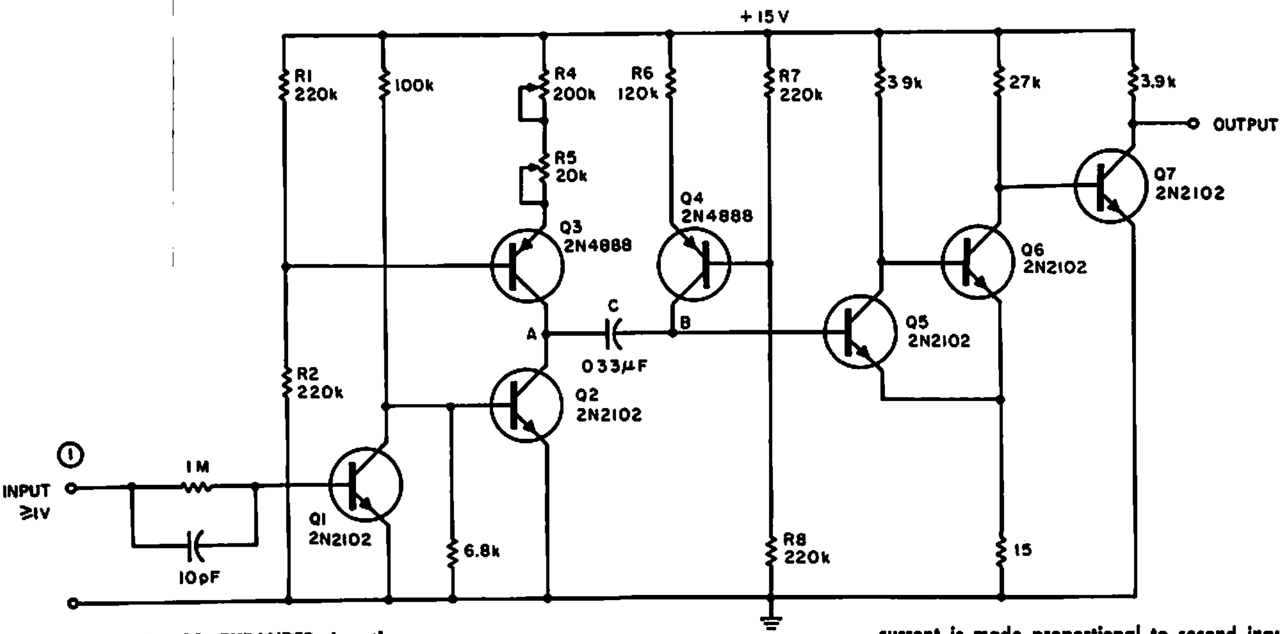
TO 1 MHZ WITH GAIN OF 100—Adding collector resistor (10 ohms) for 2N1893 increases bandwidth, to give essentially flat response from d-c up to 1 MHz.—T. Mollinga, Designing D-C Amplifiers, *EEE*, Feb. 1968, p 46–51.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

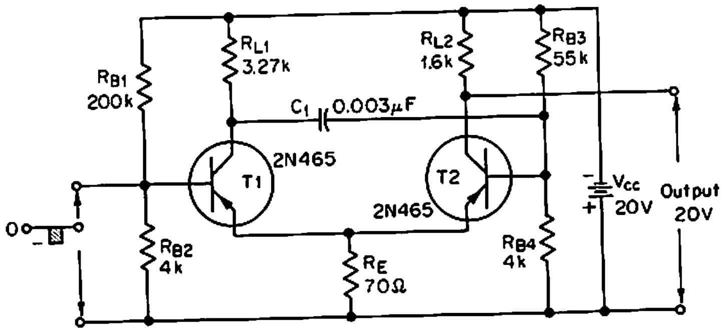
CHAPTER 23
Delay Circuits


E₁=+6V
D₁
Iₚ=4ma
D-C CONTROL CURRENT 0-6ma
OUTPUT
t₂ t₃
0.4v
R₁ 1.2k
L 1mh
D₂ 1N916
R₂ 470
1 ma
t₁ t₃
INPUT
Q₁ 2N706
D₃ 1N916
R₃ 330
E₂ = -6V

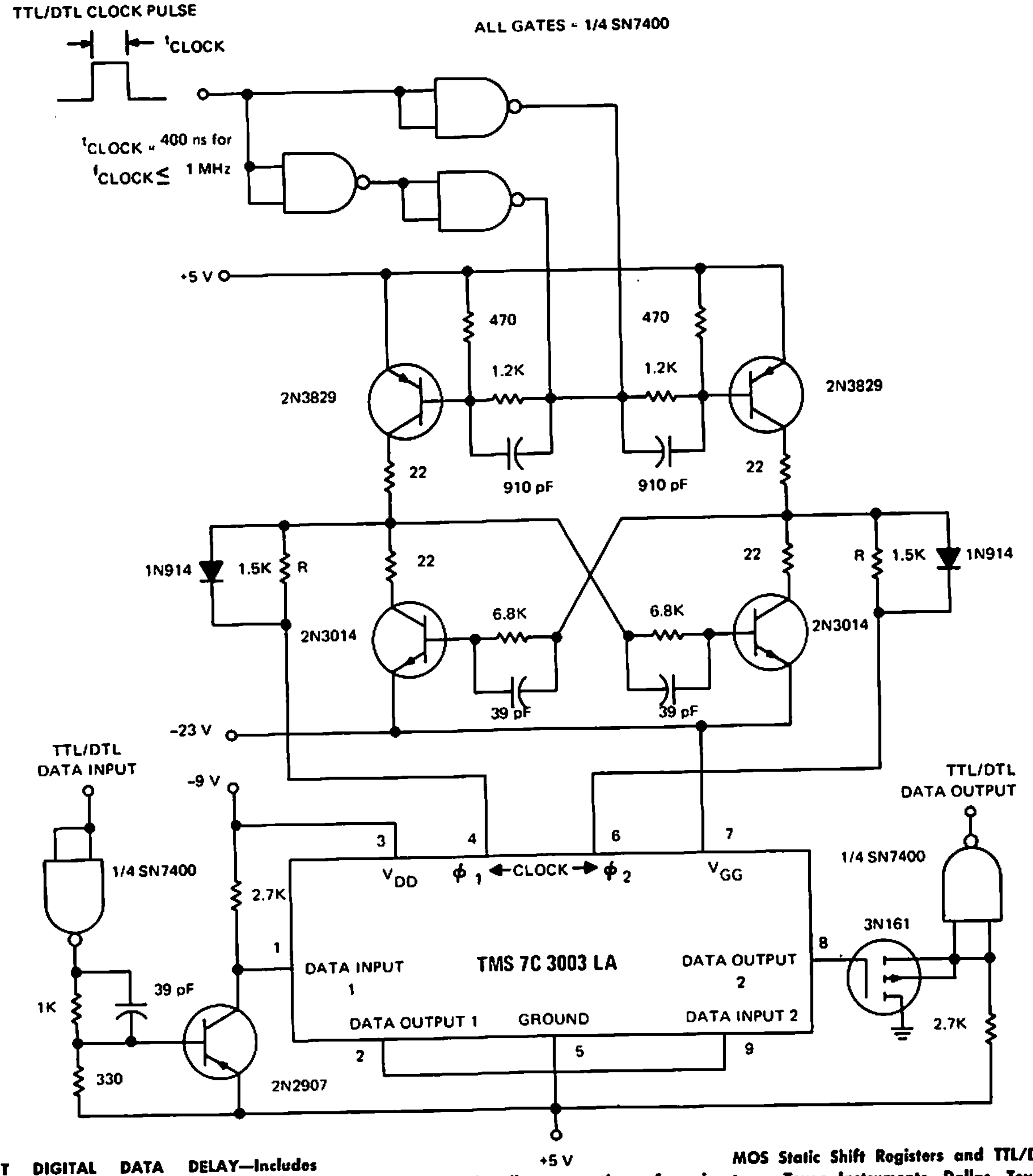
ADJUSTABLE LEADING-EDGE DELAY—Changing direct current through tunnel diode provides proportional change in delay between leading edges of output and input signals. Values shown give delay range from zero up to a few microseconds.—T. Hornak, Control Current Slows Pulse's Leading Edge, *Electronics*, Aug. 18, 1969, p 96.


+15V
R1 220k
100k
R4 200k
R5 20k
R6 120k
R7 220k
3.9k
27k
3.9k
OUTPUT
Q3 2N4888
Q4 2N4888
Q7 2N2102
Q6 2N2102
Q5 2N2102
A
B
C
.033μF
R2 220k
Q2 2N2102
①
INPUT ≥1V
1M
10pF
Q1 2N2102
6.8k
R8 220k
15

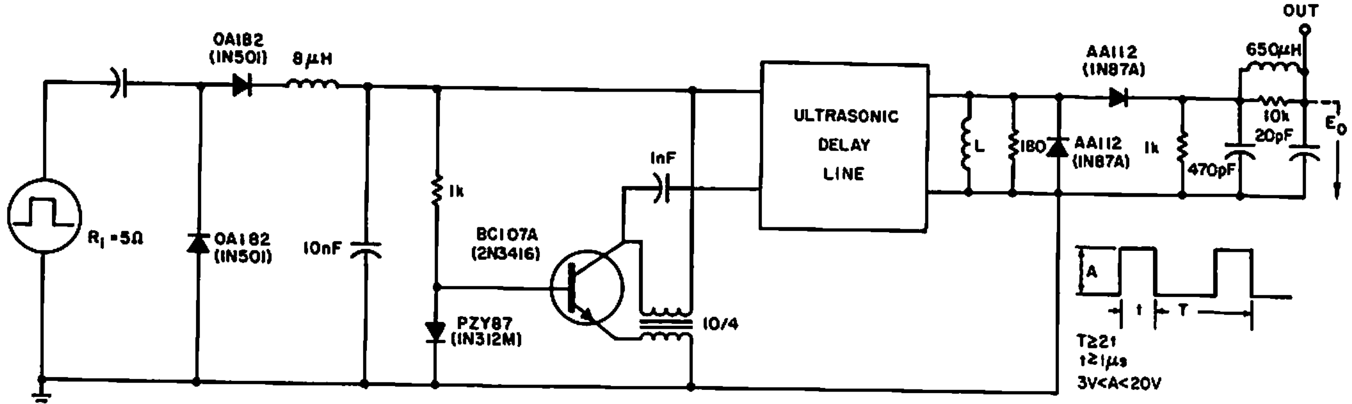
PULSE COMPRESSOR OR EXPANDER—Length of output pulse is proportional to length of input pulse, with output pulse being delayed for duration of input pulse. R4 and R5 provide wide adjustment range (0.1 to 10) for ratio of input to output pulse width. Can be used for pulse width modulation if Q2 current is made proportional to second input signal.—T. Weisz, Compress or Expand Pulses With A Simple Circuit, *Electronic Design*, Dec. 6, 1967, p 122 and 124.


RB1
200k
RL1
3.27k
C1 0.003μF
RL2
1.6k
RB3
55k
2N465
T1
T2
2N465
Vcc
20V
Output
20V
RB2
4k
RE
70Ω
RB4
4k

MONO FOR LAB USE—Remains in unstable state for length of time determined by reactive elements in circuit. Can be used for generating delay pulses and for standardizing pulses of random ON times. C1 helps determine duration of unstable state; reducing C1 reduces unstable time and therefore increases frequency.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 220.

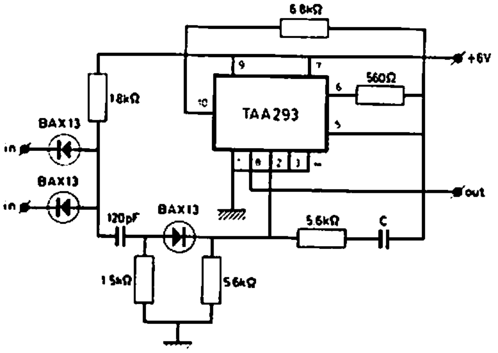

TTL/DTL CLOCK PULSE
tCLOCK
tCLOCK ≈ 400 ns for
fCLOCK ≤ 1 MHz
ALL GATES = 1/4 SN7400
+5 V
470
470
1.2K
1.2K
2N3829
2N3829
910 pF
910 pF
22
22
1N914
1.5K
R
22
22
R
1.5K
1N914
2N3014
6.8K
6.8K
2N3014
39 pF
39 pF
-23 V
TTL/DTL
DATA INPUT
-9 V
TTL/DTL
DATA OUTPUT
1/4 SN7400
2.7K
3
4
6
7
VDD
φ1 ◄CLOCK► φ2
VGG
1/4 SN7400
3N161
1
DATA INPUT 1
TMS 7C 3003 LA
DATA OUTPUT 2
8
39 pF
1K
DATA OUTPUT 1
GROUND
DATA INPUT 2
2.7K
330
2
5
9
2N2907
+5 V

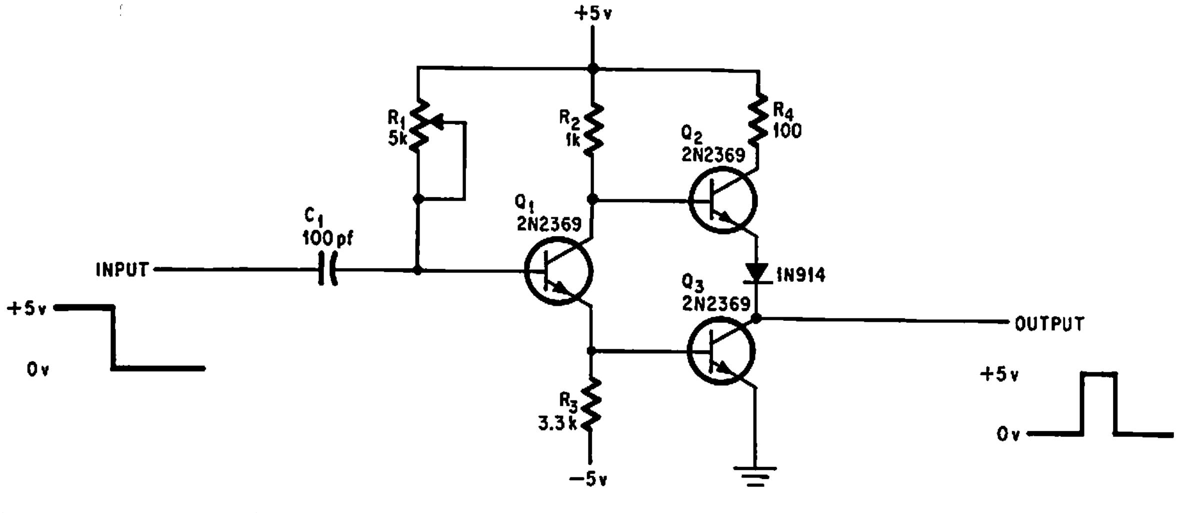
200-BIT DIGITAL DATA DELAY—Includes complete interface and clock driver circuitry for operation at rates from d-c to above 1 MHz. Report describes operation of each section of system in detail.—G. B. Hoffman, MOS Static Shift Registers and TTL/DTL Systems, Texas Instruments, Dallas, Texas, CA-114.


OUT
0A182
(1N501)
8µH
AA112
(1N87A)
650µH
R₁ =5Ω
0A182
(1N501)
10nF
1k
InF
ULTRASONIC
DELAY
LINE
L
180
AA112
(1N87A)
1k
470pF
10k
20pF
E₀
BC107A
(2N3416)
PZY87
(1N312M)
10/4
A
t
T
T≥2t
t≥1µs
3V<A<20V

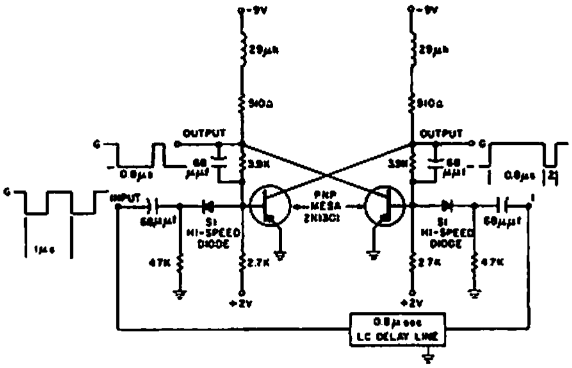
64-MICROSECOND PULSE DELAY—Self-powered circuit uses 7-inch glass rod driven by r-f oscillator as ultrasonic delay for single or repetitive positive pulses. Other lengths or types of delay lines can be used to obtain different delays. Input pulses provide supply voltage for transistor oscillator. Oscillator is amplitude-modulated with input pulses, and pulsed r-f signal at output of delay line is demodulated to filter out r-f.—P. Zamperoni, Ultrasonic Delay Line Needs No Power Supply, *Electronic Design*, Aug. 15, 1968, p 230 and 232.

MONO WITH POSITIVE-GOING EDGE DELAY—Uses Philips TAA293 general-purpose amplifier. Circuit has effect of delaying positive-going edge of rectangular input pulse. Delay time is about 100 µs when C is 10 nF. Times for other values of C are in direct proportion to C down to about 1 µs.—The TAA293 as a Schmitt Trigger and Multivibrator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 25, 1968.

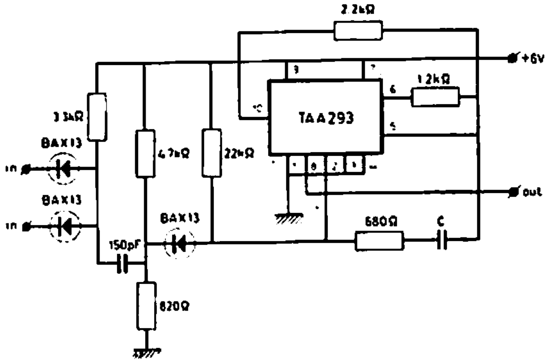

6.8kΩ
+6V
9
7
560Ω
6
18kΩ
10
TAA293
5
BAX13
in
BAX13
in
8
2
3
out
120pF
BAX13
5.6kΩ
C
1.5kΩ
56kΩ


+5v
R₁
5k
R₂
1k
R₄
100
Q₂
2N2369
Q₁
2N2369
C₁
100pf
INPUT
+5v
0v
1N914
Q₃
2N2369
OUTPUT
+5v
0v
R₃
3.3k
−5v

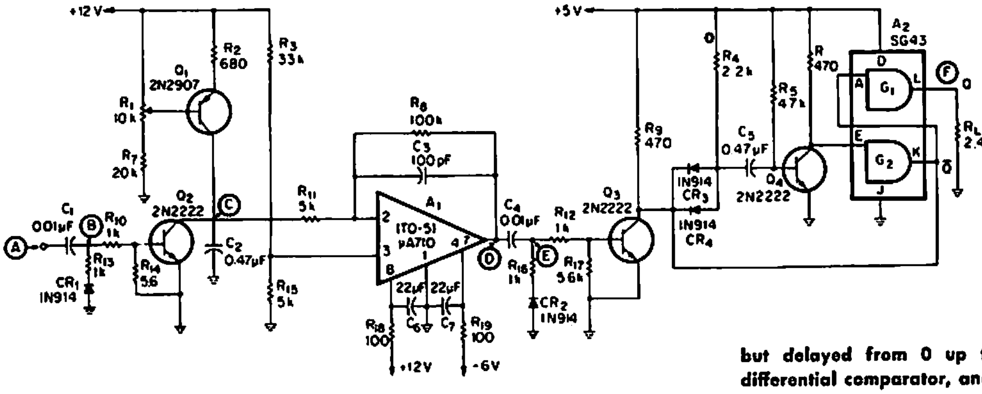
20-NS PULSE WITH DELAY—One-shot mvbr depends on fast removal of stored charge to give pulses as narrow as 20 ns with rise and fall times of only 10 ns. Pulse widths or delays up to 100 ns are determined by setting of R1. Stability is good for temperature and voltage changes.—L. V. Hendricks, Fast Discharge Reduces Multivibrator's Rise Time, *Electronics*, Nov. 25, 1968, p 82–83.


-9V
-9V
29μh
29μh
910Ω
910Ω
OUTPUT
OUTPUT
0.8μs
0.8μs
68 μμf
68 μμf
3.9K
3.9K
INPUT
68μμf
68μμf
Si HI-SPEED DIODE
Si HI-SPEED DIODE
PNP MESA 2N1301
47K
47K
2.7K
2.7K
+2V
+2V
1μs
0.8μsec LC DELAY LINE

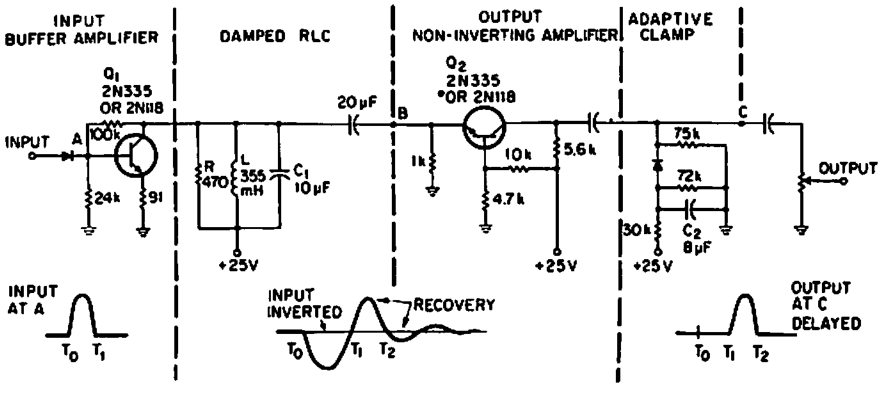
DELAY-LINE PULSE STRETCHER—Uses high-speed mesa-transistor flip-flop in which width of output pulse is accurately controlled by delay line, independently of input pulse width. Accuracy of output pulse width is the same as 1% accuracy in length of delay. With 1-MHz square-wave input, leading edge of pulse switches output of flip-flop and goes through delay line to reset flip-flop from other side, giving 0.8-μs output pulse when using 0.8-μs delay line. Remaining 0.2 μs is sufficient for flip-flop recovery.—J. Shirman, High-Speed Pulse-Stretcher Depends Upon Delay Line Time, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 46.


2.2kΩ
+6V
1.2kΩ
3.3kΩ
TAA293
BAX13
BAX13
BAX13
in
in
4.7kΩ
22kΩ
150pF
820Ω
680Ω
C
out

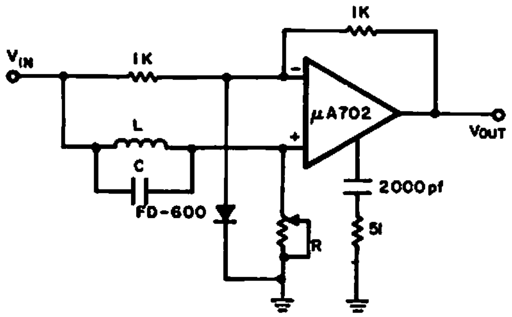
DELAY MONO FROM IC AMPLIFIER—Uses Philips TAA293 general-purpose amplifier. Output terminal rests in low state. Rectangular input pulse makes mvbr switch, driving output terminal to high state at 6 V. Circuit reverts to rest state after time delay, to give effect of delaying negative-going edge of input signal. Circuit cannot be retriggered until after recovery time nominally equal to delay time, both of which are about 100 μs when C is 10 nF. Times for other values of C are in direct proportion to C down to about 1 μs.—The TAA293 as a Schmitt Trigger and Multivibrator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 25, 1968.


+12V
R2 680
R3 33k
Q1 2N2907
R1 10k
R7 20k
Q2 2N2222
C
C1 .001μF
A
B
R10 1k
R13 1k
CR1 1N914
R14 56
C2 0.47μF
R15 5k
R11 5k
R8 100k
C3 100pF
A1 ITO-51 μA710
22μF
22μF
C6
C7
R18 100
R19 100
+12V
-6V
C4 0.01μF
D
R12 1k
E
R16 1k
R17 56k
CR2 1N914
Q3 2N2222
+5V
R9 470
R4 2.2k
R5 47k
R 470
C5 0.47μF
1N914 CR3
1N914 CR4
Q4 2N2222
A2 SG43
G1
G2
F
Q
Q̄
RL 2.4k

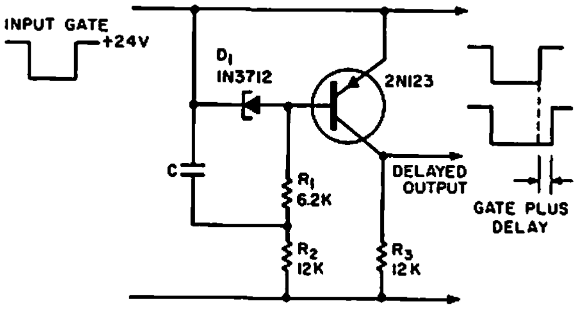
400-HZ VARIABLE APPARENT DELAY—Circuit senses positive excursion of 400-Hz input square wave and provides delay depending on value of control voltage or setting of R1. Delayed signal triggers 1.25-ms one-shot, to make output look like original square wave but delayed from 0 up to 2.5 ms. A1 is differential comparator, and one-shot A2 uses standard SUHL gates.—L. L. Pechi, Voltage or Pot-Variable 400-Hz Delay, *EEE*, Oct. 1969, p 112.


INPUT BUFFER AMPLIFIER
DAMPED RLC
OUTPUT NON-INVERTING AMPLIFIER
ADAPTIVE CLAMP
Q1 2N335 OR 2N118
INPUT
A
100k
24k
91
R 470
L 355 mH
C1 10μF
+25V
20μF
B
1k
Q2 2N335 *OR 2N118
10k
4.7k
5.6k
+25V
C
75k
72k
30k
C2 8μF
+25V
OUTPUT
INPUT AT A
T0 T1
INPUT INVERTED
RECOVERY
T0 T1 T2
OUTPUT AT C DELAYED
T0 T1 T2

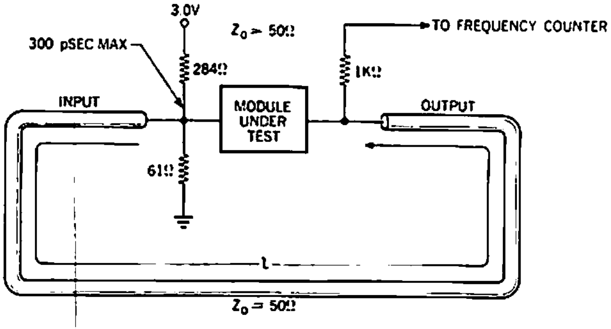
6-MS SIGNAL DELAY—With positive input, circuit provides 6-ms delay over range of 25 to 150 Hz. Output amplitude follows input amplitude linearly over dynamic range of about 30 dB.—D. J. Savage, Simple Analog Delay, *EEE*, Oct. 1969, p 109.


V_IN
1K
1K
L
C
FD-600
μA702
V_OUT
2000pf
51
R

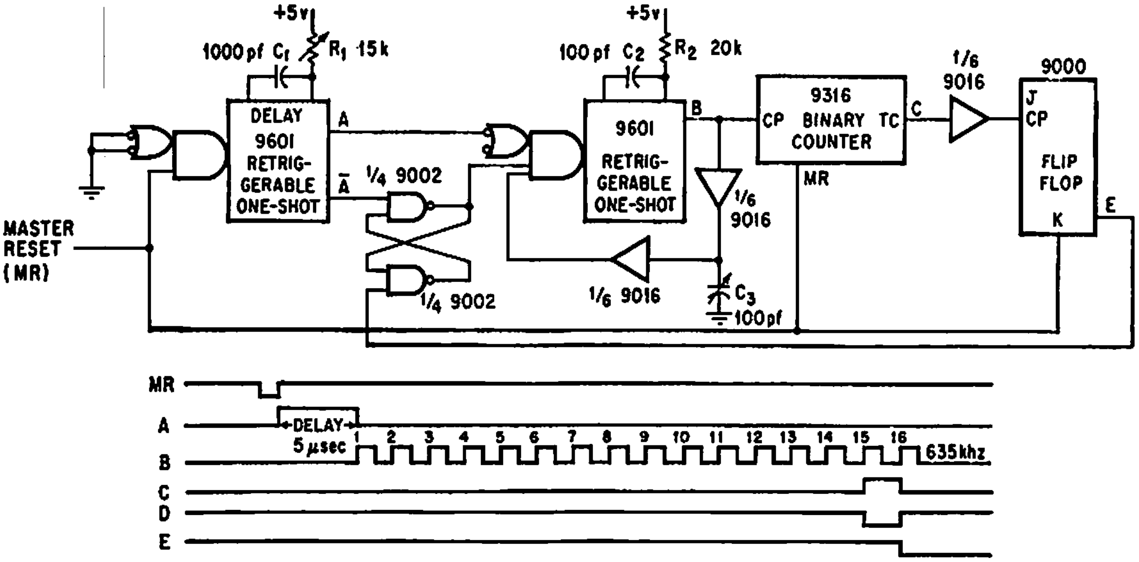
DELAY EQUALIZER—Uses Fairchild IC opamp as d-c amplifier to compensate for delay distortion in facsimile, high-speed telegraphy, and data-transmission carrier systems. Acts as all-pass circuit having amplitude characteristic that is independent of frequency over useful frequency range.—J. Toffler, The Integrated Operational Amplifier: A Versatile and Economical Circuit, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 189–194.


INPUT GATE
+24V
D1
IN3712
2N123
C
R1
6.2K
R2
12K
R3
12K
DELAYED OUTPUT
GATE PLUS DELAY

PULSE DELAY WITHOUT DISTORTION—Single transistor and tunnel diode generate delayed pulse or gate while maintaining or even improving sharp rise-time of input signal. With 0.002 μF for C, delay is 10 μs. Larger values of C give delays up to several seconds.—R. L. Shaum, Tunnel Diode Circuit Offers Non-Distorted Delayed Pulse, *Electronic Design*, May 10, 1965, p 46–47.


3.0V
300 pSEC MAX
Z0 = 50Ω
TO FREQUENCY COUNTER
284Ω
1KΩ
INPUT
MODULE UNDER TEST
OUTPUT
61Ω
l
Z0 = 50Ω

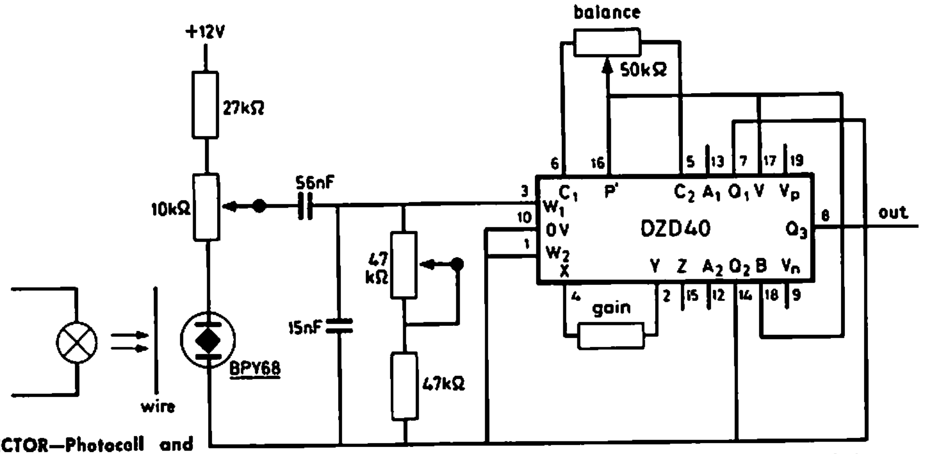
TESTING IC SWITCHING SPEED—Circulating loop test for ASLT modules permits rapid measurement of switching speed for each critical path in module. Unique test circuit drives input module from its own output, delayed in time by electrical length of cable in ns, to produce switching action. Counter then indicates number of switching actions during time period for test, from which switching speed is determined quickly and accurately.—R. F. Sechler, A. R. Strube, and J. R. Turnbull, ASLT Circuit Design, *IBM Journal*, Jan. 1967, p 74–85.


+5v
1000pf C1
R1 15k
DELAY 9601 RETRIGGERABLE ONE-SHOT
A
Ā
1/4 9002
1/4 9002
MASTER RESET (MR)
+5v
100pf C2
R2 20k
9601 RETRIGGERABLE ONE-SHOT
B
1/6 9016
1/6 9016
C3 100pf
9316 CP BINARY TC COUNTER
MR
C
1/6 9016
9000
J
CP
FLIP FLOP
K
E
MR
A
B
C
D
E
DELAY
5μsec
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
635khz

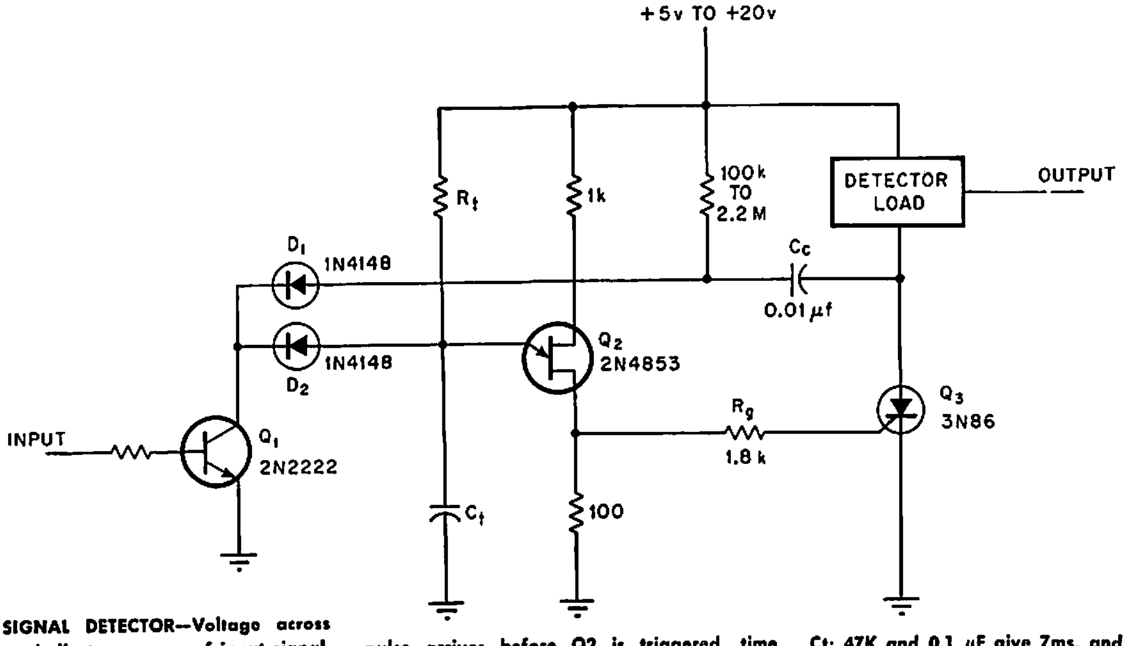
TRIGGERED DELAY FOR A/N DISPLAY—Used in alphanumeric cathode-ray display systems requiring that an oscillator start at preset time after arrival of trigger pulse, generate predetermined number of clock pulses, then shut down until next trigger arrives.—A. Liu, Retriggerable One-Shots Form Delayed-Key Oscillator, *Electronics*, Sept. 29, 1969, p 96.

CHAPTER 24

Detector Circuits

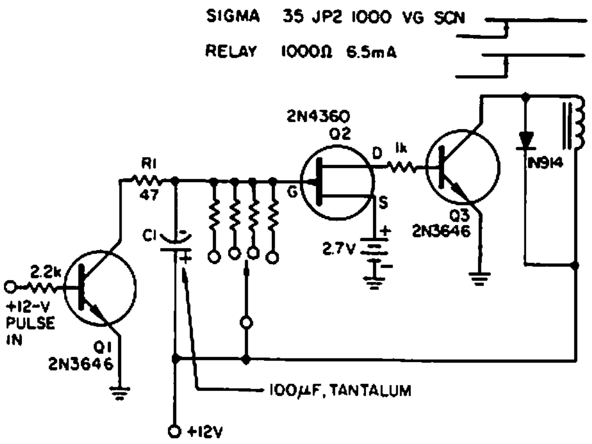

+12V
27kΩ
10kΩ
56nF
15nF
47 kΩ
47kΩ
BPY68
wire
balance
50kΩ
gain
6
16
5
13
7
17
19
3
10
1
8
4
2
15
12
14
18
9
C1
P'
C2 A1 Q1 V Vp
W1
0V
W2
X
DZD40
Q3
Y Z A2 Q2 B Vn
out

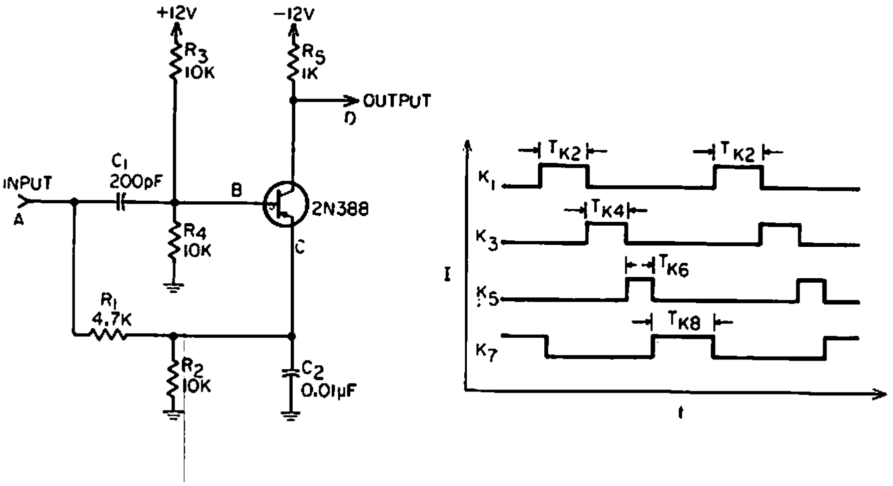
THREAD MOTION DETECTOR—Photocell and Philips DZD40 differential zero detector have sufficient sensitivity to detect shadow caused by moving wire or thread. Voltage peak produced across 56-nF capacitor by photocell trips DZD40 and makes its output switch to full supply voltage of 12 V. After wire has passed, sudden fall in photocell resistance makes DZD40 switch back to 0 V output. Slow changes in light on photocell have no effect.—Detection of Small Moving Objects Using the DZD40, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 29.


+5v TO +20v
Rt
1k
100k TO 2.2 M
DETECTOR LOAD
OUTPUT
D1
1N4148
Cc
0.01 µf
1N4148
D2
Q2
2N4853
Rg
1.8 k
Q3
3N86
INPUT
Q1
2N2222
Ct
100

UJT-SCR SIGNAL DETECTOR—Voltage across load rises to indicate presence of input signal. When input signal terminates, ujt timing circuit is freed after time lapse determined by period of ujt circuit; if another input pulse arrives before Q2 is triggered, time lapse is restarted. Holding time can be anywhere between a few microseconds and several seconds, depending on values of Rt and Ct; 47K and 0.1 μF give 7ms, and 390K and 2.2 μF give 1.4 s.—D. K. Smith, Signal Detector Operates From 5-Volt Supply, *Electronics*, Mar. 30, 1970, p 95.

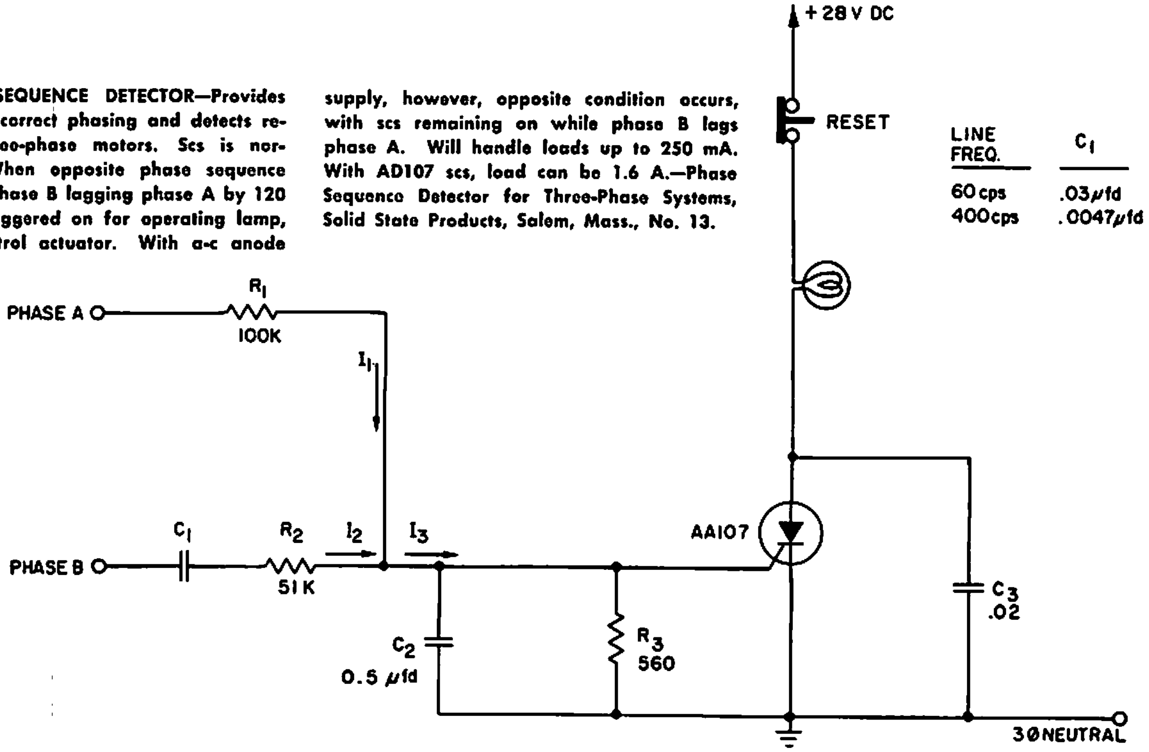
RAIN-GAGE RECORDER TURN-ON—Activator circuit turns on recorder only when it is raining. Hold feature prevents turn-off at drizzle rates. Used with system of tipping-bucket rain gages, each of which produces coded tone burst with arrival of each hundredth inch of precipitation. Each filled bucket produces 12-V 200-ms pulse at base of Q1 to turn it on and charge C1, which takes 20 ms. Circuit then pulls in relay that turns on recorder. With 100 meg switched in to gate of fet, C1 holds charge and keeps recorder on for 1.3 hours of drizzle.—J. Pike, Data-System Activator Has Hold Feature, *Electronic Design*, June 21, 1970, p 96 and 98.


SIGMA 35 JP2 1000 VG SCN
RELAY 1000Ω 6.5mA
2N4360
Q2
D
1k
G
S
R1
47
C1
2.7V
Q3
2N3646
IN914
2.2k
+12-V
PULSE
IN
Q1
2N3646
100μF, TANTALUM
+12V

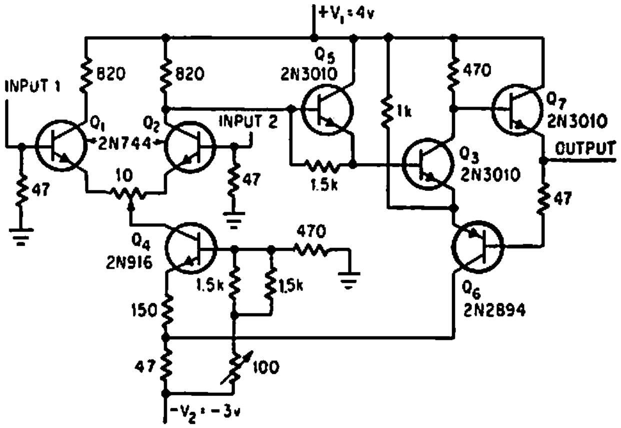

+12V
-12V
R3
10K
R5
1K
OUTPUT
D
INPUT
A
C1
200pF
B
2N388
C
R4
10K
R1
4.7K
R2
10K
C2
0.01μF
TK2
TK2
K1
TK4
K3
TK6
K5
TK8
K7
I
t

PULSE WIDTH SORTER—Simple bootstrap circuit delivers output pulse only when triggered by input pulse whose width is greater than predetermined value. Leading edge of positive-going output pulse coincides with trailing edge of input pulse. Useful as sync detector in pulse data systems.—C. Becklein and M. Yagud, Pulse-Width Sorter, *EEE*, Feb. 1967, p 146–147.

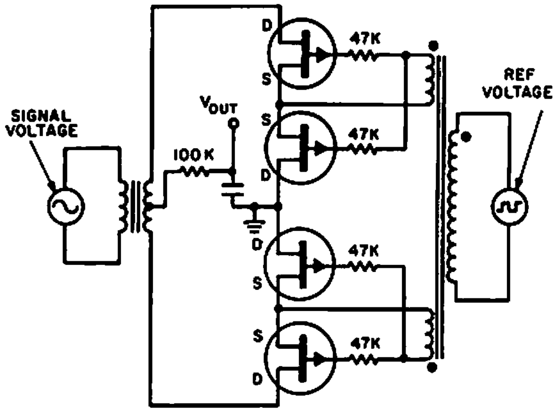
SCS PHASE SEQUENCE DETECTOR—Provides warning of incorrect phasing and detects reversal of three-phase motors. Scs is normally off. When opposite phase sequence occurs, with phase B lagging phase A by 120 deg, scs is triggered on for operating lamp, relay, or control actuator. With a-c anode supply, however, opposite condition occurs, with scs remaining on while phase B lags phase A. Will handle loads up to 250 mA. With AD107 scs, load can be 1.6 A.—Phase Sequence Detector for Three-Phase Systems, Solid State Products, Salem, Mass., No. 13.


+28 V DC
RESET
PHASE A
R1
100K
I1
PHASE B
C1
R2
51 K
I2
I3
AA107
C2
0.5 μfd
R3
560
C3
.02
3ØNEUTRAL

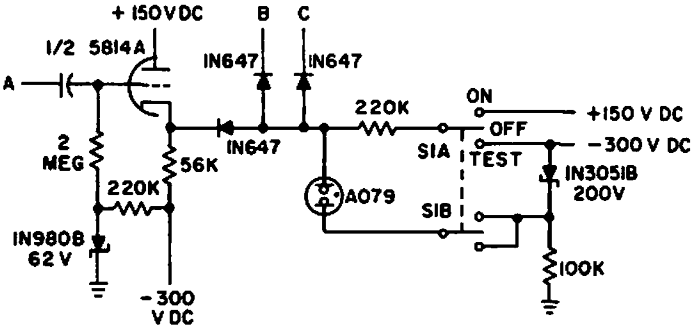
LINE FREQ.	C_1
60 cps	.03μfd
400cps	.0047μfd

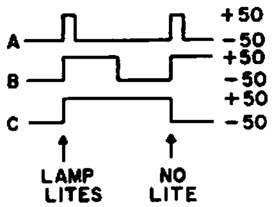

+V₁=4v
INPUT 1
820
820
Q5 2N3010
470
Q1
Q2
2N744
INPUT 2
1k
Q7 2N3010
OUTPUT
47
10
47
1.5k
Q3 2N3010
47
Q4 2N916
470
1.5k
1.5k
Q6 2N2894
150
47
100
-V₂=-3v

DIFFERENTIAL-INPUT WEAK-SIGNAL DETECTOR—Variation of paired Schmitt-trigger detector can detect absolute value of difference between two input signals riding on common-mode input signal of 0.5 V p-p at 14 MHz, for absolute difference values down to 15 mV. Dual input reduces hysteresis of detector one order of magnitude.—T. Weisz, Pairing Schmitt Triggers Produces Lower Hysteresis and Faster Switching, *Electronics*, Nov. 28, 1966, p 75–79.

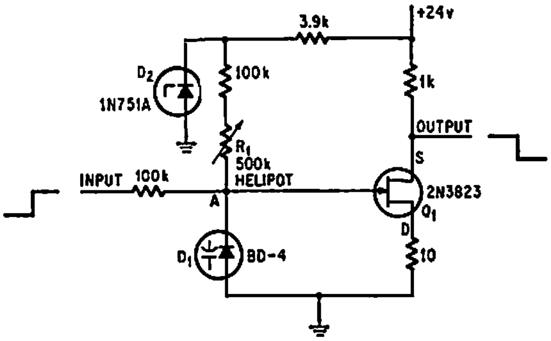

SIGNAL VOLTAGE
V_OUT
100K
D
S
S
D
D
S
S
D
47K
47K
47K
47K
REF VOLTAGE

DETECTING SIGNALS BURIED IN NOISE—Amelco FG37 200-V field-effect transistors connected back-to-back provide detection of millivolt in-phase signals buried in noise having peak amplitudes several orders of magnitude greater. Reference voltage is 60-V p-p square-wave. May be operated at frequencies well up into higher audio range, with negligible switching time.—W. D. Hindson and T. Nishizaki, FET Makes High Level Phase-Sensitive Detector, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 29.


+150VDC
B
C
1/2 5814A
A
IN647
IN647
IN647
220K
ON
+150 V DC
OFF
-300 V DC
2 MEG
56K
S1A
TEST
IN3051B 200V
220K
A079
S1B
IN9808 62V
100K
-300 V DC

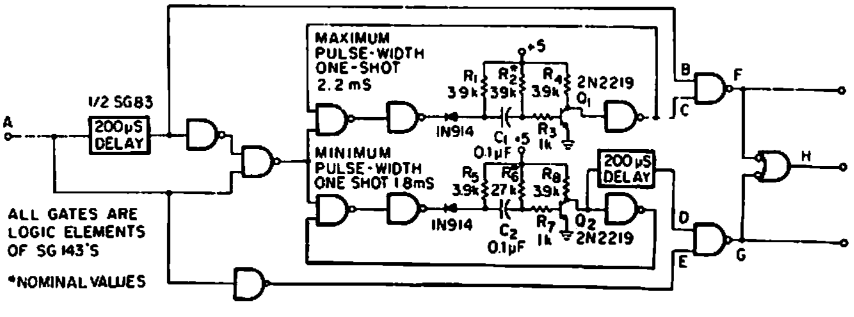

A
B
C
+50
-50
+50
-50
+50
-50
LAMP LITES
NO LITE

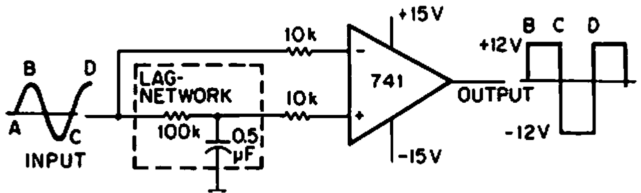
SIMULTANEOUS PULSES—With S1 in ON position, neon lamp lights only when all three 50-V positive pulses, at A, B, and C, occur at same time.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 151.


3.9k
+24v
D2
1N751A
100k
1k
OUTPUT
R1 500k HELIPOT
INPUT 100k
A
S
2N3823
Q1
D
D1
BD-4
10

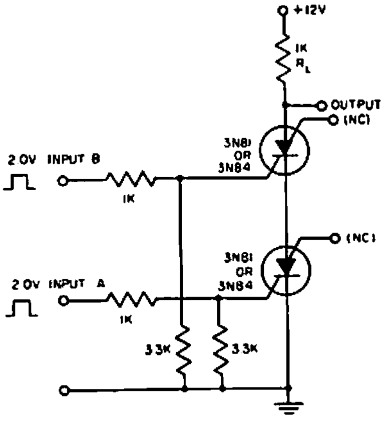
LOW-CURRENT DETECTOR—Will detect 1-μA currents with accuracy of 1%. When input signal exceeds preset threshold, sum of currents through backward diode D1 switches it to high-voltage state, generating pulse for amplification by fet output stage. Threshold jitter is negligible.—E. Elad, Backward Diode Plus FET Detects Low Currents, *Electronics*, Oct. 16, 1967, p 95–96.

MEASURING 2-MS PULSES—Provides output pulse whenever input pulse is less than minimum value or greater than maximum value. Can also be used as pulse-width error detector by providing error pulses of width equal to amount that input pulse width deviates from allowable limits. Developed for measuring 2-ms pulse widths within test window of 10%—I. Spector, Pulse-Width Discriminator, *EEE*, Sept. 1969, p 133–134.

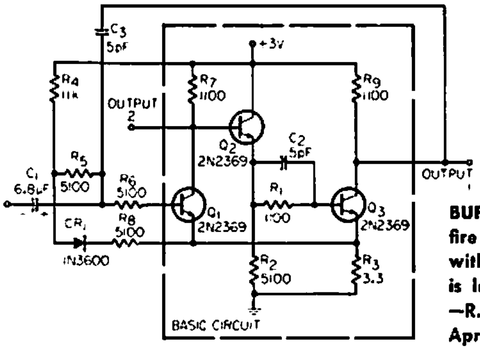

MAXIMUM PULSE-WIDTH ONE-SHOT 2.2 mS
+5
R1 39k
R2* 39k
R4 39k
2N2219 Q1
1/2 SG83
A
200μS DELAY
IN914
C1 0.1μF
*5
R3 1k
MINIMUM PULSE-WIDTH ONE SHOT 1.8mS
R5 3.9k
R6 27k
R8 39k
200μS DELAY
IN914
C2 0.1μF
R7 1k
Q2 2N2219
B
C
F
H
D
E
G
ALL GATES ARE LOGIC ELEMENTS OF SG 143'S
*NOMINAL VALUES


B
D
A
C
INPUT
LAG-NETWORK
100k
0.5 μF
10k
10k
741
+15V
-15V
+12V
-12V
B C D
OUTPUT

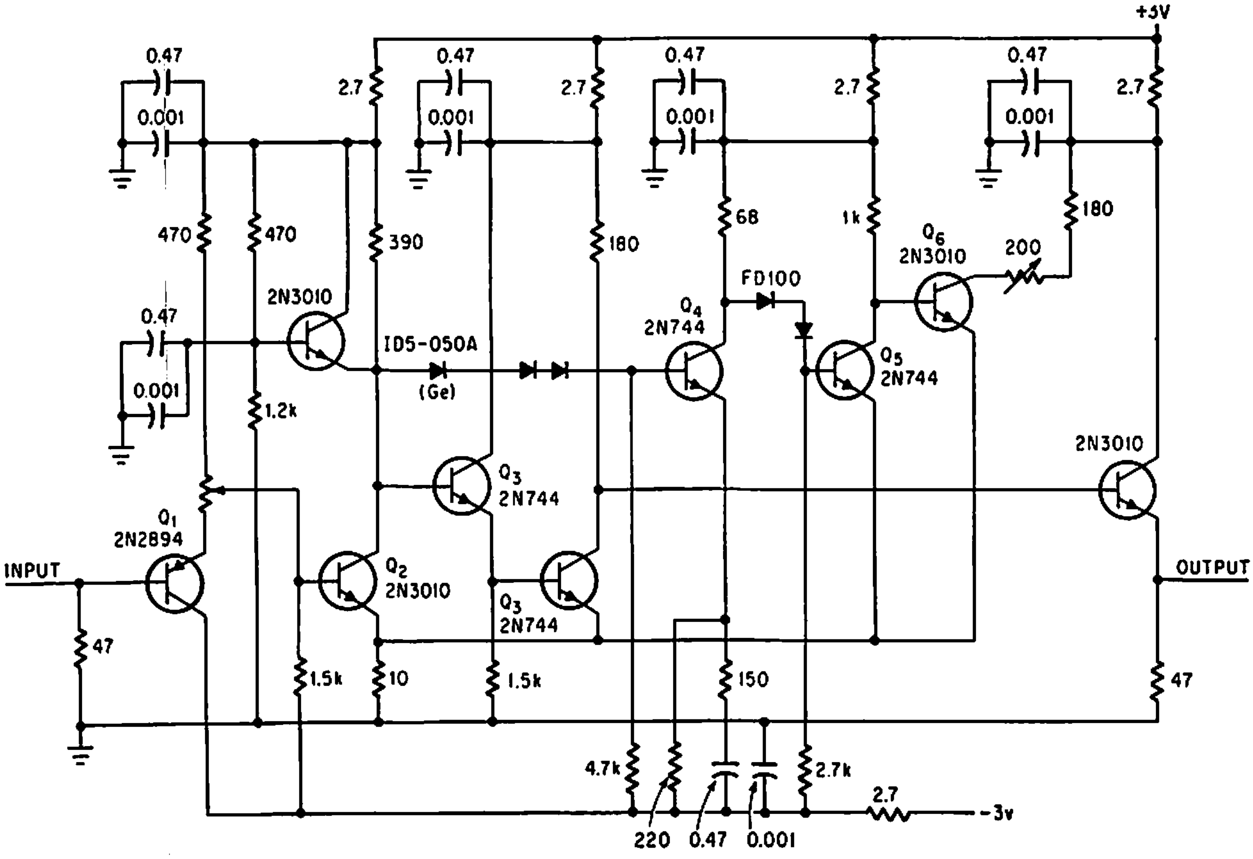
SLOPE CHANGE DETECTOR—Output is square wave in which high and low levels indicate changes in slope of input signal. Operation is independent of input level, and independent of distortion provided irregularities in distorted signal do not reverse slope at too high an amplitude. If distortion is severe, additional filtering is required in input line to make use of fundamental frequency. Lag network ahead of IC opamp has time constant of 50 ms and is useful from 0.1 to 10 Hz.—R. Antelman, Change-Of-Slope Detector, *EEE*, June 1970, p 94–95.


+12V
1K
R_L
OUTPUT
(NC)
3N81 OR 3N84
2.0V INPUT B
1K
(NC)
3N81 OR 3N84
2.0V INPUT A
1K
3.3K
3.3K

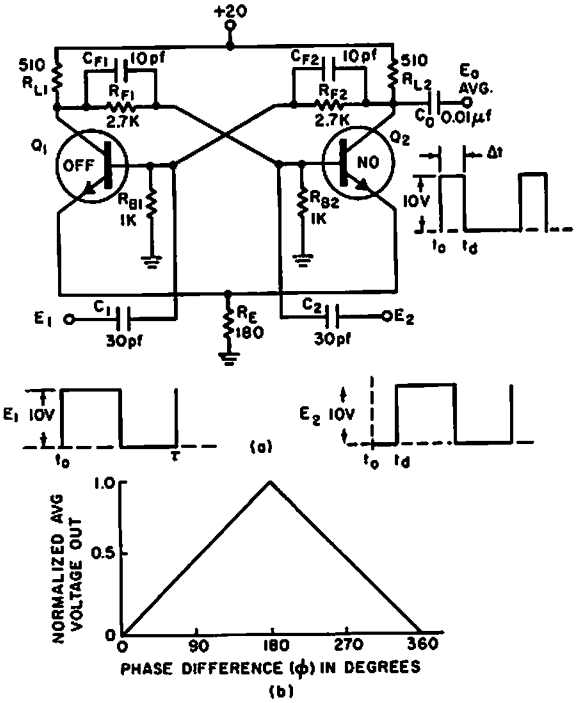
SCS PULSE COINCIDENCE DETECTOR—Voltage is developed across load RL only when inputs A and B occur simultaneously with amplitudes of 2 to 3 V. Pulse overlap of less than 1 μs is sufficient to give output. To detect coincidence of negative inputs, use scs units in complementary scr configuration, with detection by gates GA instead of GC. —Planar Silicon Controlled Switch 3N81/3N-82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


C_3 5pF
+3V
R_4 11K
OUTPUT 2
R_7 1100
R_9 1100
Q_2 2N2369
C_2 5pF
C_1 6.8μF
R_5 5100
R_6 5100
R_1 100
Q_1 2N2369
Q_3 2N2369
OUTPUT
CR_1 1N3600
R_8 5100
R_2 5100
R_3 3.3
BASIC CIRCUIT

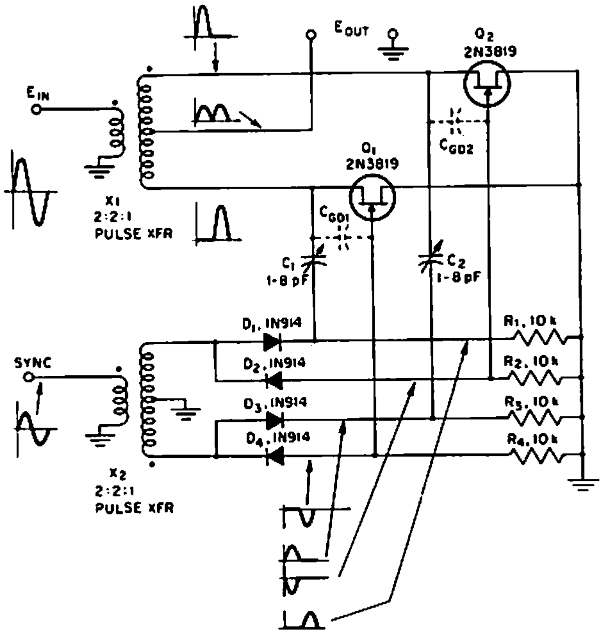
BUFFERED DETECTOR—Input of 1 mV p-p will fire circuit comparable to Schmitt trigger but with buffer Q2 in feedback path. Hysteresis is low for wide range of reference voltages. —R. H. Zimmerman, Buffered Detector, *EEE*, April 1967, p 138.


+5V
0.47
0.001
2.7
0.47
0.001
2.7
0.47
0.001
2.7
0.47
0.001
2.7
470
470
390
180
68
1k
180
Q_6 2N3010
200
FD100
Q_4 2N744
2N3010
1D5-050A
(Ge)
Q_5 2N744
0.47
0.001
1.2k
Q_3 2N744
2N3010
Q_1 2N2894
INPUT
Q_2 2N3010
Q_3 2N744
OUTPUT
47
1.5k
10
1.5k
150
47
4.7k
2.7k
2.7
-3v
220
0.47
0.001

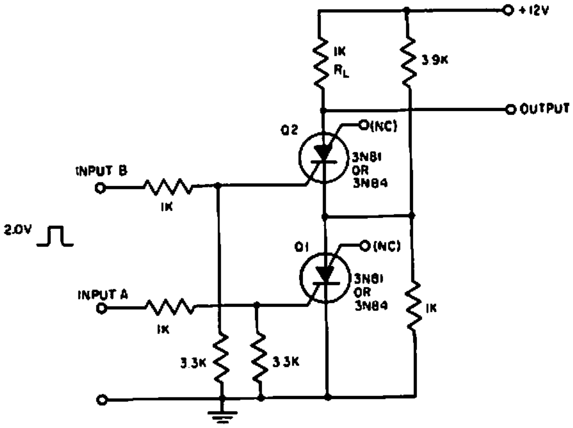
LOW-LEVEL SIGNAL DETECTOR—Pairs of Schmitt triggers provide high switching and cycling speeds with extremely low hysteresis, for detector of low-level signals at high frequencies. Can be used as sense amplifiers in high-speed computer memory systems. Article gives operating theory and limiting design equations. Circuit performed satisfactorily at 13 MHz, with hysteresis of only 2 mV.—T. Weisz, Pairing Schmitt Triggers Produces Lower Hysteresis and Faster Switching, *Electronics*, Nov. 28, 1966, p 75–79.


+20
510
R_{L1}
C_{F1}
10pf
R_{F1}
2.7K
C_{F2}
10pf
R_{F2}
2.7K
510
R_{L2}
E_0 AVG.
C_0 0.01μf
Q_1
OFF
R_{B1}
1K
Q_2
ON
R_{B2}
1K
Δt
10V
t_0
t_d
E_1
C_1
30pf
R_E
180
C_2
30pf
E_2
E_1 10V
t_0
T
(a)
E_2 10V
t_0 t_d
1.0
0.5
0
NORMALIZED AVG VOLTAGE OUT
0
90
180
270
360
PHASE DIFFERENCE (ϕ) IN DEGREES
(b)

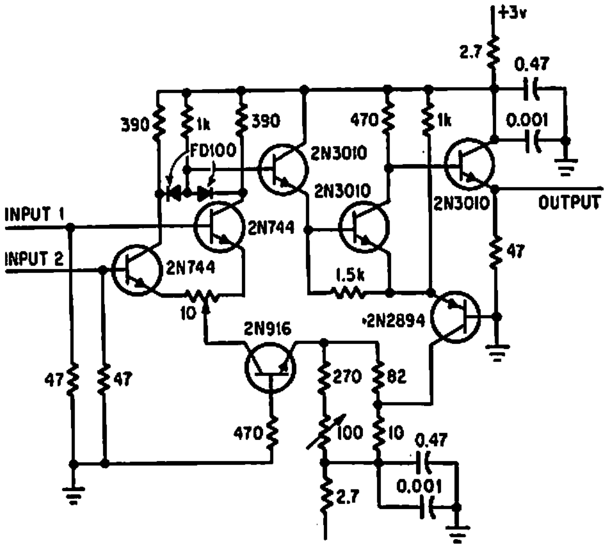
SQUARE-WAVE PHASE DETECTOR—Nonsaturating flip-flop provides linear average voltage output as function of phase difference between two 1-MHz square-wave signals. Average output voltage is zero when inputs E1 and E2 are in phase or 360 deg out-of-phase. Transistors are 2N2222.—J. F. Panicello, Flip-Flop Phase Detects RF Square Wave, *Electronic Design*, Nov. 9, 1964, p 71–72.


E_{OUT}
Q_2
2N3819
E_{IN}
C_{GD2}
Q_1
2N3819
X_1
2:2:1
PULSE XFR
C_{GD1}
C_1
1-8 pF
C_2
1-8 pF
D_1, IN914
R_1, 10 k
SYNC
D_2, IN914
R_2, 10 k
D_3, IN914
R_3, 10 k
D_4, IN914
R_4, 10 k
X_2
2:2:1
PULSE XFR

SYNCHRONOUS DETECTOR—Circuit shown overcomes capacitance problem in typical fet chopper by producing signal opposite in polarity to sync signal and feeding it to drain of fet through capacitance exactly equal to gate-drain capacitance. Dynamic range is 80 dB at 100 kHz.—R. P. Lackey, High-Speed Synchronous Detector, *EEE*, May 1970, p 103.


+12V
1K
R_L
3.9K
OUTPUT
Q2
(NC)
3N81 OR 3N84
INPUT B
1K
2.0V
Q1
(NC)
3N81 OR 3N84
INPUT A
1K
1K
3.3K
3.3K

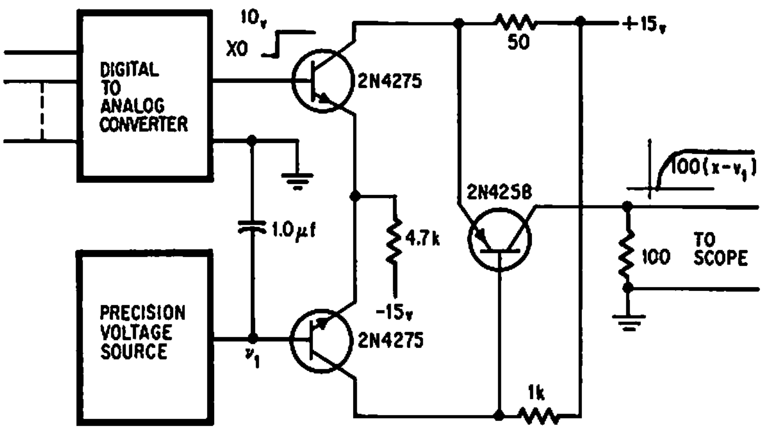
PULSE SEQUENCE DETECTOR—Resistor divider between Q1 and Q2 prevents input B from triggering Q2 unless Q1 is conducting. When pulse is applied in input A to make Q1 conducting, next pulse at input B triggers Q2 and sends current through load RL.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


+3v
2.7
0.47
390
1k
390
470
1k
0.001
FD100
2N3010
2N3010
2N3010
OUTPUT
INPUT 1
2N744
INPUT 2
2N744
47
1.5k
10
2N916
2N2894
47
47
270
82
470
100
10
0.47
0.001
2.7

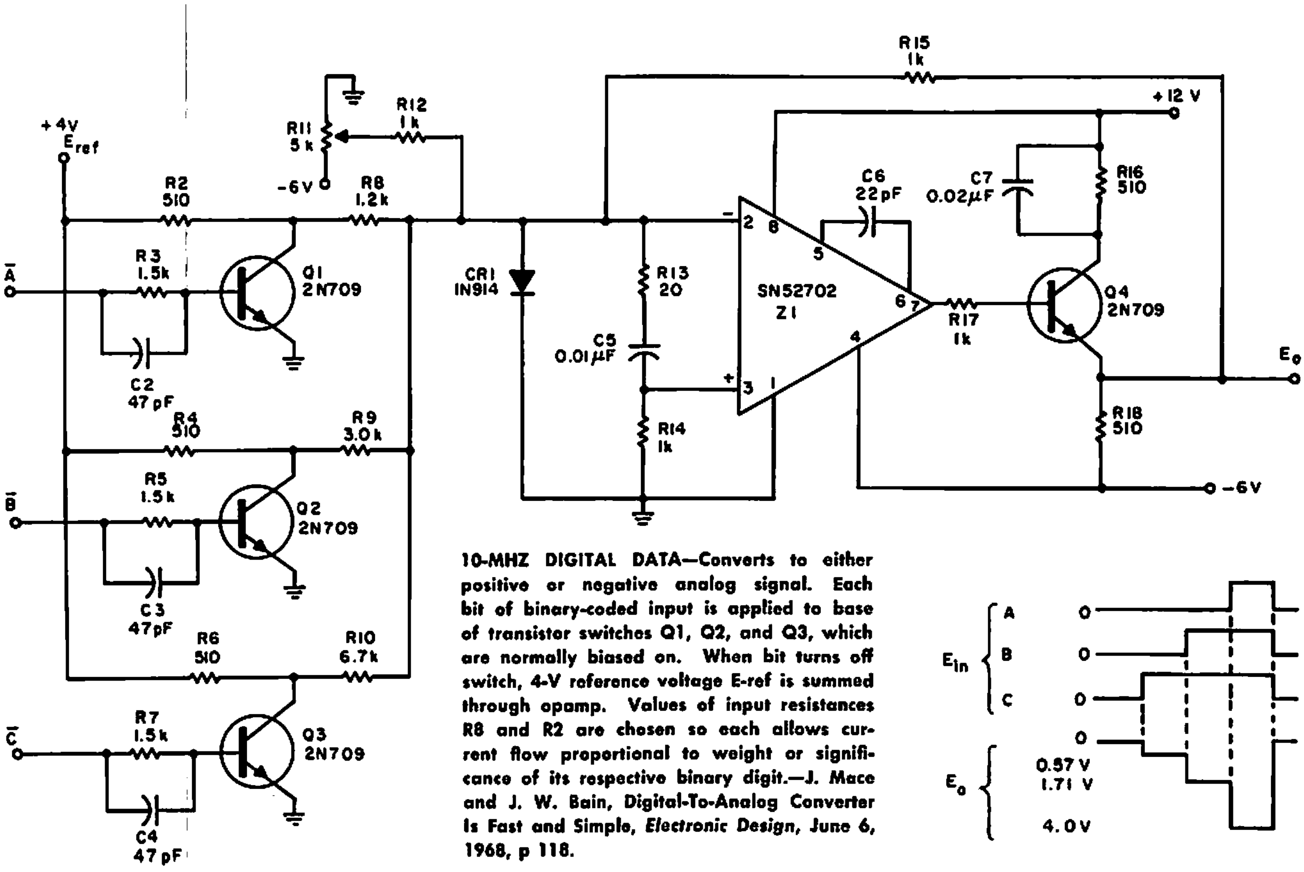
VOLTAGE BAND DETECTOR—Modification of paired Schmitt triggers produces output only when input 2 is within predetermined limits that are above voltage at input 1. Circuit thus detects absolute differences between two low-level input signals.—T. Weisz, Pairing Schmitt Triggers Produces Lower Hysteresis and Faster Switching, *Electronics*, Nov. 28, 1966, p 75–79.

CHAPTER 25

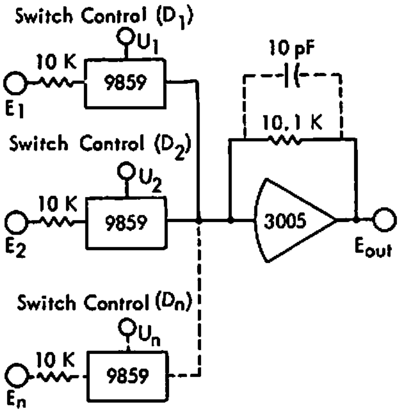
Digital-Analog Converter Circuits


DIGITAL TO ANALOG CONVERTER
PRECISION VOLTAGE SOURCE
10_v
XO
2N4275
2N4275
1.0μf
v_1
4.7k
-15_v
50
$+15_v$
2N4258
$100(x-v_1)$
100
TO SCOPE
1k

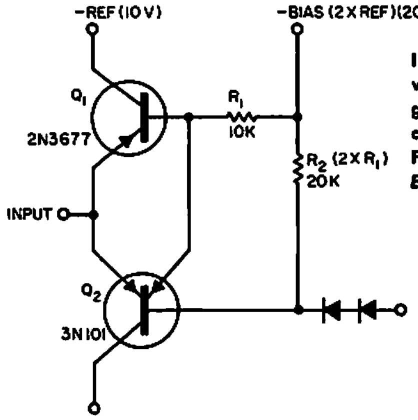
BOOSTER—Simple differential preamp ahead of cro provides necessary gain and sensitivity for measuring rise and settling times of d-a converter. Sufficient offset is provided by voltage source to look only at top of converter waveform.—J. J. Pastoriza, Know Your D-A Converter's Capability, *Electronics*, Nov. 10, 1969, p 129–130.


+4V
E_{ref}
R2 510
R3 1.5k
Q1 2N709
C2 47pF
R4 510
R9 3.0k
R5 1.5k
Q2 2N709
C3 47pF
R6 510
R10 6.7k
R7 1.5k
Q3 2N709
C4 47pF
$\bar{A}$
$\bar{B}$
$\bar{C}$
R11 5k
-6V
R12 1k
R8 1.2k
CR1 IN914
R13 20
C5 0.01μF
R14 1k
R15 1k
+12 V
C6 22pF
C7 0.02μF
R16 510
SN52702 Z1
R17 1k
Q4 2N709
R18 510
E_o
-6V
E_{in}
A
B
C
0
E_o
0.57 V
1.71 V
4.0 V

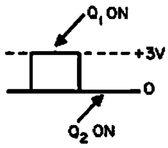
10-MHZ DIGITAL DATA—Converts to either positive or negative analog signal. Each bit of binary-coded input is applied to base of transistor switches Q1, Q2, and Q3, which are normally biased on. When bit turns off switch, 4-V reference voltage E-ref is summed through opamp. Values of input resistances R8 and R2 are chosen so each allows current flow proportional to weight or significance of its respective binary digit.—J. Mace and J. W. Bain, Digital-To-Analog Converter Is Fast and Simple, *Electronic Design*, June 6, 1968, p 118.

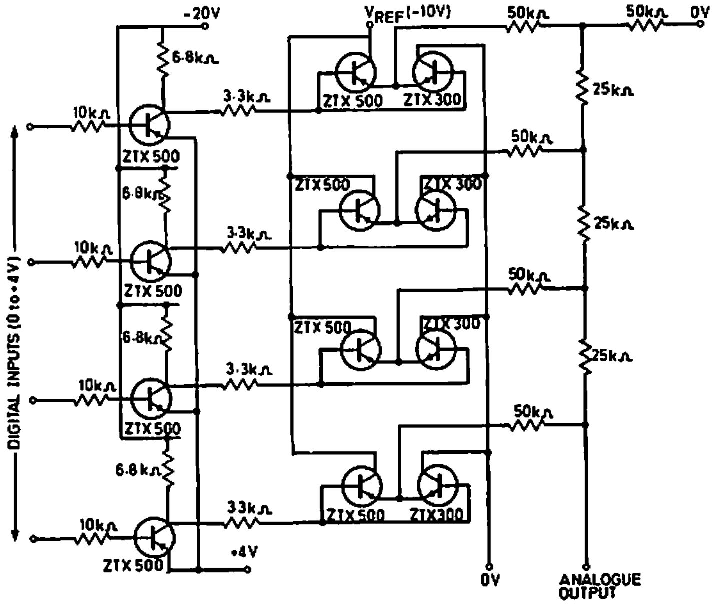

Switch Control (D1)
U1
10 K
9859
E1
10 pF
10.1 K
Switch Control (D2)
U2
10 K
9859
E2
3005
Eout
Switch Control (Dn)
Un
10 K
9859
En

MULTIPLEXER—Any number of Burr-Brown 9859/15 integrate-hold electronic switch modules may be combined as shown for multiplexing at output of opamp if properly sequenced control pulses are fed to switches. With properly weighted input summing resistors, set of n switches may be used to construct n-bit digital-analog converter or n-bit multiplying digital-analog converter.—Integrate/Hold Electronic Switch, Burr-Brown Research, Tucson, Ariz., PDS189, 1967.

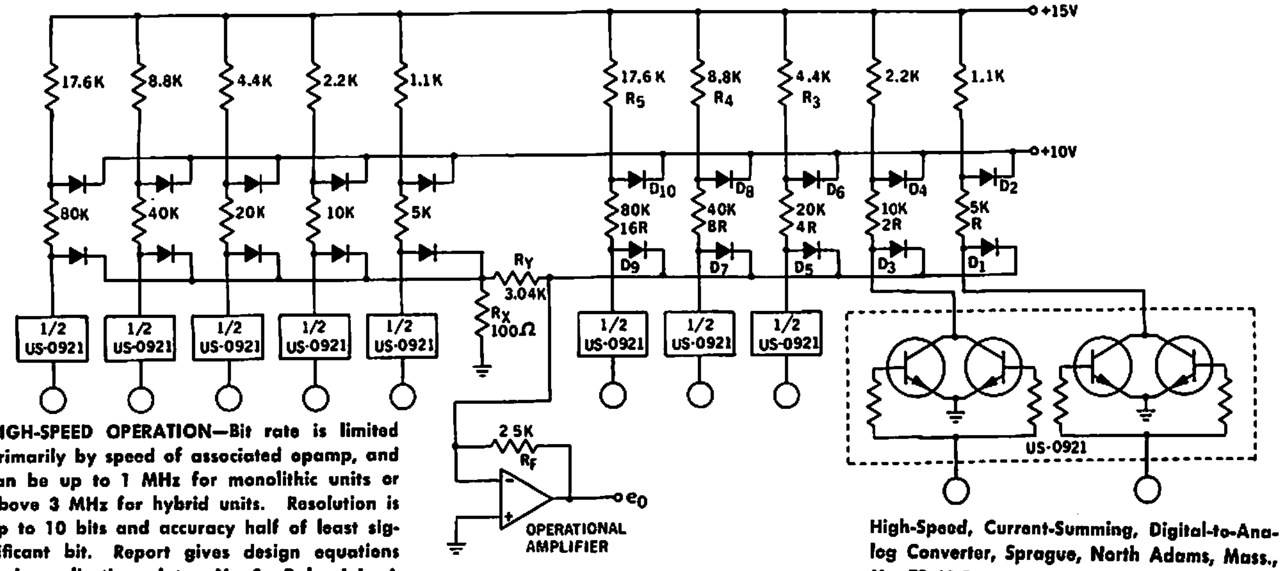

-REF (10 V)
-BIAS (2 X REF)(20V)
Q1
2N3677
R1
10K
R2 (2 X R1)
20K
INPUT
Q2
3N101

INTEGRATED CHOPPER—Digital-to-analog conversion is produced by spdt action of integrated chopper Q2, without complex drive circuitry.—J. M. Cohen, Integrated Chopper Forms Simple Digital-to-Analog Converter, *Electronic Design*, Nov. 22, 1965, p 60–61.

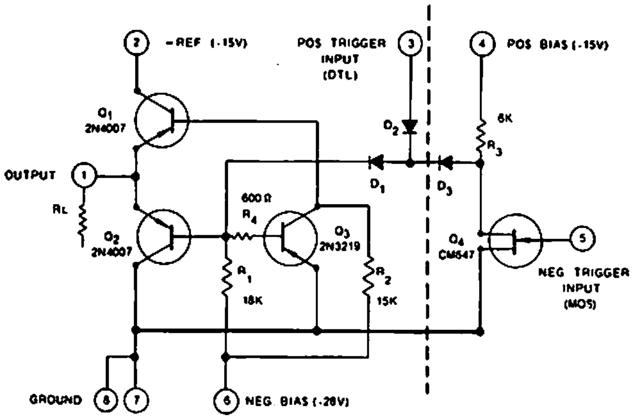

Q1 ON
+3V
0
Q2 ON


-20V
6·8kΩ
10kΩ
ZTX 500
3·3kΩ
VREF (-10V)
50kΩ
50kΩ
0V
ZTX 500
ZTX 300
25kΩ
DIGITAL INPUTS (0 to +4 V)
+4V
0V
ANALOGUE OUTPUT

4-BIT DIGITAL-ANALOG—Uses complementary transistors as switches. Driver transistors at left operate from higher negative supply voltage to ensure that switching transistors will bottom satisfactorily. Ladder network, made up of close-tolerance resistors, is used for summing outputs.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 49.

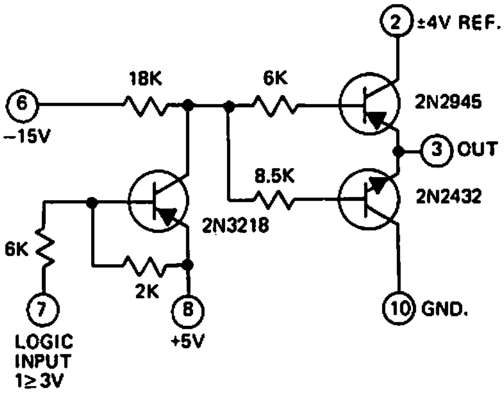

+15V
17.6K
8.8K
4.4K
2.2K
1.1K
17.6 K R5
8.8K R4
4.4K R3
2.2K
1.1K
+10V
80K
40K
20K
10K
5K
80K 16R
40K 8R
20K 4R
10K 2R
5K R
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
RY 3.04K
RX 100Ω
1/2 US-0921
US-0921
2.5K
RF
eO
OPERATIONAL AMPLIFIER

HIGH-SPEED OPERATION—Bit rate is limited primarily by speed of associated opamp, and can be up to 1 MHz for monolithic units or above 3 MHz for hybrid units. Resolution is up to 10 bits and accuracy half of least significant bit. Report gives design equations and application data.—N. S. Palazzini, A High-Speed, Current-Summing, Digital-to-Analog Converter, Sprague, North Adams, Mass., No. TP-68-9.



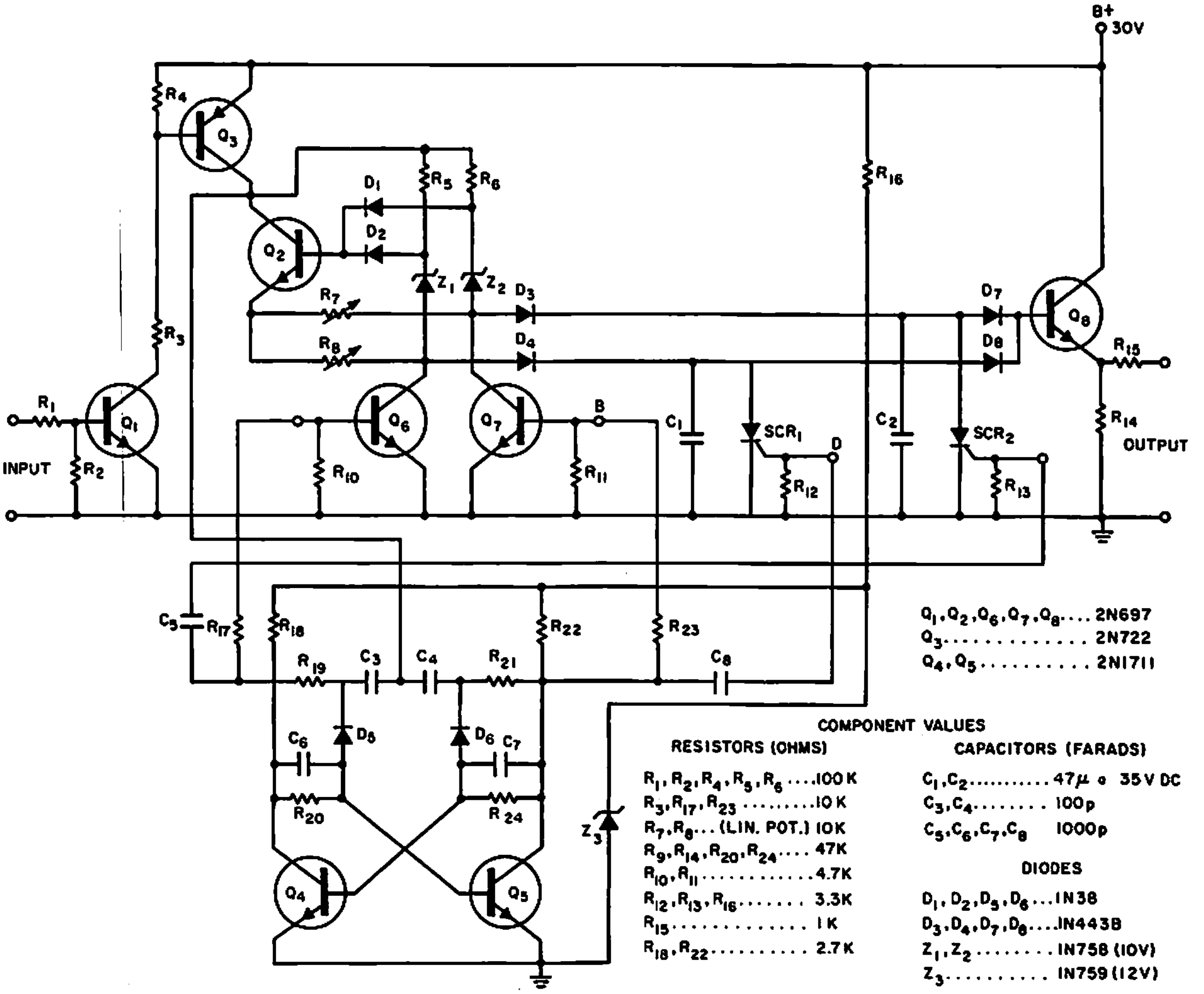
2 −REF (-15V)
POS TRIGGER INPUT (DTL) 3
4 POS BIAS (-15V)
Q1 2N4007
D2
6K R3
OUTPUT 1
RL
D1
D3
600 Ω R4
Q2 2N4007
Q3 2N3219
Q4 CM647
5
NEG TRIGGER INPUT (MOS)
R1 18K
R2 15K
GROUND 8 7
6 NEG. BIAS (-28V)

LADDER SWITCH—Crystalonics CDA1-2 packaged ladder switch for digital-analog converters accepts either 6-V positive or 24-V negative triggers directly from logic. Contains series-shunt switch and driver. Uses chips bonded directly to substrate.—Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.



2 ±4V REF.
6 −15V
18K
6K
2N2945
3 OUT
8.5K
2N2432
2N3218
6K
2K
7 LOGIC INPUT 1≥3V
8 +5V
10 GND.

BIPOLAR-REFERENCE LADDER SWITCH—Crystalonics CDA5 hybrid package for digital-analog converters has maximum switching delay of only 3 μs, operating from either positive or negative 4-V reference.—Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.



B+ 30V
R4
Q3
D1
D2
R5
R6
Q2
Z1
Z2
D3
D4
R7
R8
R3
R16
D7
D8
Q8
R15
R1
Q1
INPUT
R2
Q6
Q7
B
R10
R11
C1
SCR1
D
R12
C2
SCR2
R13
R14
OUTPUT
C5
R17
R18
R19
C3
C4
R21
R22
R23
C8
C6
D5
D6
C7
R20
R24
Z3
Q4
Q5

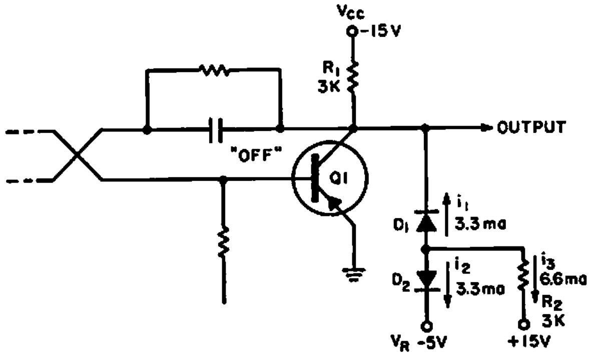
Q_1, Q_2, Q_6, Q_7, Q_8.... 2N697
Q_3.............. 2N722
Q_4, Q_5........... 2N1711

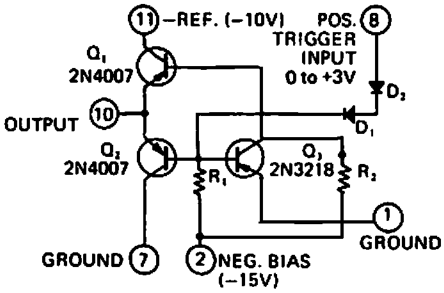
COMPONENT VALUES

RESISTORS (OHMS)		CAPACITORS (FARADS)	
R_1, R_2, R_4, R_5, R_6	100 K	C_1, C_2	47μ @ 35 V DC
R_3, R_{17}, R_{23}	10 K	C_3, C_4	100p
R_7, R_8 ... (LIN. POT.)	10K	C_5, C_6, C_7, C_8	1000p
$R_9, R_{14}, R_{20}, R_{24}$	47K	DIODES	
R_{10}, R_{11}	4.7K	D_1, D_2, D_5, D_6	IN38
R_{12}, R_{13}, R_{16}	3.3K	D_3, D_4, D_7, D_8	IN443B
R_{15}	1 K	Z_1, Z_2	IN758 (10V)
R_{18}, R_{22}	2.7 K	Z_3	IN759 (12V)

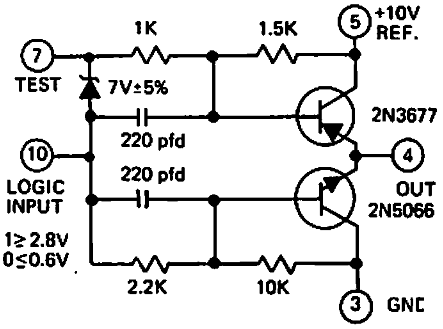
CONVERTING PULSE WIDTH TO VOLTAGE—Can be used to convert voice-modulated variable-width pulses back to analog voltages over narrow-bandwidth space communication channels. Output is linearily proportional to pulse width. Operates over duty-cycle range from 0.06 to 60%, with pulse periods up to 500 ms. Requires only about 600 mW power. Can handle up to 10,000 pps.—A. L. Newcomb, Jr., Solid-State Integrator Combines Low Duty Cycle With Low Ripple, *Electronic Design*, April 12, 1965, p 42—45.

CLAMPED LOAD—Diode-resistor arrangement at right cuts cost of OFF level standardizer for driving flip-flop in digital-analog converter driven by counter or register. For 5-V logic level, output voltage error is less than 0.2 mV per degree C. Diodes can be unmatched but should be mounted close together to minimize temperature errors.—E. J. Rogers, Accurate Binary Levels In a Clamped Circuit, *Electronic Design*, April 27, 1964, p 91–92.

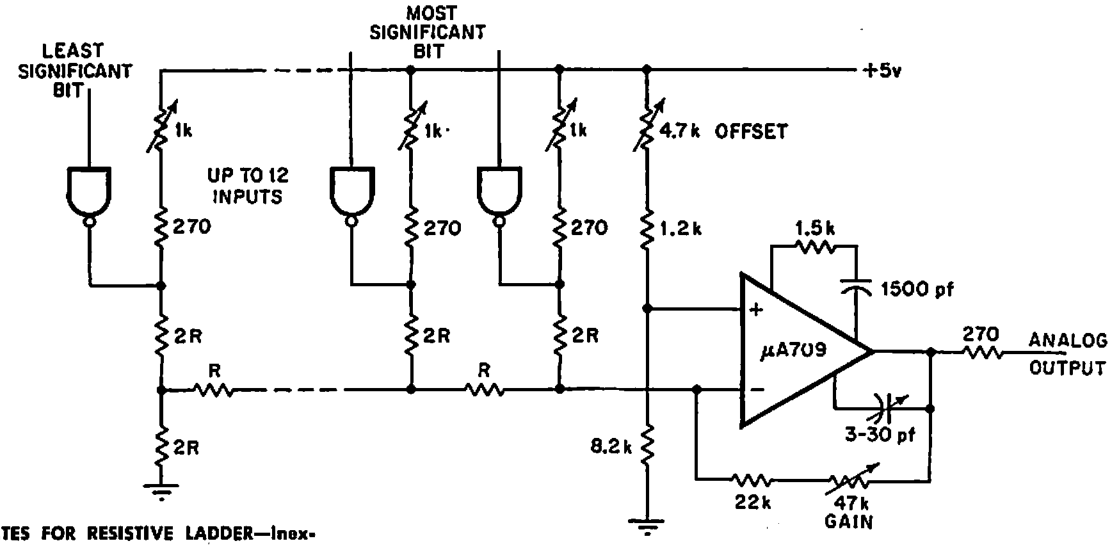

Vcc
-15V
R1
3K
OUTPUT
"OFF"
Q1
D1
i1
3.3ma
D2
i2
3.3ma
i3
6.6ma
R2
3K
VR -5V
+15V


11
-REF. (-10V)
POS. 8
TRIGGER
INPUT
0 to +3V
Q1
2N4007
D2
OUTPUT
10
D1
Q2
2N4007
R1
Q3
2N3218
R2
1
GROUND
GROUND 7
2 NEG. BIAS
(-15V)

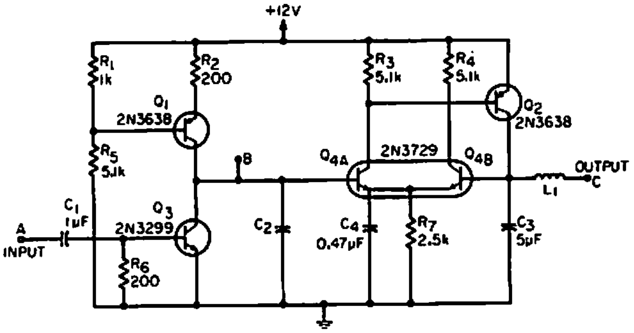
NEGATIVE-REFERENCE LADDER SWITCH—Crystalonics CMDA1 hybrid package for digital-analog converters gives 10-bit accuracy when used with 10K/20K ladder. Works directly from logic. Consists of series-shunt switch and driver.—Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.


1K
1.5K
5
+10V
REF.
7
TEST
7V±5%
2N3677
220 pfd
10
220 pfd
4
LOGIC
INPUT
OUT
2N5066
1≥2.8V
0≤0.6V
2.2K
10K
3
GND

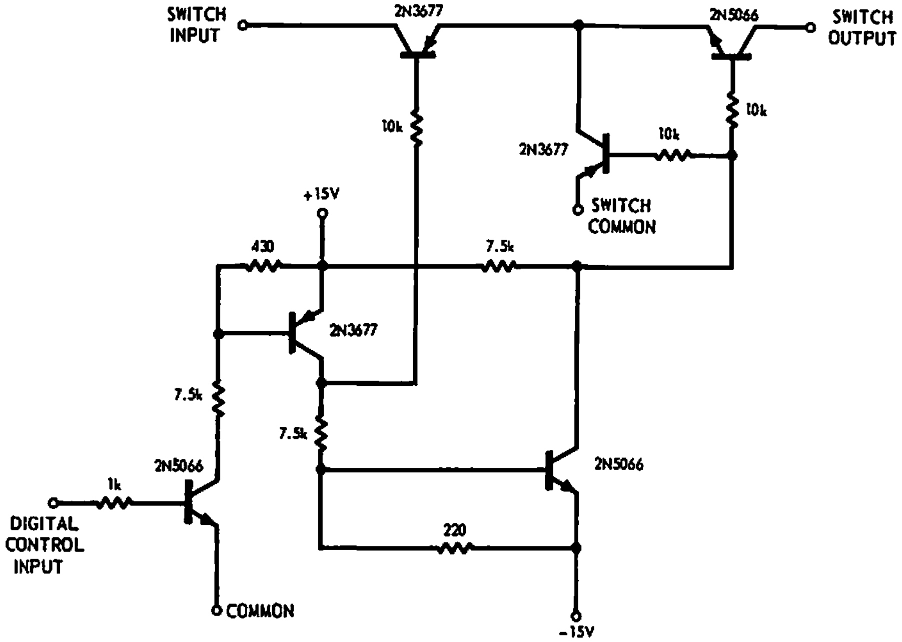
POSITIVE-REFERENCE LADDER SWITCH—Crystalonics CDA4A hybrid package for digital-analog converters gives 12-bit accuracy, works directly from logic, and uses positive 10-V reference.—Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.


LEAST
SIGNIFICANT
BIT
MOST
SIGNIFICANT
BIT
+5v
1k
1k
1k
4.7k OFFSET
UP TO 12
INPUTS
270
270
270
1.2k
1.5k
1500 pf
2R
2R
2R
μA709
270
ANALOG
OUTPUT
R
R
3-30 pf
2R
8.2k
22k
47k
GAIN

12 TTL GATES FOR RESISTIVE LADDER—Inexpensive, easily assembled d-a converter serves as low-cost drive for crt display terminals. TTL used must have open collector for external resistor and power supply, such as SN7401 quad NAND gate and SN7401 hex inverter. Current proportional to digital input is summed into one input of opamp. Resistive ladder network weights currents switched by logic gates according to significance of their input bits on binary scale. Value of R should be between 10K and 50K for best accuracy and settling time.—C. S. L. Keay and J. A. Kennewell, D-A Converter Switches Digital Inputs with TTL Gates, *Electronics*, Dec. 8, 1969, p 89.


+12V
R1
1k
R2
200
R3
5.1k
R4
5.1k
Q2
2N3638
Q1
2N3638
R5
5.1k
B
Q4A
2N3729
Q4B
OUTPUT
C
L1
C1
1μF
A
INPUT
Q3
2N3299
R6
200
C2
C4
0.47μF
R7
2.5k
C3
5μF

PWM TO VOLTAGE—Provides linear conversion from pulse width to analog output voltage, from input repetition frequencies of 1 kHZ to 1 MHz and duty cycles from 5 to 95%. Q1 generates linear ramp across C2, with duration and height controlled by input pulse width. Ramp voltage is applied to one input of differential amplifier Q4, and inverted output of amplifier Q2 is applied to other input. Feedback tends to maintain output voltage across C3.—O. Lykins, Simple Circuit Converts Pulse Duty Cycle Into Analog Voltage, *EEE*, July 1968, p 98–99.

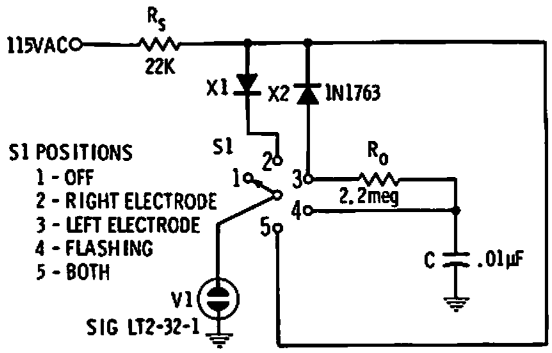

SWITCH INPUT
2N3677
2N5066
SWITCH OUTPUT
10k
10k
2N3677
10k
SWITCH COMMON
+15V
430
7.5k
2N3677
7.5k
7.5k
2N5066
1k
DIGITAL CONTROL INPUT
2N5066
220
COMMON
-15V

HIGH-LEVEL SIGNAL SWITCH—Controlled by standard TTL or DTL logic having ON-OFF time of about 200 ns. Complementary transistors isolate drive from signal current. Can be used for digital-analog conversion, video switching, and sample-and-hold. ON resistance is about 10 ohms.—R. C. Gerdes, High-Level Analog Switch, *EDN*, Sept. 1, 1969, p 73.

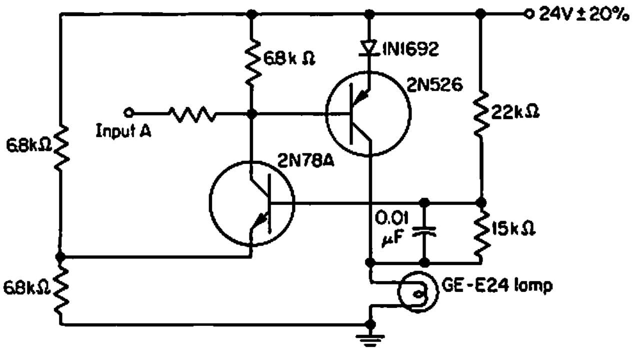
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 26

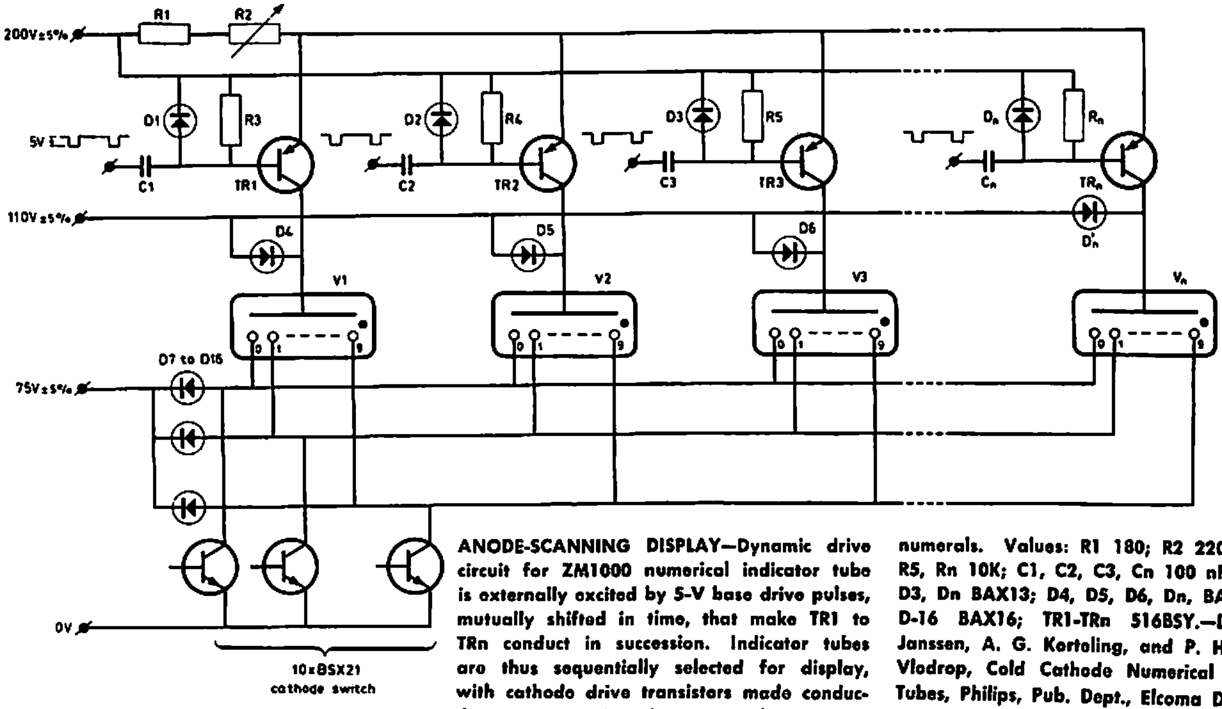
Display Circuits


115VAC
R_S
22K
X1
X2
1N1763
S1 POSITIONS
1 - OFF
2 - RIGHT ELECTRODE
3 - LEFT ELECTRODE
4 - FLASHING
5 - BOTH
S1
1
2
3
4
5
R0
2.2meg
C
.01µF
V1
SIG LT2-32-1

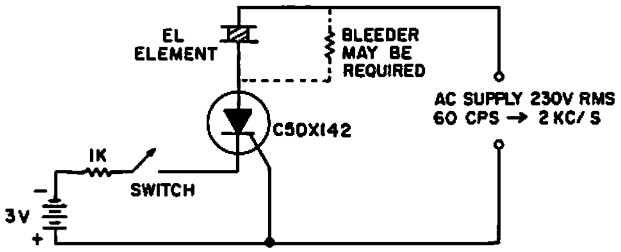
FIVE-CONDITION INDICATOR—Represents any of five states, using single neon lamp, by switching S1.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 23.


24V ± 20%
68k Ω
1N1692
2N526
22kΩ
Input A
6.8kΩ
2N78A
0.01 µF
15kΩ
6.8kΩ
GE-E24 lamp

BISTABLE INDICATOR LAMP DRIVER—Lamp is turned on by short trigger pulse at input A and then remains on. Lamp is turned off by positive pulse at A and will remain off. Used with logical flip-flop.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 260.

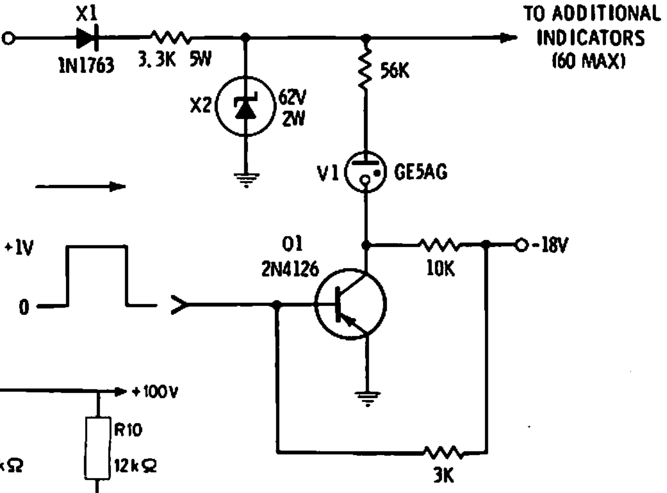

200V±5%
R1
R2
5V
D1
R3
C1
TR1
D2
R4
C2
TR2
D3
R5
C3
TR3
Dn
Rn
Cn
TRn
110V±5%
D4
D5
D6
D'n
V1
V2
V3
Vn
0
1
9
D7 to D15
75V±5%
0V
10xBSX21
cathode switch

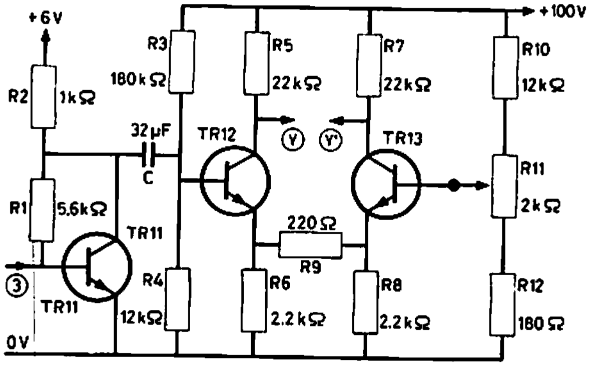
ANODE-SCANNING DISPLAY—Dynamic drive circuit for ZM1000 numerical indicator tube is externally excited by 5-V base drive pulses, mutually shifted in time, that make TR1 to TRn conduct in succession. Indicator tubes are thus sequentially selected for display, with cathode drive transistors made conductive at appropriate instant to show correct numerals. Values: R1 180; R2 220; R3, R4, R5, Rn 10K; C1, C2, C3, Cn 100 nF; D1, D2, D3, Dn BAX13; D4, D5, D6, Dn, BAX16; D7-D-16 BAX16; TR1-TRn 516BSY.—D. J. G. Janssen, A. G. Korteling, and P. H. G. van Vladrop, Cold Cathode Numerical Indicator Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 327, 1968.


EL ELEMENT
BLEEDER MAY BE REQUIRED
AC SUPPLY 230V RMS 60 CPS → 2KC/S
C50X142
IK
SWITCH
3V
-
+

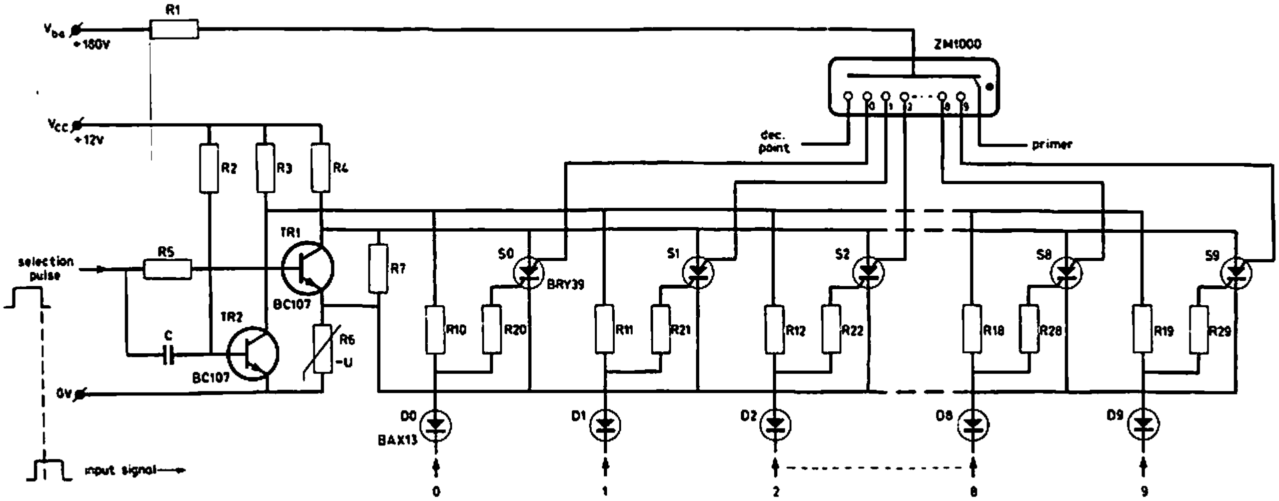
SERIES DRIVE FOR EL—Electroluminescent panel is off when switch is open. When switch is closed, scr gate is positive and scr conducts, with a-c load current flowing through scr, switch, 1K resistor, and control battery.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 40.

LOW-VOLTAGE NONLATCHING INDICATOR—Neon receives −18 V when Q1 is cut off by 1-V pulse. Together with zener voltage, this fires lamp.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 20.


115 VAC
X1
1N1763
3.3K 5W
56K
TO ADDITIONAL INDICATORS (60 MAX)
X2
62V 2W
V1
GE5AG
Q1
2N4126
10K
-18V
+1V
0
3K


+6V
R2
1kΩ
R1
5.6kΩ
TR11
③
TR11
0V
R3
180kΩ
32µF
C
R4
12kΩ
TR12
R5
22kΩ
Y
Y'
R7
22kΩ
TR13
220Ω
R9
R6
2.2kΩ
R8
2.2kΩ
+100V
R10
12kΩ
R11
2kΩ
R12
180Ω

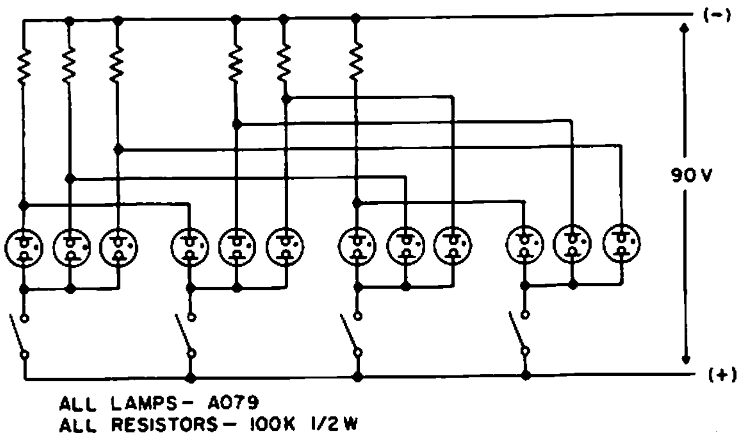
Y AMPLIFIER FOR NUMERICAL DISPLAY—Differential output stage is fed by preamp to which deflection signals from bar matrix generator and column or row selector are applied. TR11 is BSX20; TR12 and TR13 are BSX21.—A. P. Tanis, Numerical Display with Bar Matrix Character Generator, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966–1967, p 73–83.


V_{bb}
+180V
R1
ZM1000
0
1
2
8
9
dec. point
primer
V_{cc}
+12V
R2
R3
R4
TR1
BC107
selection pulse
R5
C
TR2
BC107
R6
-U
R7
S0
BRY39
S1
S2
S8
S9
R10
R20
R11
R21
R12
R22
R18
R28
R19
R29
0V
D0
BAX13
D1
D2
D8
D9
input signal
0
1
2
8
9

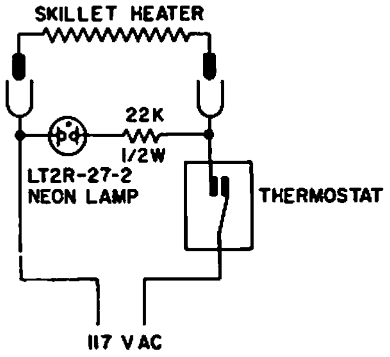
DISPLAY BANK WITH MEMORY—Circuit controls one numerical indicator tube in bank of such tubes, displaying parallel digits representing information from computer or calculator. Scs associated with each digit acts both as switch and memory so display is held after input signal has ceased. Display tubes are energized in sequence until entire numeral is visible. Display is blanked out by applying positive pulse to all selection pulse inputs, to turn off every conducting scs and extinguish all indicator tubes.—D. J. G. Janssen, A. G. Kortoling, and P. H. G. van Vladrop, Cold Cathode Numerical Indicator Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 327, 1968.

R1 = 16 kΩ
R2 = 10 kΩ
R3 = 1.2 kΩ
R4 = 2.2 kΩ
R5, R6 = VDR

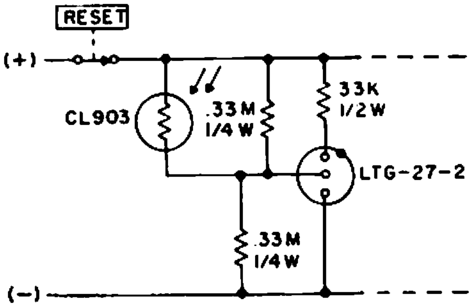
R7 = 8.2 kΩ
R10 to R19 = 8.2 kΩ
R20 to R29 = 3.3 kΩ
C = 2.7 nF
S0 to S9 = BRY39


(−)
90 V
(+)
ALL LAMPS- A079
ALL RESISTORS- 100K 1/2 W

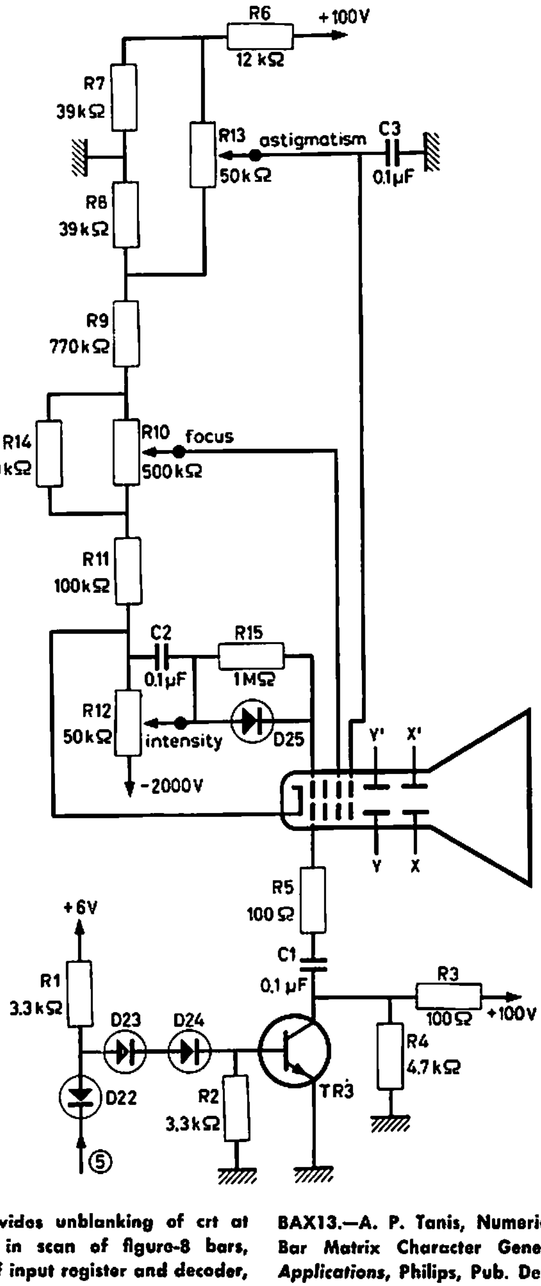
SWITCHED SEQUENCE—First microswitch to close causes three neon lamps to glow. Second switch lights only two lamps, third lights one, and fourth doesn't light any lamp.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 143.


SKILLET HEATER
22K
1/2W
LT2R-27-2
NEON LAMP
THERMOSTAT
117 VAC

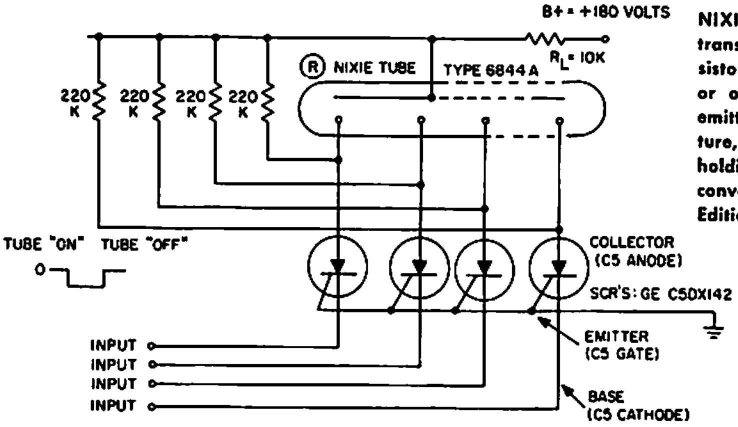
APPLIANCE ON INDICATOR—Neon lamp indicates when thermostatically controlled heating element is on.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 138.


RESET
(+)
CL903
.33M
1/4 W
33K
1/2 W
LTG-27-2
.33M
1/4 W
(−)

WRITE WITH FLASHLIGHT—Light excites one photocell in bank of 1,000, causing corresponding three-element neon lamp in bank of 1,000 to glow. Lamps remain on until reset button is pushed to turn all lamps off at once. Power source is 145 V.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 116.

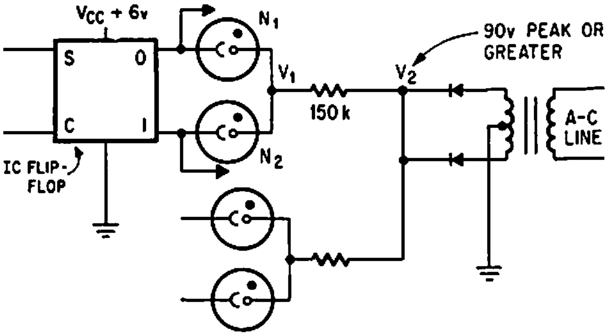

R6
+100V
12 kΩ
R7
39kΩ
R13
astigmatism
C3
50kΩ
0.1μF
R8
39kΩ
R9
770kΩ
R14
120kΩ
R10
focus
500kΩ
R11
100kΩ
C2
R15
0.1μF
1MΩ
R12
50kΩ
intensity
D25
-2000V
Y'
X'
Y
X
R5
100Ω
+6V
C1
0.1μF
R1
3.3kΩ
R3
D23
D24
100Ω
+100V
R4
4.7kΩ
D22
R2
3.3kΩ
TR3
⑤

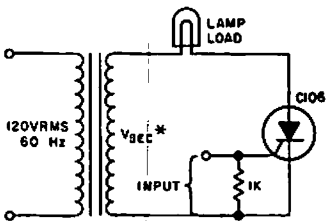
Z AMPLIFIER—Provides unblanking of crt at required instants in scan of figure-8 bars, under command of input register and decoder, for generating desired numeral on crt display. Transistor is BF177 and all diodes are BAX13.—A. P. Tanis, Numerical Display with Bar Matrix Character Generator, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966–1967, p 73–83.


B+ = +180 VOLTS
R_L = 10K
Ⓡ NIXIE TUBE
TYPE 6844 A
220 K
220 K
220 K
220 K
TUBE "ON"
TUBE "OFF"
0
COLLECTOR (C5 ANODE)
SCR'S: GE C50X142
EMITTER (C5 GATE)
BASE (C5 CATHODE)
INPUT
INPUT
INPUT
INPUT

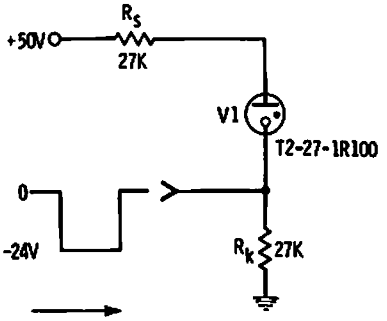
NIXIE DRIVER—Scr biased as remote-base transistor makes excellent high-voltage transistor for driving each element of Nixie, neon, or other type of digital display. Common-emitter current gain is 2. For memory feature, with display initiated by pulse and holding until reset externally, connect C5 conventionally as scr.—"SCR Manual," 4th Edition, General Electric, 1967, p 170–171.

4 V TURNS ON NEONS—Low-voltage IC flip-flop turns neon glow-lamp indicators such as NE-23 on and off even though IC cannot handle 71-V breakdown of lamps. Pulsating d-c voltage at V2, obtained from a-c line, can turn lamps on and off with each cycle of a-c line. Only one lamp of a parallel pair can fire at a time. When lamp connected to "1" output of IC (4 V) turns on, V1 drops to maintaining voltage of 60 V and other lamp cannot turn on.—G. V. Wintriss, Integrated Circuit Drives Neons Directly, *Electronics*, Nov. 13, 1967, p 99.

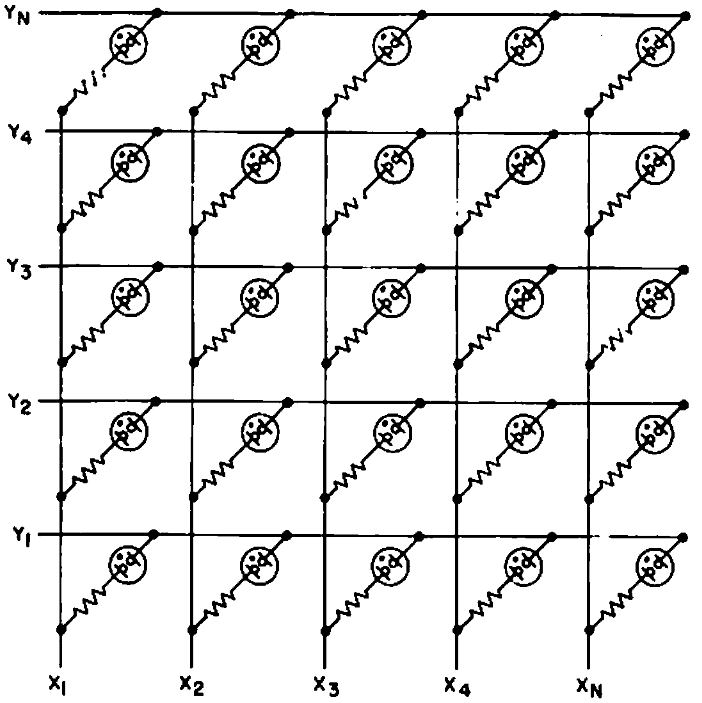

V_{CC} + 6v
S
0
C
1
IC FLIP-FLOP
N_1
N_2
V_1
150 k
V_2
90v PEAK OR GREATER
A-C LINE


LAMP LOAD
C106
120VRMS 60 Hz
V_{SEC}*
INPUT
1K

SCR DRIVER FOR LAMP—Designed for No. 24 24-V lamp requiring 34 V rms from transformer secondary for normal brilliance on half-wave.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 25.


R_S
+50V
27K
V1
T2-27-1R100
0
-24V
R_K
27K

NONLATCHING INDICATOR—Neon glows only when negative pulse, which might come from transistor collector or other low-voltage source, is present.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 20.

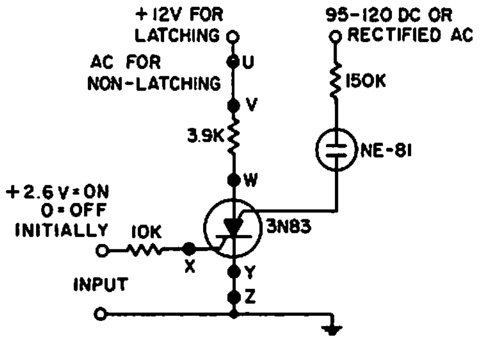

Y_N
Y_4
Y_3
Y_2
Y_1
X_1
X_2
X_3
X_4
X_N

ALL LAMPS— T2-27-IWR760
ALL RESISTORS— 22K

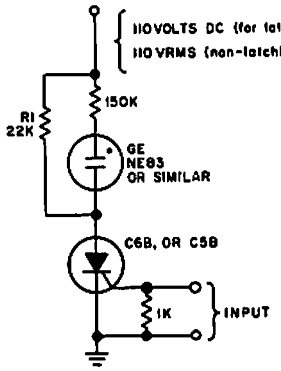
Y NORMAL +60 V
Y "ON" +105 V

X NORMAL −60 V
X "ON" −105 V

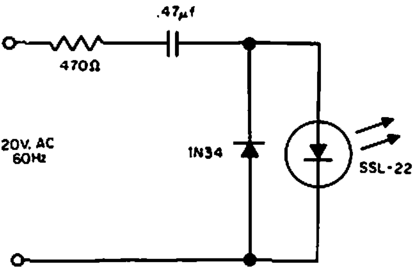
NEON X-Y MATRIX—Any one lamp lights only when both X and Y voltages on that line are increased to specified value. The matrix may be reset either by momentarily removing voltages or by reversing polarity along either axis so voltage across lamp is zero. Information may be fed in by X and Y ring counters. Readout may be visual or through photocells coupled to individual lamps and transistor circuitry.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 76.


+12V FOR LATCHING
AC FOR NON-LATCHING
95-120 DC OR RECTIFIED AC
U
V
150K
3.9K
NE-81
W
+2.6 V = ON
0 = OFF INITIALLY
10K
3N83
X
Y
INPUT
Z

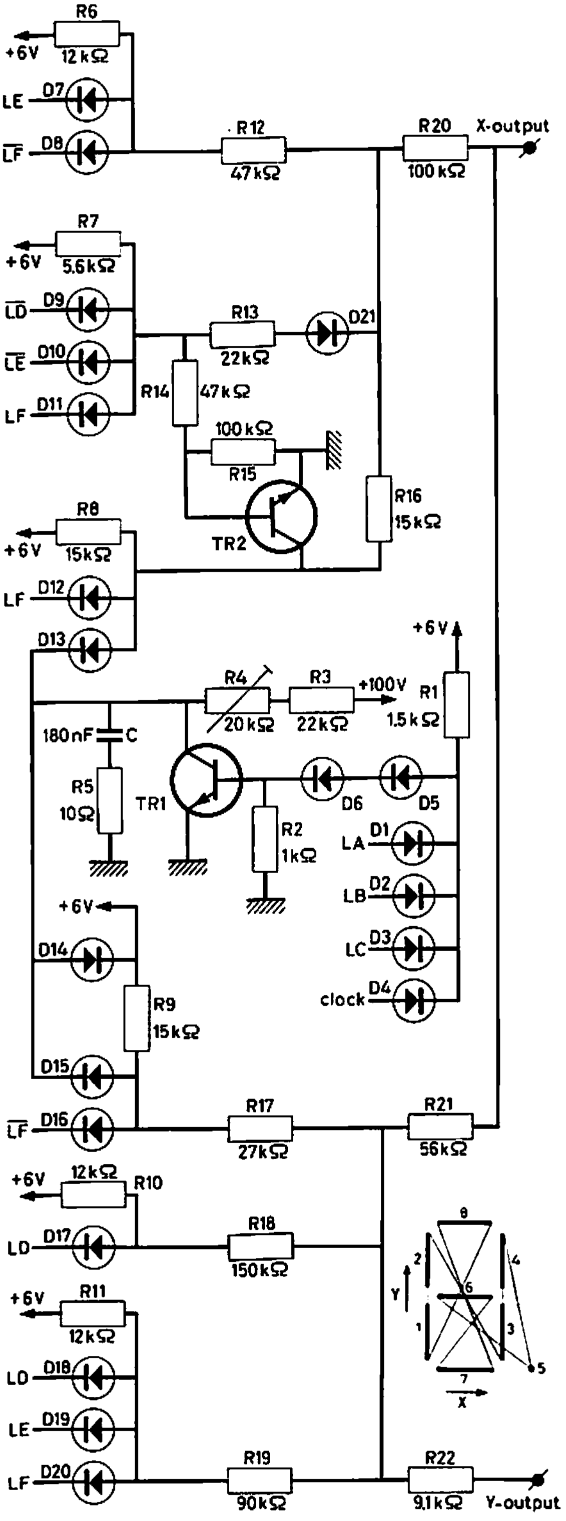
PLANAR PNPN SWITCH DRIVES NEON—Serves as low-cost latching-type driver for single neon indicator lamp, immune to triggering by line transients.—Planar Neon Driver Silicon Controlled Switch 3N83, General Electric, Syracuse, N.Y., No. 65.17, 1964.


110VOLTS DC (for latching)
110VRMS (non-latching)
150K
R1 22K
GE NE83 OR SIMILAR
C6B, OR C5B
1K
INPUT

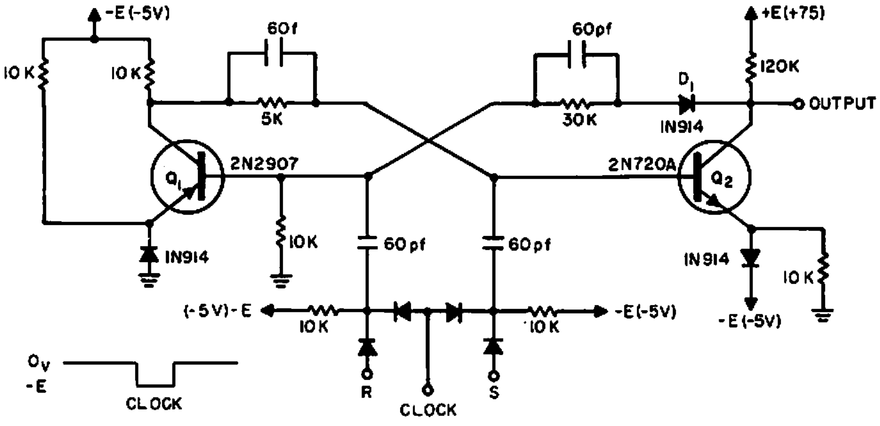
SCR DRIVER FOR NEON—Low-current scr has ample voltage capability for handling 110 V required for driving neons, Nixies, and other types of glow lamps. R1 provides holding current for scr.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 25.


.47μf
470Ω
120V. AC 60Hz
1N34
SSL-22

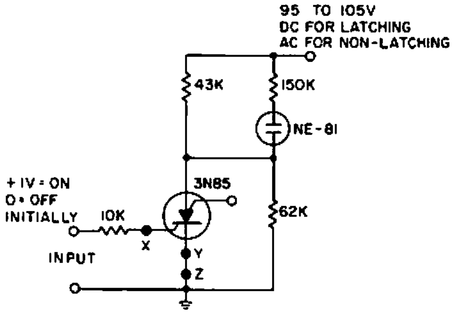
A-C LINE VOLTAGE INDICATOR—With solid-state lamp, power dissipation in circuit is less than 0.2 W. Surge-limiting resistor and surge-handling capability of diode and ssl make indicator self-protected from most line spikes or switching transients.—L. M. Hertz, Solid State Lamps—Part II, General Electric Co., Nela Park, Cleveland, Ohio, Applications Manual 3-0121, 1970, p 25.


R6
+6V
12kΩ
LE
D7
LF
D8
R12
47kΩ
R20
X-output
100kΩ
R7
+6V
5.6kΩ
LD
D9
LE
D10
LF
D11
R13
22kΩ
D21
R14
47kΩ
100kΩ
R15
R16
15kΩ
TR2
R8
+6V
15kΩ
LF
D12
D13
+6V
R4
R3
+100V
R1
20kΩ
22kΩ
1.5kΩ
180nF
C
R5
10Ω
TR1
D6
D5
R2
1kΩ
LA
D1
LB
D2
LC
D3
clock
D4
+6V
D14
R9
15kΩ
D15
LF
D16
R17
27kΩ
R21
56kΩ
+6V
12kΩ
R10
LD
D17
R18
150kΩ
8
2
4
Y
6
1
3
5
7
X
+6V
R11
12kΩ
LD
D18
LE
D19
LF
D20
R19
90kΩ
R22
9.1kΩ
Y-output

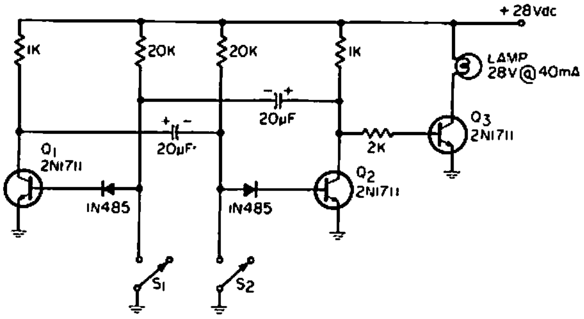
BAR MATRIX GENERATOR—Output of sawtooth generator (center) is selectively gated to X (top) and Y (bottom) deflection amplifiers of crt to repeatedly trace rectilinear figure 8 with decimal point slightly to its right, with beam being unblanked during sweep to display bars required to form desired numeral. All transistors are Philips BSX20 and diodes BAX13. Display shows four rows of 12 numerals each. Decimal point is formed by allowing beam to rest in fifth position of scan for period of 1 bar (32 μs). Field repetition frequency of 80 Hz eliminates flicker.—A. P. Tanis, Numerical Display with Bar Matrix Character Generator, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966–1967, p 73–83.


-E(-5V)
10K
10K
60f
5K
60pf
30K
D1
IN914
+E(+75)
120K
OUTPUT
Q1
2N2907
2N720A
Q2
IN914
10K
60pf
60pf
IN914
10K
(-5V)-E
10K
10K
-E(-5V)
-E(-5V)
0V
-E
CLOCK
R
CLOCK
S

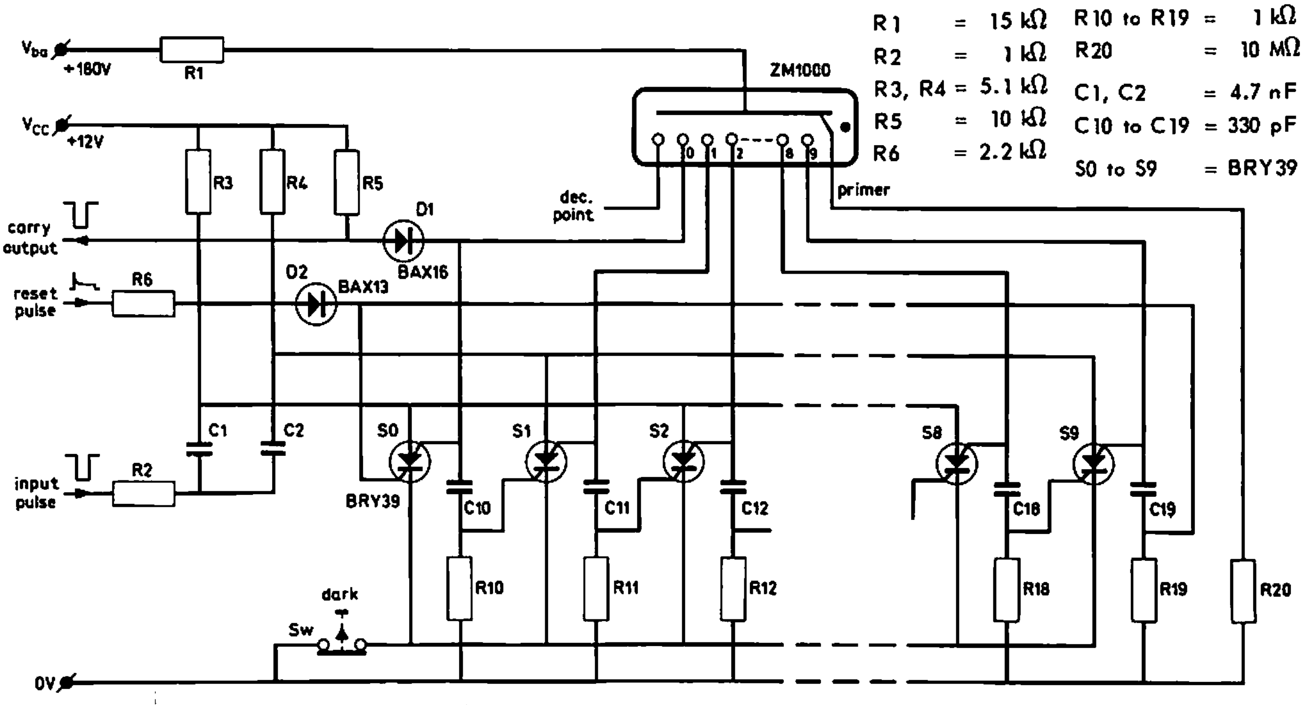
R-S FLIP-FLOP FOR NIXIE—When both transistors are on, output is −E (−5 V) and Nixie cathode is off. Circuits hold at this state until new information is received from external circuitry. Flip-flop thus serves both as driver and storage.—G. K. Kostopoulos, Nixie Driver Flip-Flop Also Stores Information, *Electronic Design*, Sept. 13, 1965, p 82.


95 TO 105V
DC FOR LATCHING
AC FOR NON-LATCHING
43K
150K
NE-81
3N85
+1V = ON
0 = OFF
INITIALLY
10K
X
INPUT
Y
Z
62K

PLANAR SCS DRIVES NEON—Gives high reliability and uniformity of operation at low cost. Immune to voltage transients.—Planar Silicon Controlled Switch 3N84/3N85, General Electric, Syracuse, N.Y., No. 65.18, 1964.

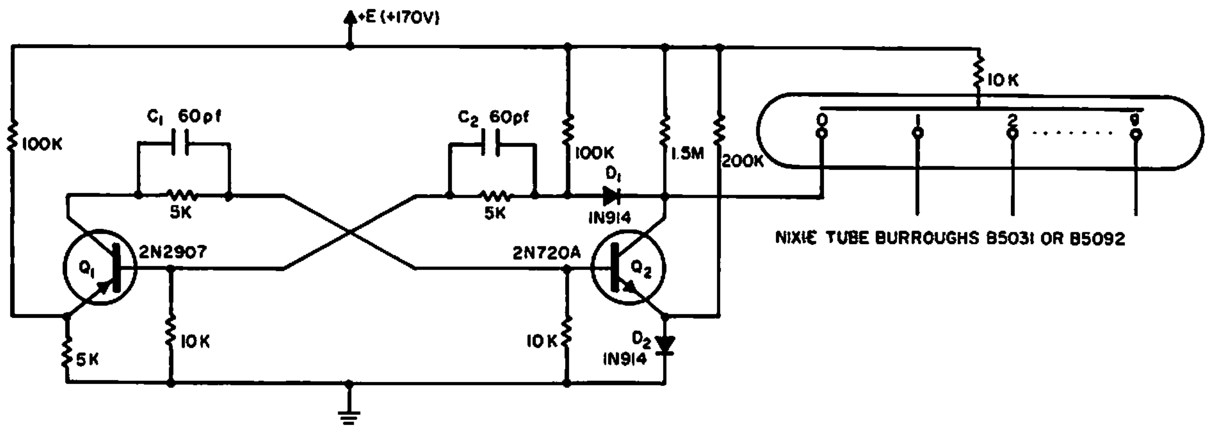

+28Vdc
1K
20K
20K
1K
LAMP
28V@40mA
20μF
20μF
Q1
2N1711
2K
Q3
2N1711
IN485
IN485
Q2
2N1711
S1
S2

THREE-MODE INDICATOR LAMP—With both switches open, Q1-Q2 form part of astable mvbr that makes lamp blink once per second. With S1 open and S2 closed, lamp stays on. With S1 closed and S2 open, lamp goes out. Transistors or relays may be used in place of switches.—P. E. Dingwell, Three-State Indicator, *EEE*, March 1967, p 166.

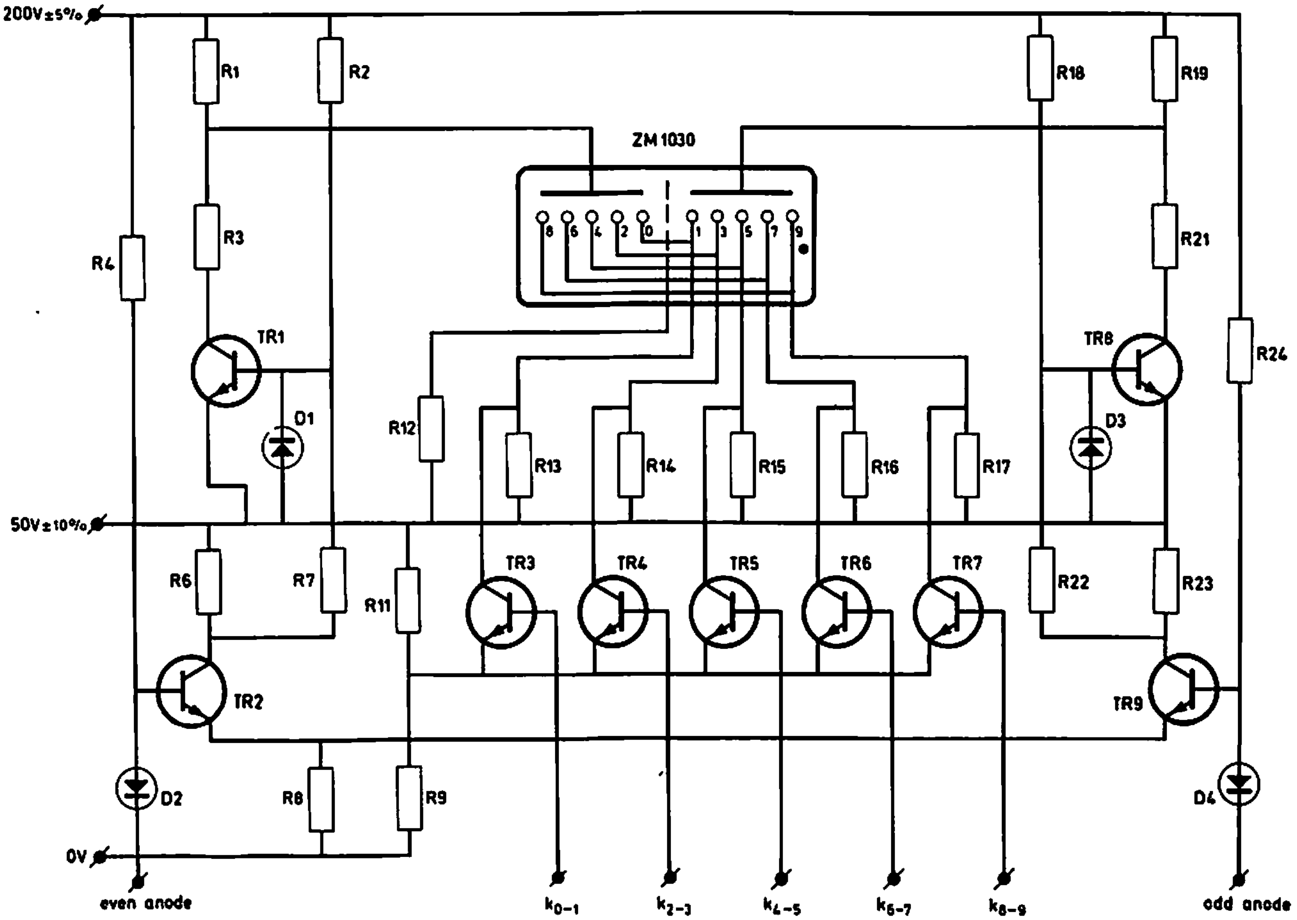

Vba
+180V
R1
ZM1000
Vcc
+12V
R3
R4
R5
0
1
2
8
9
dec. point
primer
carry output
D1
BAX16
reset pulse
R6
D2
BAX13
C1
C2
S0
S1
S2
S8
S9
input pulse
R2
BRY39
C10
C11
C12
C18
C19
R10
R11
R12
R18
R19
R20
dark
Sw
0V

R1 = 15 kΩ
R2 = 1 kΩ
R3, R4 = 5.1 kΩ
R5 = 10 kΩ
R6 = 2.2 kΩ
R10 to R19 = 1 kΩ
R20 = 10 MΩ
C1, C2 = 4.7 nF
C10 to C19 = 330 pF
S0 to S9 = BRY39

MULTI-DIGIT DISPLAY—Uses scs ring counter to provide static display on several numerical indicator tubes, with final count being held after train of counting pulses is terminated. When ring counter goes from position 9 back to 0, carry pulse is produced to drive identically designed succeeding display stage. Maximum count rate is 40 kHz.—D. J. G. Janssen, A. G. Korteling, and P. H. G. van Vlodrop, Cold Cathode Numerical Indicator Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 327, 1968.


+E (+170V)
100K
C1 60pf
5K
C2 60pf
5K
100K
D1
1N914
1.5M
200K
10K
0
1
2
9
NIXIE TUBE BURROUGHS B5031 OR B5092
Q1
2N2907
2N720A
Q2
10K
10K
5K
D2
1N914

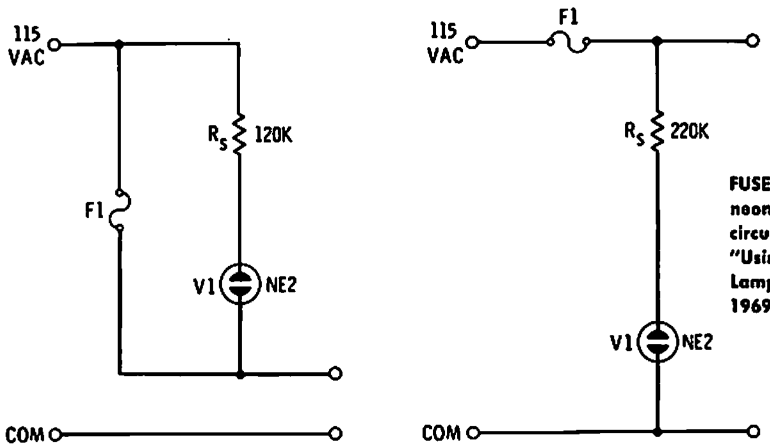
FLIP-FLOP STORAGE DRIVES NIXIE—Circuit shown drives one Nixie cathode and holds until new information is received from external circuitry. Power dissipation is very low. Both transistors are either on or off; when on, output voltage to cathode of Nixie is +1 V, and Nixie is on.—G. K. Kostopoulos, Nixie Driver Flip-Flop Also Stores Information, *Electronic Design*, Sept. 13, 1965, p 82.


200V±5%
50V±10%
0V
ZM1030
8
6
4
2
0
1
3
5
7
9
R1
R2
R3
R4
R6
R7
R8
R9
R11
R12
R13
R14
R15
R16
R17
R18
R19
R21
R22
R23
R24
TR1
TR2
TR3
TR4
TR5
TR6
TR7
TR8
TR9
D1
D2
D3
D4
even anode
k_{0-1}
k_{2-3}
k_{4-5}
k_{6-7}
k_{8-9}
odd anode

R1 = 15 kΩ
R2 = 270 kΩ
R3 = 6.8 kΩ
R4 = 750 kΩ
R6 = 15 kΩ
R7 = 47 kΩ
R8 = 330 kΩ
R11 = 470 kΩ

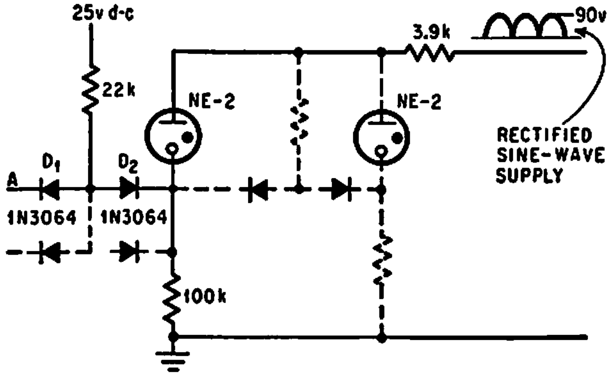
R12 = 10 kΩ
R13 to R17 = 100 kΩ
R18 = 270 kΩ
R19 = 15 kΩ
R21 = 6.8 kΩ
R22 = 47 kΩ
R23 = 15 kΩ
R24 = 750 kΩ

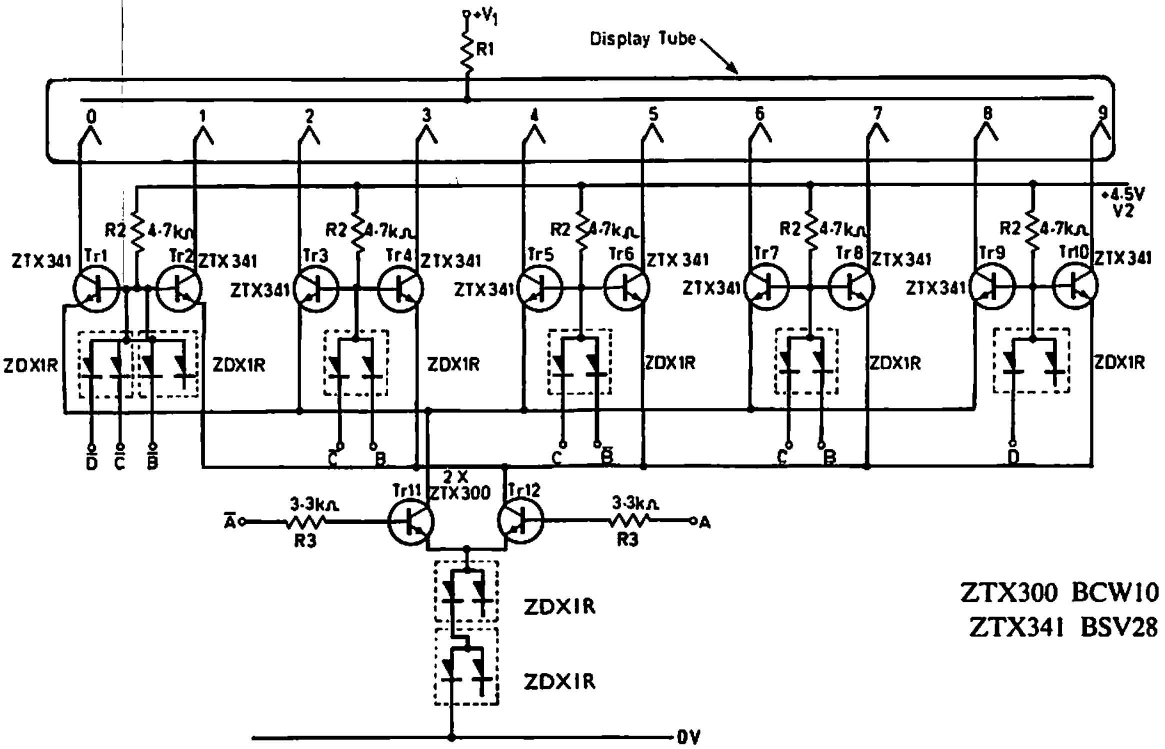
BIQUINARY INDICATOR DRIVE—Uses levels of 3 V for conducting anode and 0 V for nonconducting anode, corresponding to "1" and "0" signals respectively. With "1" at "even" anode terminal, TR2 will be bottomed and base of TR1 pulled negative to cut it off. Simultaneously, "0" is applied at "odd" anode input, to cut off TR9 and make TR8 conducting. Now, if one of the cathode switches TR3 to TR7 is made conducting, an "even" anode ignites and an "even" numeral is illuminated on display. R9 is VDR.—D. J. G. Janssen, A. G. Korteling, and P. H. G. van Vledrop, Cold Cathode Numerical Indicator Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 327, 1968.


115 VAC
F1
R_S 120K
V1
NE2
COM
115 VAC
F1
R_S 220K
V1
NE2
COM

FUSE-CONDITION INDICATORS—Glowing neon lamp indicates either blown fuse in first circuit or good fuse in second.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 23.

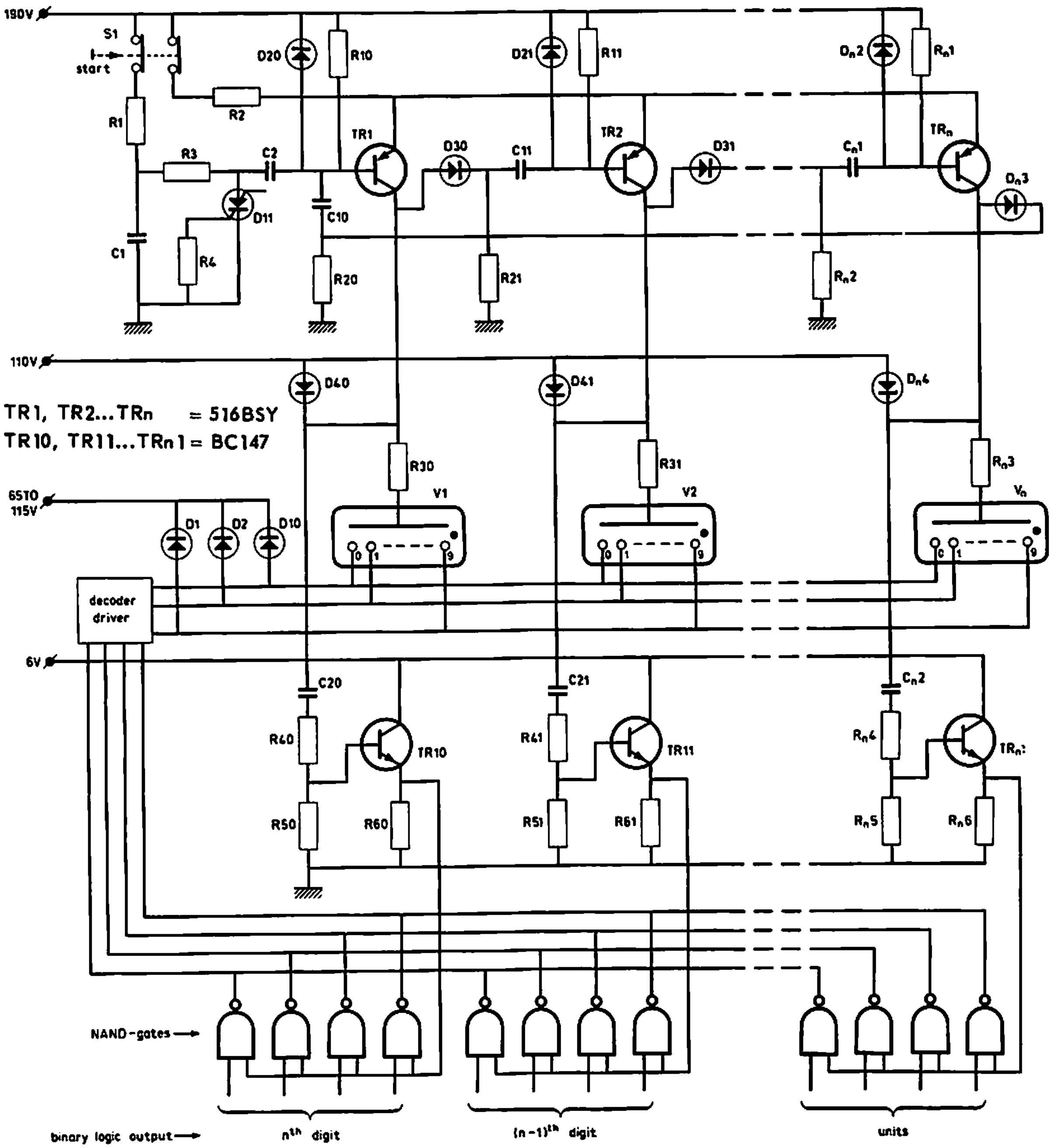
DIODES FOR NEON LAMP—Two inexpensive diodes replace costly high-voltage transistor for switching neon lamp on and off. Dashed connections show how additional lamps can be connected in parallel and operated from same supply. Diodes are part of logic circuit producing decimal readout for time and frequency meter. To hold lamp off, point A is connected directly to 25-V supply; lamp comes on when point A is grounded to raise lamp voltage above 75-V minimum for firing. While lighted, lamp turns on and off 120 times a second but flicker is not noticeable. In decimal readout, D1 is arm of AND gate, and D2 is arm of OR gate.—C. J. Ulrick, Diodes Reduce Cost of Switching Neon Lamps, *Electronics*, Feb. 6, 1967, p 70.


25v d-c
22k
NE-2
NE-2
3.9k
90v
RECTIFIED SINE-WAVE SUPPLY
A
D_1
D_2
1N3064
1N3064
100k


+V_1
R1
Display Tube
0
1
2
3
4
5
6
7
8
9
+4.5V
V2
R2 4·7kΩ
Tr1
Tr2
Tr3
Tr4
Tr5
Tr6
Tr7
Tr8
Tr9
Tr10
ZTX341
ZDX1R
D
C
B
2 X ZTX300
Tr11
Tr12
3·3kΩ
R3
$\bar{A}$
A
0V

ZTX300 BCW10
ZTX341 BSV28

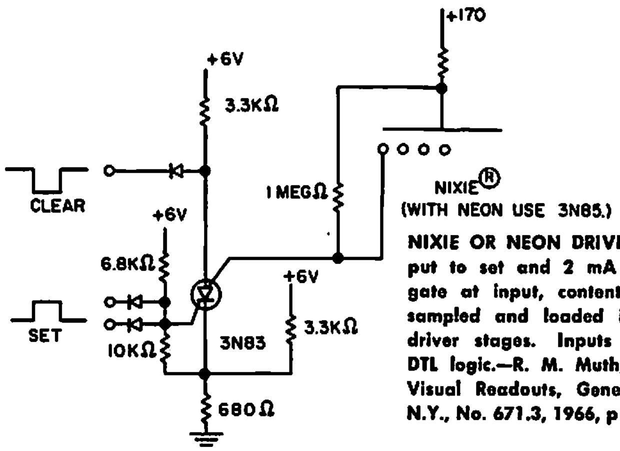
NIXIE DECODER AND DRIVER—Circuit accepts 8-line logical input in 8-4-2-1 binary coded decimal and decodes it to obtain decimal equivalent for energizing appropriate digit from 0 to 9 stacked together as cathodes of gas-filled indicator tube. Uses two stages of selection, based on fact that if least significant digit is eliminated, pairs of odd and even numbers share same logic. First selection stage decides into which of five pairs required number falls, and second stage decides whether number is odd or even. Only one output can satisfy both conditions.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 52.


180V
S1
start
R1
R2
R3
C2
C1
R4
D11
D20
R10
TR1
C10
R20
D30
C11
D21
R11
TR2
R21
D31
D_n2
R_n1
C_n1
TR_n
D_n3
R_n2
110V
D40
D41
D_n4
TR1, TR2...TRn = 516BSY
TR10, TR11...TRn1 = BC147
R30
R31
R_n3
V1
V2
V_n
0 1 9
6510
115V
D1
D2
D10
decoder driver
6V
C20
C21
C_n2
R40
R41
R_n4
TR10
TR11
TR_n1
R50
R60
R51
R61
R_n5
R_n6
NAND-gates
binary logic output
n^{th} digit
$(n-1)^{th}$ digit
units

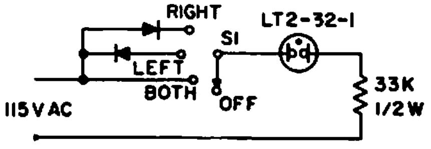
R1 = 1 MΩ
R2 = 270 Ω
R3 = 270 Ω
R4 = 10 kΩ
R10, R11...Rn1 = 10 kΩ
R20, R21...Rn2 = 150 kΩ
R30, R31...Rn3 = 3.3 kΩ
R40, R41...Rn4 = 100 kΩ
R50, R51...Rn5 = 10 kΩ
R60, R61...Rn6 = 100 Ω

C1 = 100 nF
C2 = 33 pF
C10, C11...Cn1 = 1 nF
C20, C21...Cn2 = 10 nF
D1, D2...D10 = BAX16
D11 BRY39
D20, D21...Dn2 = BAX16
D30, D30...Dn3 = BAX16
D40, D41...Dn4 = BAX16

SELF-EXCITED DYNAMIC DRIVE FOR INDICATORS—Circuit is designed to display information presented to all digital inputs in parallel. After operation of start switch, anode switches TR1 through TRn are activated in turn in continuous cyclical order to provide scanning of binary information supplied to NAND gates.—D. J. G. Janssen, A. G. Korteling, and P. H. G. van Vlodrop, Cold Cathode Numerical Indicator Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 327, 1968.

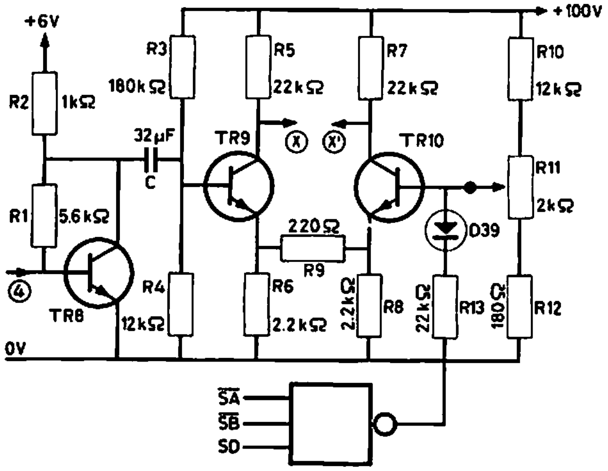

+170
+6V
3.3KΩ
CLEAR
1 MEGΩ
NIXIE®
(WITH NEON USE 3N85.)
+6V
6.8KΩ
+6V
SET
10KΩ
3N83
3.3KΩ
680Ω

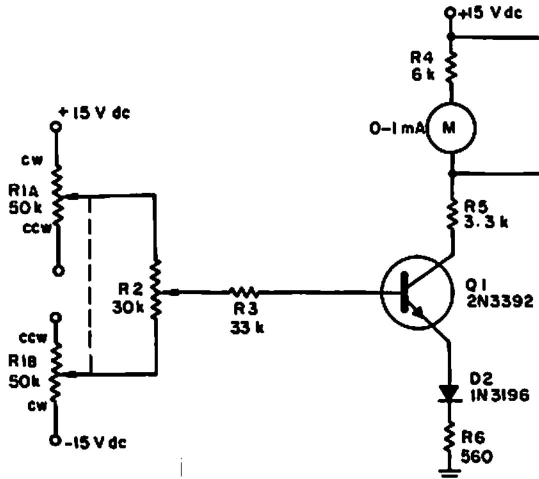
NIXIE OR NEON DRIVER—Requires 1 mA input to set and 2 mA to clear. With AND gate at input, contents of register can be sampled and loaded into series of similar driver stages. Inputs are compatible with DTL logic.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 11.


RIGHT
LT2-32-1
S1
LEFT
BOTH
OFF
115 VAC
33K
1/2W

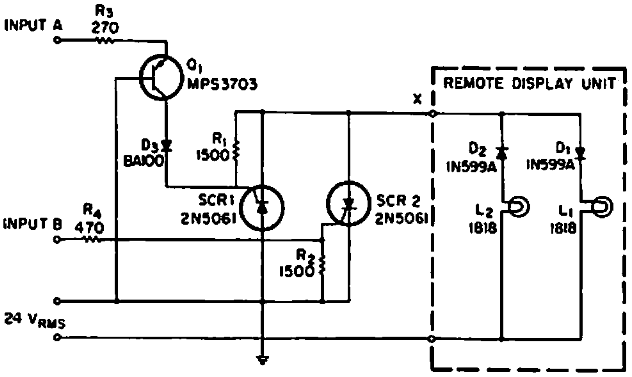
FOUR-CONDITION INDICATOR—Uses single neon lamp. By switching S1, either right, left, none, or both electrodes of lamp may be activated.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 149.

X AMPLIFIER FOR NUMERICAL DISPLAY—Differential output stage is fed by preamp to which deflection signals from bar matrix generator and column or row selector are applied. NAND gate connected to base of TR10 centers numeral 1 in its space. TR8 is BSX20, TR9 and TR10 are BSX21, and diode is BAX13.—A. P. Tanis, Numerical Display with Bar Matrix Character Generator, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966–1967, p 73–83.

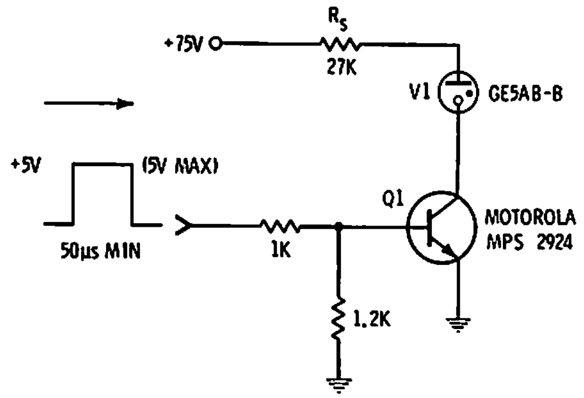

+6V
+100V
R3
180kΩ
R5
22kΩ
R7
22kΩ
R10
12kΩ
R2
1kΩ
32μF
C
TR9
X
X'
TR10
R11
2kΩ
R1
5.6kΩ
220Ω
R9
D39
4
TR8
R4
12kΩ
R6
2.2kΩ
2.2kΩ
R8
22kΩ
R13
180Ω
R12
0V
SA
SB
SD


+15 Vdc
R4
6k
D1
1N1520
5.6V
0–1 mA
M
+15 V dc
CW
R1A
50k
CCW
R5
3.3k
R2
30k
R3
33k
Q1
2N3392
CCW
R1B
50k
CW
D2
1N3196
-15 Vdc
R6
560

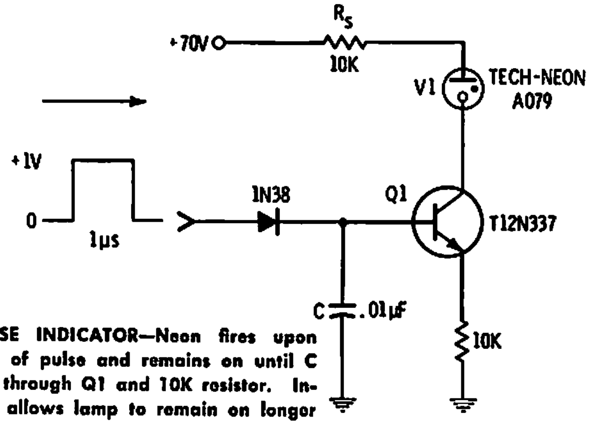
POT POSITION DISPLAY—Simple transistor amplifier for meter provides accurate display of potentiometer position on meter. D1 protects meter against large position changes. Dual pot permits setting electrical zero at any potentiometer position.—R. M. Reinking and D. R. McCusker, Simple Circuit Solves Position Display Problem, *Electronic Design*, Nov. 8, 1967, p 122.


INPUT A
R3
270
Q1
MPS3703
REMOTE DISPLAY UNIT
X
D3
BA100
R1
1500
D2
1N599A
D1
1N599A
SCR1
2N5061
SCR 2
2N5061
L2
1818
L1
1818
INPUT B
R4
470
R2
1500
24 VRMS

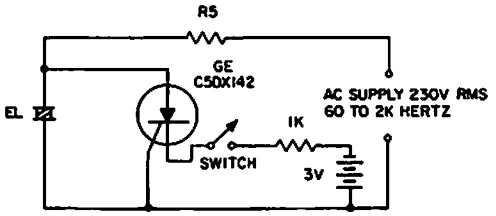
REMOTE LAMP DRIVER—Circuit minimizes number of lines to remote lamp displays. Diodes in series with lamps, connected with opposite polarity, and scr's similarly connected with opposite polarity at source cut number of lines to one for every two lamps, plus one common line. Inputs are compatible with Motorola MRTL logic. 24-V lamps are required for long life, because half-cycles from 24-V source heat filaments of 14.4-V lamps excessively and shorten life.—W. Lindenbach, Lamp Driver Minimizes Lines to Remote Display Unit, *EEE*, Dec. 1969, p 91–92.


+75V
R_S
27K
V1
GE5AB-B
+5V
(5V MAX)
50μs MIN
1K
Q1
MOTOROLA
MPS 2924
1.2K

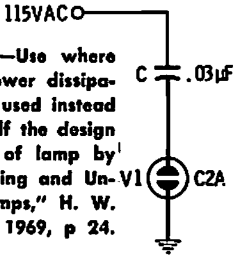
TRANSISTOR-OPERATED INDICATOR—Neon fires upon application of voltage pulse. 1.2K resistor prevents false starting by minimizing leakage effects.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 22.


+70V
R_S
10K
V1
TECH-NEON
A079
+1V
0
1μs
1N38
Q1
T12N337
C
.01μF
10K

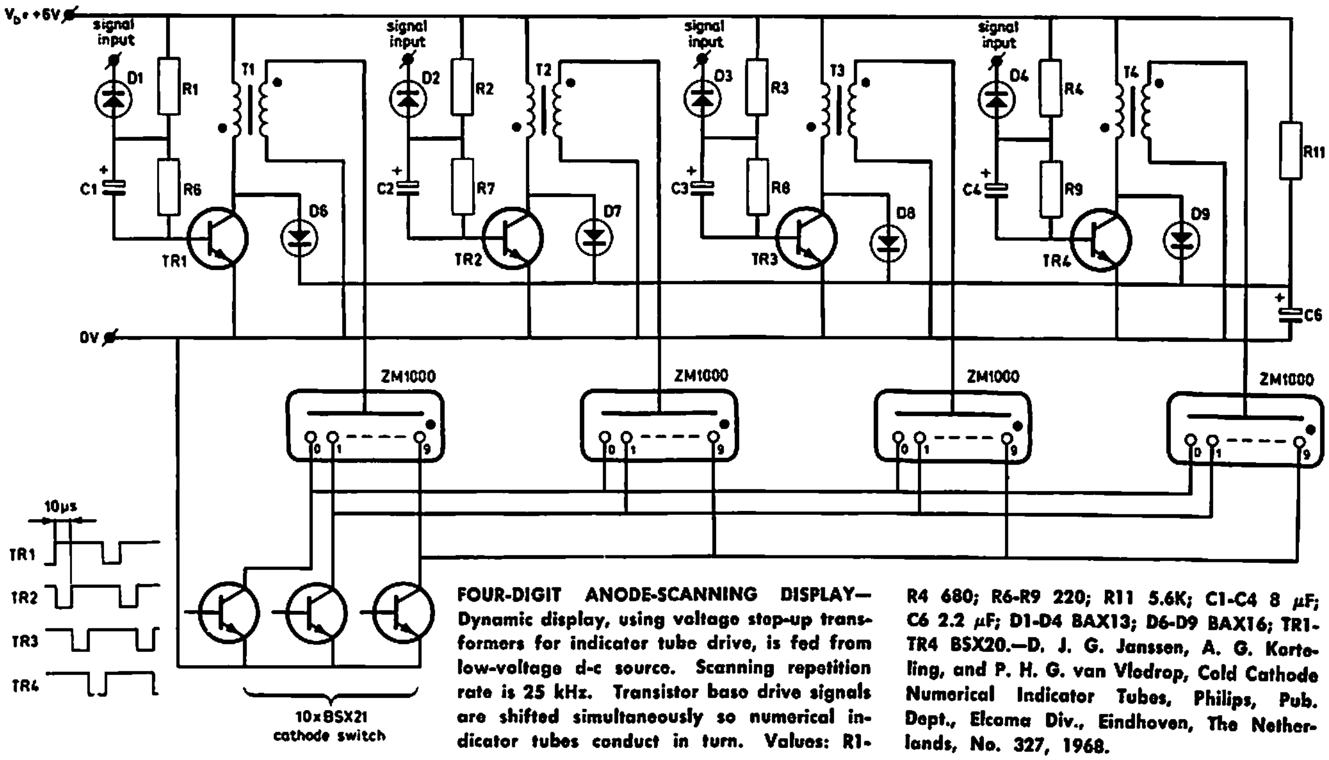
SHORT-PULSE INDICATOR—Neon fires upon application of pulse and remains on until C discharges through Q1 and 10K resistor. Increasing C allows lamp to remain on longer but decreases input sensitivity of circuit.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 22.


R5
GE
C50X142
EL
AC SUPPLY 230V RMS
60 TO 2K HERTZ
1K
SWITCH
3V

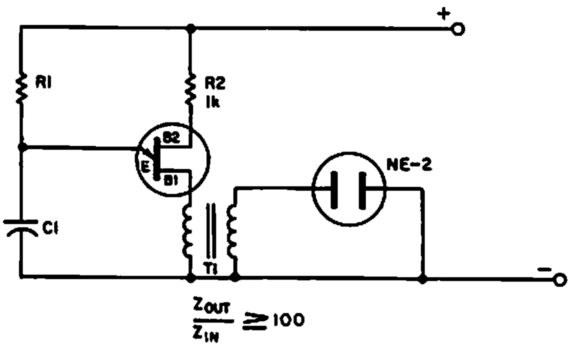
SHUNT DRIVE FOR EL PANEL—Electroluminescent display is on when switch is open (no 3-V control signal).—"SCR Manual," 4th Edition, General Electric, 1967, p 171.


115VAC
C
.03μF
V1
C2A

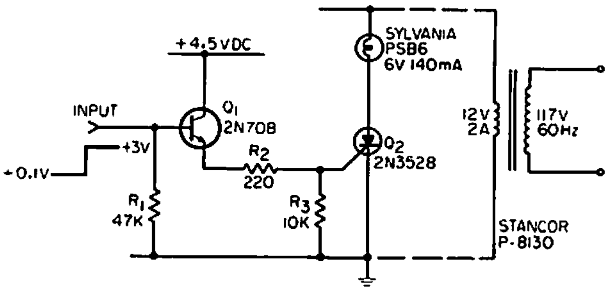
ONE-MILLION-HOUR INDICATOR—Use where extremely long life and low power dissipation are required. Capacitor is used instead of resistor to limit current to half the design current, thereby increasing life of lamp by factor of 64.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 24.


V_b = +6V
signal input
D1
R1
T1
C1
R6
TR1
D6
signal input
D2
R2
T2
C2
R7
TR2
D7
signal input
D3
R3
T3
C3
R8
TR3
D8
signal input
D4
R4
T4
C4
R9
TR4
D9
R11
C6
0V
ZM1000
ZM1000
ZM1000
ZM1000
0
1
9
10μs
TR1
TR2
TR3
TR4
10×BSX21
cathode switch

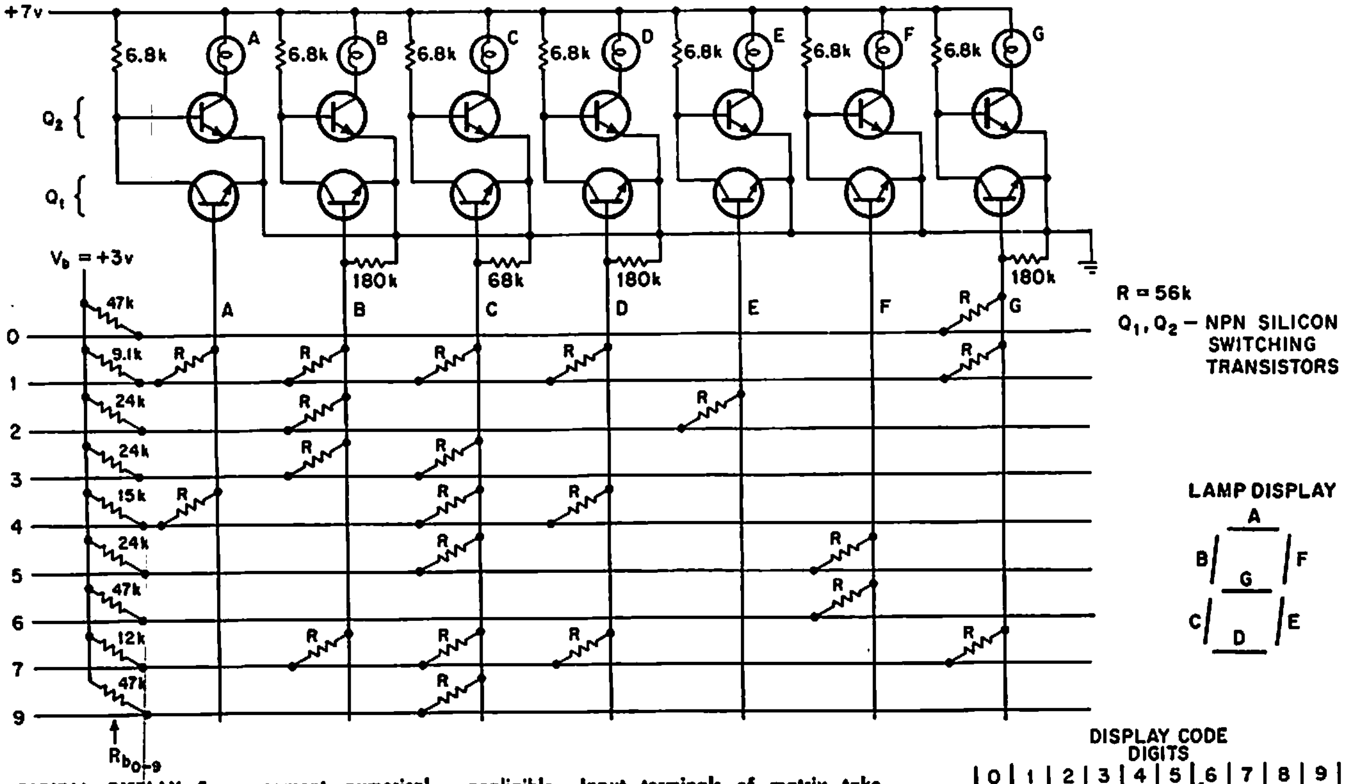
FOUR-DIGIT ANODE-SCANNING DISPLAY—Dynamic display, using voltage step-up transformers for indicator tube drive, is fed from low-voltage d-c source. Scanning repetition rate is 25 kHz. Transistor base drive signals are shifted simultaneously so numerical indicator tubes conduct in turn. Values: R1-R4 680; R6-R9 220; R11 5.6K; C1-C4 8 μF; C6 2.2 μF; D1-D4 BAX13; D6-D9 BAX16; TR1-TR4 BSX20.—D. J. G. Janssen, A. G. Korteling, and P. H. G. van Vledrop, Cold Cathode Numerical Indicator Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 327, 1968.


+
R1
R2
1k
B2
E
B1
C1
T1
NE-2
−
$\frac{Z_{OUT}}{Z_{IN}} \geq 100$

OPERATING NEON ON 1.5 V—Ujt oscillator and transformer step up battery supply voltage to that required for driving neon power-on indicator, for use in battery-operated equipment where power drawn by incandescent pilot lamp is more than that drawn by circuitry itself. By keeping frequency and duty cycle low to give flashing indication, power consumption is further reduced. Almost any ujt may be used for 6 to 40 V, but 2N2840 should be used if supply is single 1.5-V cell. Choose R1 and C1 to give desired frequency.—L. Toth, Circuit Powers Neon Lamps from Low-Voltage Sources, *Electronic Design*, May 10, 1969, p 136.


+4.5VDC
SYLVANIA
PSB6
6V 140mA
INPUT
+3V
+0.1V
Q1
2N708
R2
220
R1
47K
R3
10K
Q2
2N3528
12V
2A
117V
60Hz
STANCOR
P-8130

BINARY STATE INDICATOR—High input of 3 V for logical 1 makes scr conduct on each positive half-cycle of a-c line and keep lamp on for as long as input is at high level. Low input of 0.1 V for logical 0 will not trigger scr and lamp will not light. Low input current requirement of about 0.2 mA makes circuit excellent as readout for integrated circuits. Transformer specified can drive up to 14 identical readouts.—P. Galluzzi, Readout Circuit for Digital ICs, *EEE*, Jan. 1967, p 115.


+7v
6.8k
A
B
C
D
E
F
G
Q2
Q1
$V_b = +3v$
47k
9.1k
24k
24k
15k
24k
47k
12k
47k
R
180k
68k
180k
180k
0
1
2
3
4
5
6
7
9
$R_{b_{0-9}}$
R = 56k
Q_1, Q_2 – NPN SILICON SWITCHING TRANSISTORS
LAMP DISPLAY

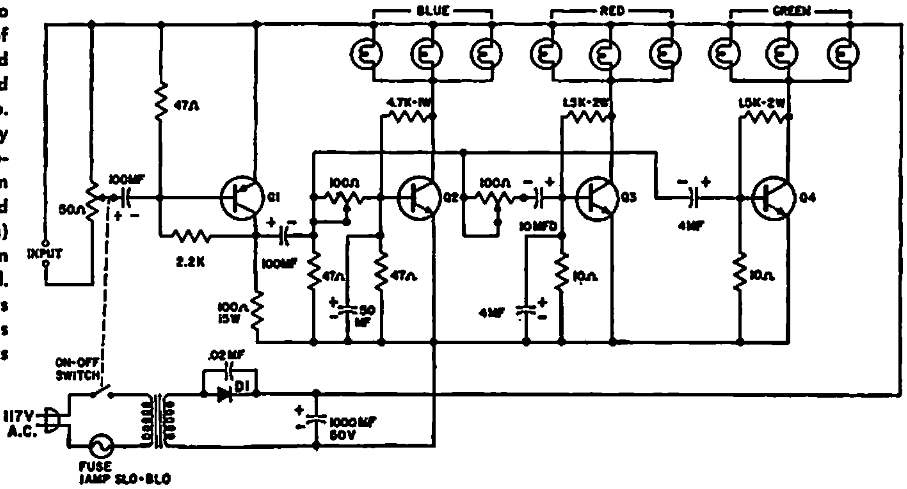
DISPLAY CODE

LAMPS	DIGITS 0	1	2	3	4	5	6	7	8	9
A		X			X					
B		X	X	X				X		
C		X		X	X	X		X		X
D		X			X			X		
E			X							
F						X	X			
G	X	X						X		

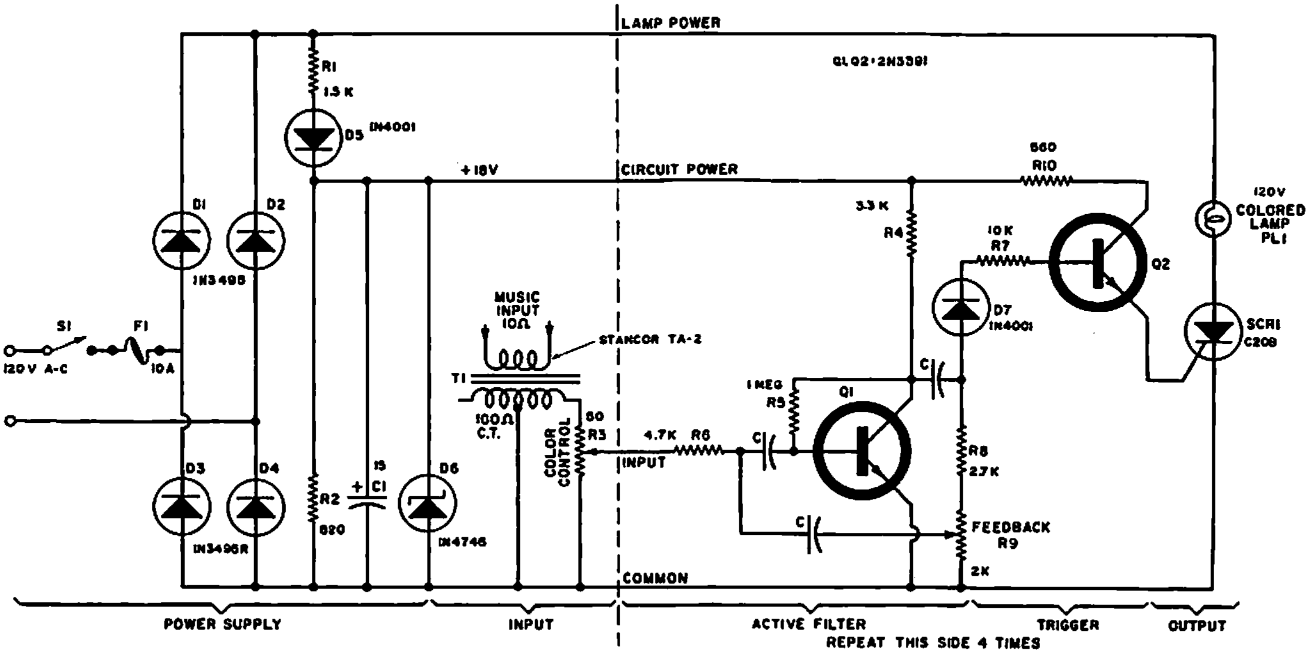
DIGITAL DISPLAY—Seven-segment numerical display uses 21-resistor matrix and gives greater reliability than more costly 49-diode conventional matrix. All lamps glow when there is no input. Desired digit is obtained by turning off unwanted lamps. Use of high-value resistors makes current delivered to undesired transistors small enough to be negligible. Input terminals of matrix take signals from decoder that converts bcd output of binary counter into decimal numbers. Numeral 8 is formed when all lamps are on, so no input terminal is needed for it.—R. K. Sharma, Resistors Come to Light in Digital Display System, *Electronics*, Jan. 5, 1970, p 97–98.

CHAPTER 27

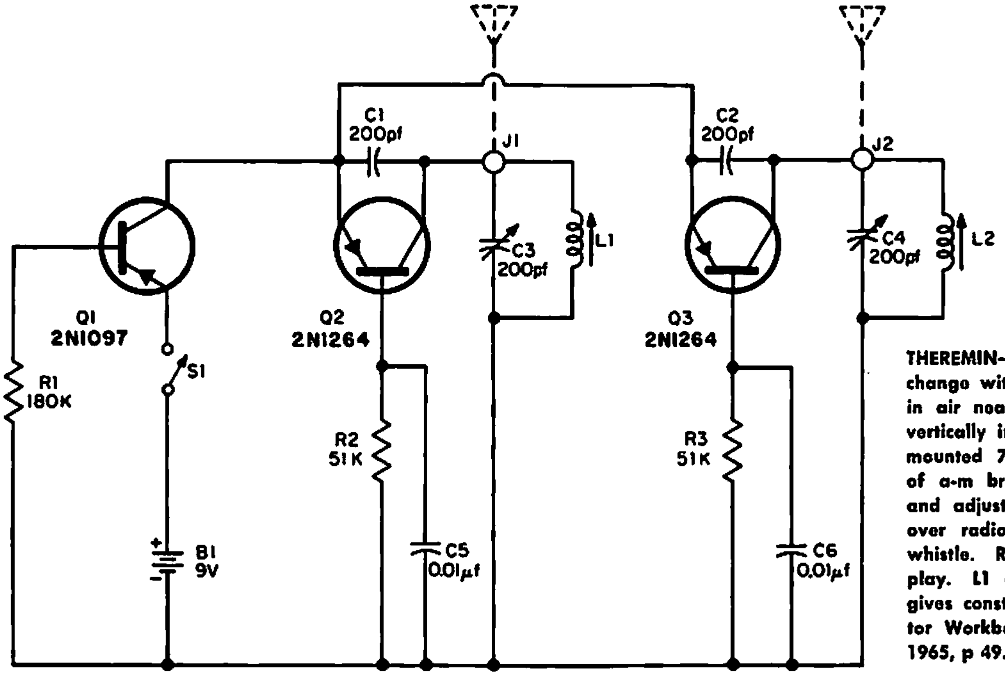
Electronic Music Circuits


BLUE
RED
GREEN
47Ω
4.7K-1W
1.5K-2W
1.0K-2W
100MF
+ -
50Ω
Q1
100Ω
Q2
100Ω
- +
Q3
- +
Q4
INPUT
2.2K
100MF
+ -
47Ω
47Ω
10MFD
10Ω
4MF
10Ω
100Ω
15W
+ -
50 MF
4MF
+ -
ON-OFF
SWITCH
.02MF
D1
117V
A.C.
+ -
1000MF
50V
FUSE
1AMP SLO-BLO

PSYCHEDELIC DISPLAY—When connected to hi-fi speaker, circuit activates three sets of colored lamps in accordance with volume and frequency of sound, to give multicolored display changing in time to music. Uses No. 93 12-V 1-A automotive lamps permanently colored by manufacturer; blue is for low frequencies, red for mid-frequencies, and green for highs. Six additional No. 1488 colored lamps rated 12 V at 150 mA (not shown) are used at sides and corners of aluminum reflector behind translucent plastic panel. Used in Eico Model 3440 kit. Pots in inputs of two channels permit changing patterns as desired.—New Color-Organ Kit, *Electronics World*, May 1969, p 80.

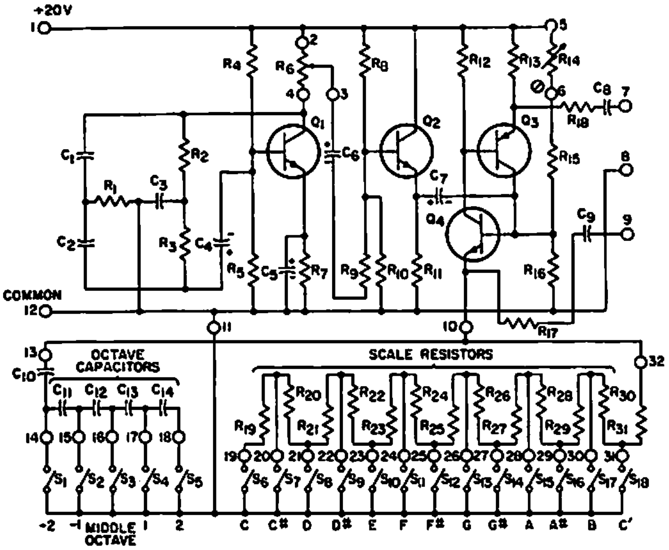

LAMP POWER
Q1,Q2 = 2N3391
R1
1.5 K
D5 1N4001
+18V
CIRCUIT POWER
560
R10
120V
COLORED
LAMP
PL1
D1
D2
1N3498
3.3 K
R4
10 K
R7
Q2
D7
1N4001
MUSIC
INPUT
10Ω
STANCOR TA-2
S1
F1
120V A-C
10A
SCR1
C20B
T1
1 MEG
R5
Q1
C
C
100Ω
C.T.
COLOR
CONTROL
50
R3
4.7K R6
INPUT
R8
2.7K
D3
D4
R2
820
15
+ C1
D6
1N3498R
1N4746
C
FEEDBACK
R9
2K
COMMON
POWER SUPPLY
INPUT
ACTIVE FILTER
TRIGGER
OUTPUT
REPEAT THIS SIDE 4 TIMES

COLOR ORGAN—Music input is divided into four frequency bands by four active filters, each amplifying one frequency band much more than others. Each channel can drive up to 625-W lamp load, to give total of 2,500 W illumination in four different colors that change dynamically with musical tones even at low levels. Values of C in μF are 0.1 for green channel (lows), 0.047 for blue, 0.022 for red, and 0.01 for yellow (highs). R3 widens filter bandwidth to give effect of color blending.—J. M. Powell, A New Approach to Color-Organ Design, *Electronics World*, Jan. 1969, p 39 and 61.

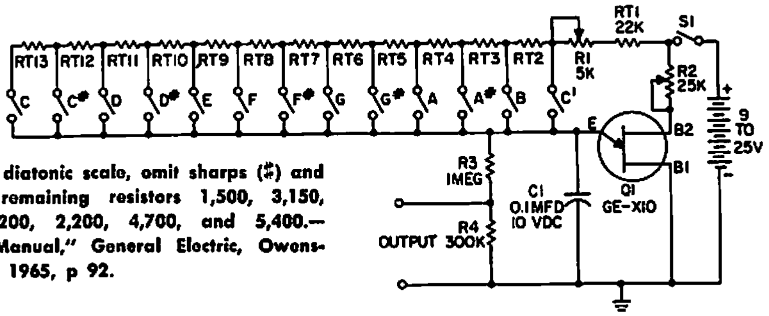

C1
200pf
J1
C2
200pf
J2
C3
200pf
L1
C4
200pf
L2
Q1
2N1097
Q2
2N1264
Q3
2N1264
S1
R1
180K
R2
51K
R3
51K
B1
9V
C5
0.01μf
C6
0.01μf

THEREMIN—Produces wailing sounds that change with frequency as hands are moved in air near 38-inch whip antennas inserted vertically in 5-way binding posts J1 and J2 mounted 7 inches apart. Place near back of a-m broadcast radio tuned to midband and adjust C3 until hissing sound is heard over radio, then adjust C4 for very loud whistle. Readjust C3 for lowest pitch, then play. L1 and L2 are vari-loopsticks. Book gives construction data.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 49.

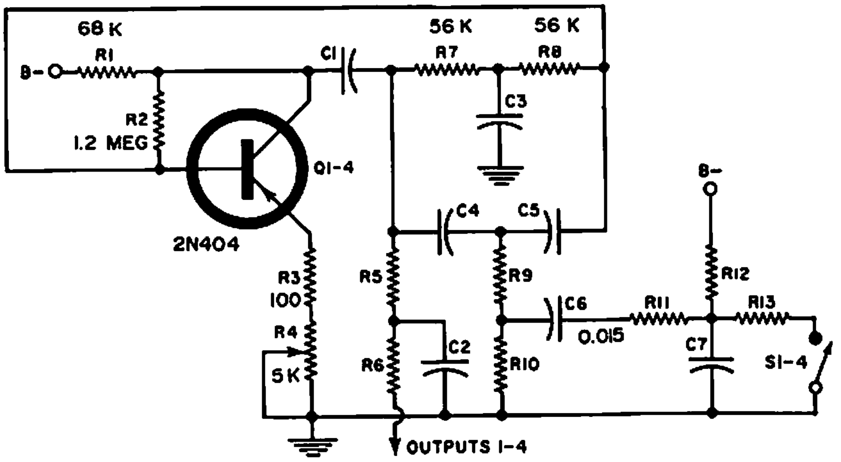
SINGLE-VOICE ORGAN—Basic tones are formed by clock oscillator Q3-Q4, with output being frequency-modulated by applying very low frequency sine-wave output of Q1 to base of Q4 and collector of Q3. Values shown give tremolo of about 6 Hz. Series-connected resistors R19-R31 provide chromatic scale, and five series capacitors permit keying up or down two octaves from middle octave. Sawtooth output at terminal 9 and pulse output at terminal 7 are fed to external mixer for changing character of tones before feeding audio power amplifier.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p. 106.


+20V
1
2
3
4
5
6
7
8
9
10
11
COMMON
12
13
32
Q1
Q2
Q3
Q4
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
OCTAVE CAPACITORS
C11 C12 C13 C14
14 15 16 17 18
S1 S2 S3 S4 S5
SCALE RESISTORS
R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R30 R31
19 20 21 22 23 24 25 26 27 28 29 30 31
S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18
-2 -1 MIDDLE OCTAVE 1 2
C C# D D# E F F# G G# A A# B C'

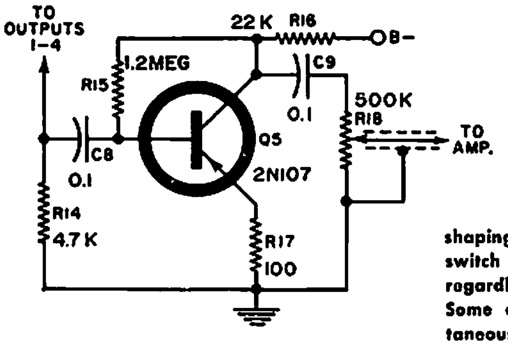
C_1 C_2 = 0.22 microfarad, 25 volts or greater, paper
C_3 C_{10} C_{11} = 0.5 microfarad, 25 volts or greater, paper
C_4 = 50 microfarads, 15 volts, electrolytic
C_5 = 100 microfarads, 6 volts, electrolytic
C_6 C_7 = 4 microfarads, 25 volts, electrolytic
C_8 C_9 = 0.1 microfarad, 25 volts or greater
C_{12} = 0.25 microfarad, 25 volts or greater
C_{13} = 0.12 microfarad and 0.005 microfarad in parallel, 25 volts or greater
C_{14} = 0.056 microfarad and 0.0068 microfarad in parallel, 25 volts or greater
Q_1 Q_2 Q_4 = transistor, RCA SK3020
Q_3 = transistor, RCA SK3005
R_1 = 33,000 ohms, 1/2 watt, 10%
R_2 R_3 = 220,000 ohms, 1/2 watt, 10%
R_4 R_8 = 330,000 ohms, 1/2 watt, 10%
R_5 R_{18} = 100,000 ohms, 1/2 watt, 10%
R_6 = potentiometer, 10,000 ohms, linear taper
R_7 = 3300 ohms, 1/2 watt 10%
R_9 = 270,000 ohms, 1/2 watt, 10%
R_{10} = 180,000 ohms, 1/2 watt, 10%
R_{11} R_{21} R_{22} = 1000 ohms, 1/2 watt, 10%
R_{12} = 1500 ohms, 1/2 watt, 10%
R_{13} = 180 ohms, 1/2 watt, 10%
R_{14} = potentiometer, 1000 ohms, linear taper
R_{15} = 1200 ohms, 1/2 watt, 10%
R_{16} = 470 ohms, 1/2 watt, 10%
R_{17} = 2.2 megohms, 1/2 watt, 10%
R_{19} R_{20} = 1100 ohms, 1/2 watt, 5%
R_{23} R_{24} = 910 ohms, 1/2 watt, 5%
R_{25} R_{26} = 820 ohms, 1/2 watt, 10%
R_{27} = 750 ohms, 1/2 watt, 5%
R_{28} R_{29} = 680 ohms, 1/2 watt, 10%
R_{30} = 620 ohms, 1/2 watt, 10%
R_{31} = 10,000 ohms, 1/2 watt, 10%

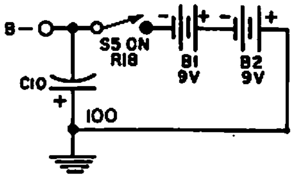

RT13
RT12
RT11
RT10
RT9
RT8
RT7
RT6
RT5
RT4
RT3
RT2
RT1
22K
S1
R1
5K
R2
25K
C
C#
D
D#
E
F
F#
G
G#
A
A#
B
C'
E
B2
B1
9
TO
25V
R3
1MEG
C1
0.1MFD
10 VDC
Q1
GE-X10
R4
OUTPUT 300K

UJT CHROMATIC-SCALE ORGAN—Gives full octave of sharp sawtooth tones that can be shaped or voiced at output, under control of 13 keys. Octave can be moved up or down with R2 from 130.81 Hz (C below middle C) to 1,046.05 Hz (C above middle C). Values in ohms of RT2 through RT13 for chromatic scale are 1,500 (B), 1,500, 1,650, 1,800, 1,800, 2,000, 2,200, 2,247, 2,470, 2,470, and 3,000 (C). R1 serves for initial calibration. For 8-key diatonic scale, omit sharps (♯) and use for remaining resistors 1,500, 3,150, 3,300, 4,200, 2,200, 4,700, and 5,400.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 92.

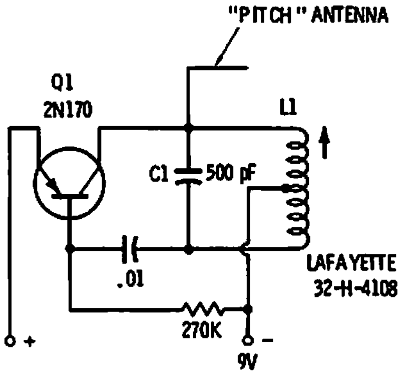

68 K
R1
B-
R2
1.2 MEG
Q1-4
2N404
C1
56 K
R7
56 K
R8
C3
C4
C5
R3
100
R4
5K
R5
R6
C2
R9
R10
C6
0.015
R11
B-
R12
R13
C7
S1-4
OUTPUTS 1-4

	DRUM	TOM-TOM	BONGO	BLOCKS
R5—	22,000	82,000	82,000	330,000
R6—	10,000	82,000	82,000	(Not used)
R9—	2700	6800	6800	6800
R10—	2200	2200	2200	2200
R11—	82,000	22,000	27,000	(Not used)
R12—	1 meg	0.56 meg	1 meg	1 meg
R13—	2700	2700	2700	6800
(Note: All resistors are ½ watt, 10%.)				
C1—	.1	.047	.047	.047
C2—	.1	.01	.01	(Not used)
C3—	.1	.047	.033	.01
C4—	.1	.027	.015	.0033
C5—	.1	.027	.015	.0033
C7—	.1	.1	.01	.1

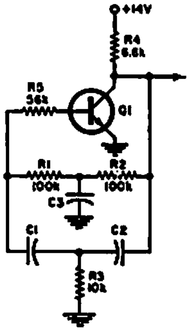

TO
OUTPUTS
1-4
22 K R16
B-
R15
1.2MEG
C9
0.1
500K
R18
TO
AMP.
C8
0.1
Q5
2N107
R14
4.7 K
R17
100


B-
S5 ON
R18
B1
9V
B2
9V
C10
100

DRUM, TOM-TOM, BONGO, BLOCKS—Uses four identical one-shot twin-T oscillators, each with its own frequency-determining and shaping circuit (Q1-Q4). Pressing pushbutton switch for desired instrument gives one beat regardless of how long button is held down. Some or all buttons can be pressed simultaneously. Preamp Q5 permits use of instrument with almost any audio system.—C. Muller, Electronic Percussion Instruments, *Electronics World*, Feb. 1967, p 36–37.


"PITCH" ANTENNA
Q1
2N170
L1
C1
500 pF
.01
LAFAYETTE
32-H-4108
270K
+
-
9V

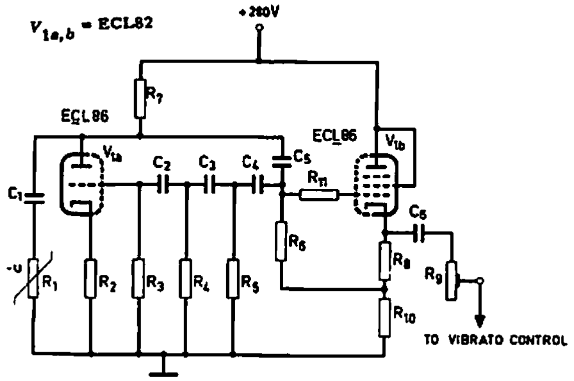
SIMPLEST THEREMIN—Makes use of ordinary broadcast receiver to supply fixed-frequency oscillator and mixer for Theremin. Place Theremin a few inches from back of receiver and tune to fairly strong station around 900 kHz, then adjust slug of L1 until most pleasing whistle tone is obtained. Moving hand near pitch antenna then makes tone change. Metal plate about 10 inches square may be used as antenna.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 76.


+14V
R4
6.8k
R5
56k
Q1
R1
100k
R2
100k
C3
C1
C2
R3
10k

Q1-MPS 6521

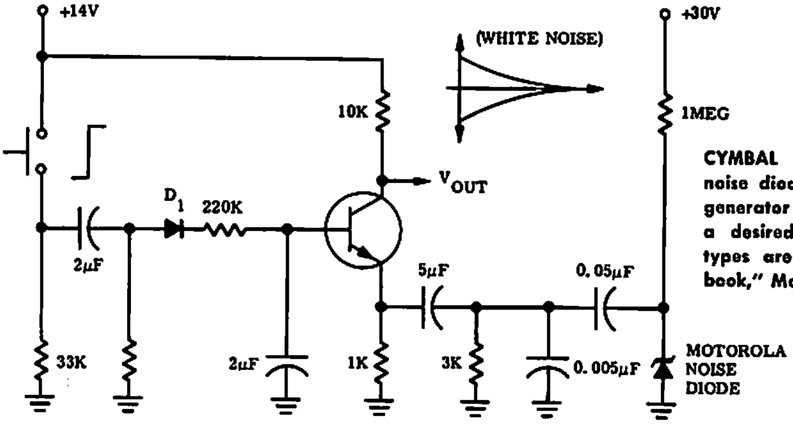
TWIN-T AUDIO—Basic circuit using Motorola high-gain silicon transistor with R-C networks is basic oscillator for many electronic music applications requiring up to 10 kHz. Article gives nomogram and design procedures for choosing capacitor values. C1 should always equal C2, in range from 0.0003 to 0.1 μF, and C3 should be twice as large as either.—F. B. Maynard, Twin T's: Designs & Applications, *Electronics World*, Aug. 1968, p 35–37 and 64.

7-HZ VIBRATO FOR ORGAN—Used to modulate frequency of each of 12 master tone generators in six-octave electronic organ. Provides wavering variation of pitch without affecting loudness. Triode in R-C phase-shifting network generates 7-Hz signal for driving pentode operating as cathode follower to match output to impedance of vibrato control potentiometer. R1 is voltage-dependent resistor.—Electronic Organ with Cold-Cathode Tube Frequency Dividers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 112, 1966.

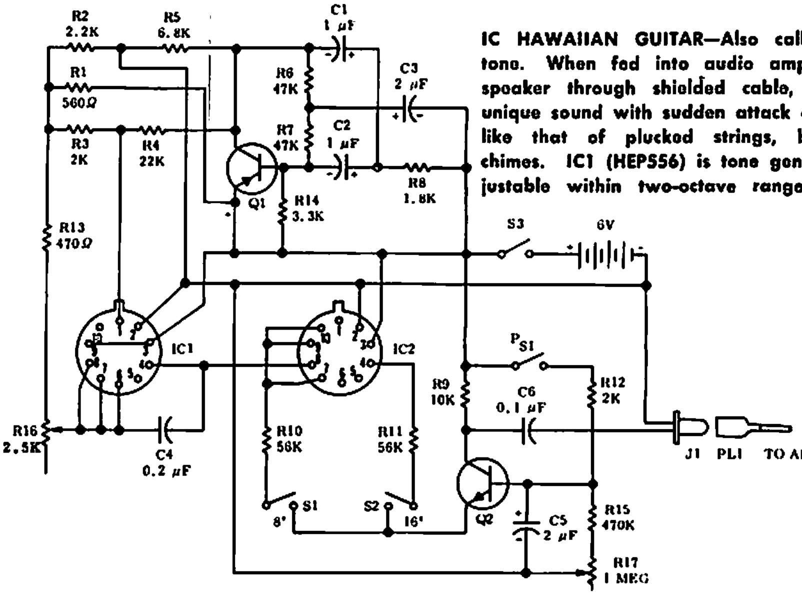

$V_{1a,b}$ = ECL82
+280V
ECL86
ECL86
V_{1a}
V_{1b}
C_1
C_2
C_3
C_4
C_5
C_6
R_7
R_{11}
-U
R_1
R_2
R_3
R_4
R_5
R_6
R_8
R_9
R_{10}
TO VIBRATO CONTROL

R_2 = 27 kΩ
R_3 = 1 MΩ
R_4 = 1 MΩ
R_5 = 1 MΩ
R_6 = 1 MΩ
R_7 = 220 kΩ
R_8 = 1.8 kΩ
R_9 = 5 kΩ

C_1 = 270 μF
C_2 = 10 μF
C_3 = 22 μF
C_4 = 27 μF
C_5 = 27 μF
C_6 = 200 μF


+14V
10K
(WHITE NOISE)
V_{OUT}
D_1
220K
2μF
33K
2μF
1K
5μF
3K
0.05μF
0.005μF
+30V
1MEG
MOTOROLA NOISE DIODE

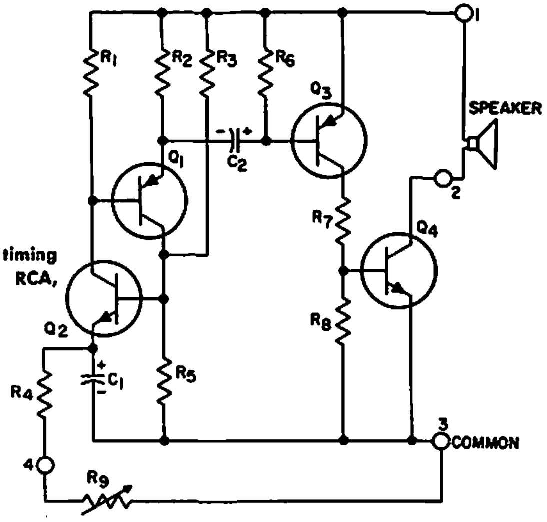
CYMBAL AFTERBEAT EFFECT—Special zener noise diode is combined with sustain control generator for use in electronic organ to create a desired noise effect. Transistor and D1 types are not critical.—"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 9–5.


R2 2.2K
R5 6.8K
C1 1 μF
R1 560Ω
R6 47K
C3 2 μF
R3 2K
R4 22K
R7 47K
C2 1 μF
Q1
R14 3.3K
R8 1.8K
R13 470Ω
S3
6V
IC1
IC2
P_{S1}
R9 10K
C6 0.1 μF
R12 2K
R16 2.5K
C4 0.2 μF
R10 56K
R11 56K
J1
PL1
TO AMP
S1
S2
8'
16'
Q2
C5 2 μF
R15 470K
R17 1 MEG

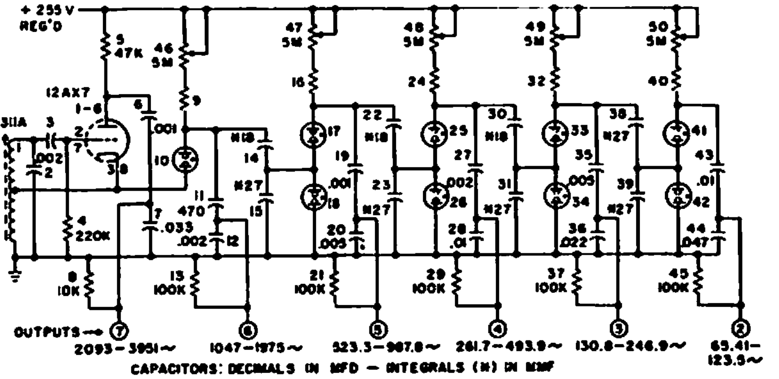
IC HAWAIIAN GUITAR—Also called Glidetone. When fed into audio amplifier and speaker through shielded cable, generates unique sound with sudden attack and decay like that of plucked strings, bells, and chimes. IC1 (HEP556) is tone generator adjustable within two-octave range by R16. This frequency is divided by IC2 (HEP558) to create tone exactly one octave lower. Stops S1 and S2 feed these tones singly or together to Q2 (HEP50) which provides sustain effect. Q1 (HEP251) provides 6-Hz vibrato. Circuit is thus similar to small portion of an electronic organ. Article gives construction details.—"Integrated Circuit Projects," Motorola, Phoenix, Ariz., 1966, p 70–79.

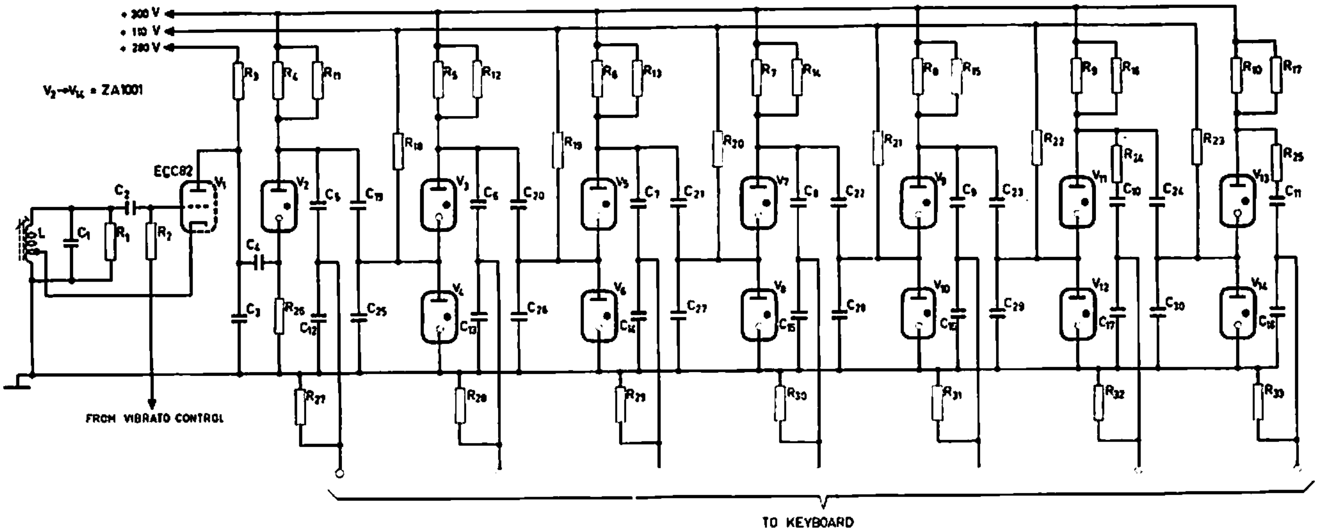
METRONOME—Produces audible beeps at rate determined by setting of R9, for metering musical cadence. If beep rate is set at 1 per second, may be used in darkroom for timing exposures.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 103.

C_1 C_2 = 20 microfarads, 12 volts, electrolytic
Q_1Q_3 = transistor, RCA SK3005
Q_2Q_4 = transistor, RCA SK3020
R_1R_3 = 1000 ohms, 1/2 watt, 10%
R_2 = 68 ohms, 1/2 watt, 10%
R_4 = 3900, 1/2 watt, 10%
R_5 = 470 ohms, 1/2 watt, 10%
R_6R_8 = 150 ohms, 1/2 watt, 10%
R_7 = 120 ohms, 1/2 watt, 10%
R_9 = potentiometer, 50,000 ohms, linear taper
Speaker = 3.2 ohms


+9V
1
R_1
R_2
R_3
R_6
Q_3
SPEAKER
Q_1
C_2
2
R_7
Q_4
Q2
R_8
R_4
C_1
R_5
3
COMMON
4
R_9

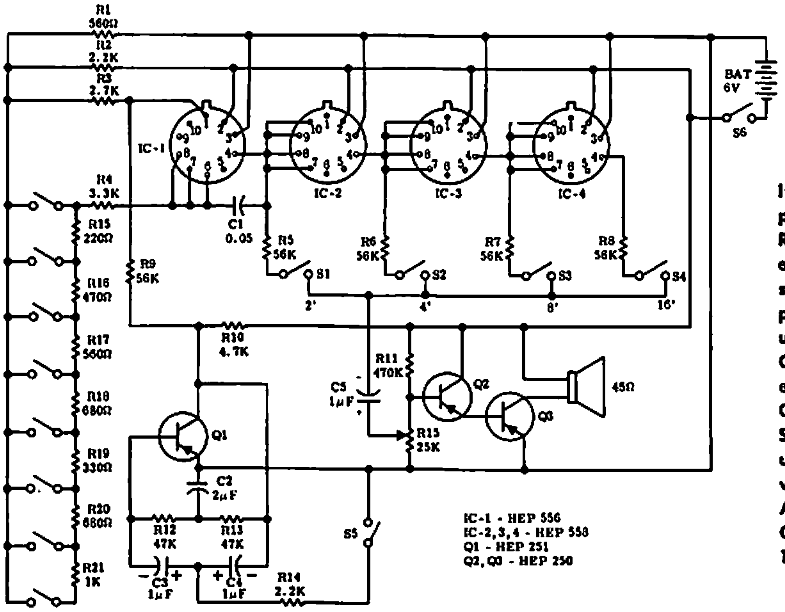
ORGAN TONE GENERATOR—Inexpensive, stable, and highly reliable circuit covers six octaves, using basic triode master oscillator and five bistable neon oscillators as frequency dividers, each cutting previous frequency in half. Capacitive voltage divider in each stage prevents output tone from coupling back into previous stage and causing audible distortion. Values of unmarked resistors, which depend on leakage resistance of neon lamps, are not critical if type A078 lamps are used. Output 5 is 523.3 Hz (C above middle C).—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 40–43.


+255 V REG'D
5 47K
46 5M
12AX7 1-6
0311A
1
3
.002
2
6 .001
7 .033
4 220K
8 10K
9
10
11 470
.002 12
M18 14
M27 15
13 100K
47 5M
16
17
18
19 .001
20 .005
21 100K
22 M18
23 M27
48 5M
24
25
26
27 .002
28 .01
29 100K
30 M18
31 M27
49 5M
32
33
34
35 .005
36 .022
37 100K
38 M27
39 M27
50 5M
40
41
42
43 .01
44 .047
45 100K
OUTPUTS → 7 6 5 4 3 2
2093–3951~
1047–1975~
523.3–987.8~
261.7–493.9~
130.8–246.9~
65.41–123.5~
CAPACITORS: DECIMALS IN MFD — INTEGRALS (M) IN MMF

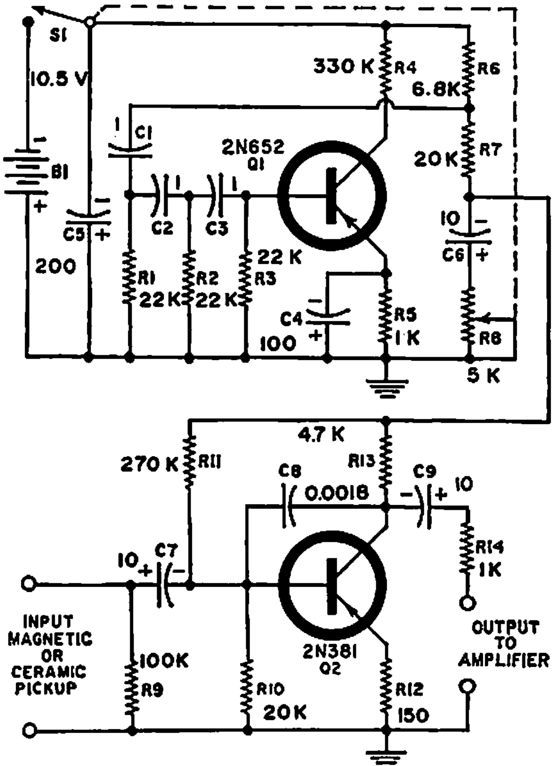

+300 V
+110 V
+280 V
V2→V14 = ZA1001
ECC82
V1
L
C1
C2
R1
R2
R3
R4
R11
C4
C3
R26
C12
C5
C19
C25
R27
FROM VIBRATO CONTROL
R5 R12 R18 V3 V4 C6 C20 C13 C26 R28
R6 R13 R19 V5 V6 C7 C21 C14 C27 R29
R7 R14 R20 V7 V8 C8 C22 C15 C28 R30
R8 R15 R21 V9 V10 C9 C23 C16 C29 R31
R9 R16 R22 R24 V11 V12 C10 C24 C17 C30 R32
R10 R17 R23 R25 V13 V14 C11 C18 R33
TO KEYBOARD

		Note:	C	B	A#	A	G#	G	F#	F	E	D#	D	C#	
		Frequency	8372	7902	7459	7040	6645	6272	5920	5588	5274	4978	4699	4435.	Hz
C_1	polystyrene	125 V	8.2	8.2	10	12	12	15	15	18	22	22	27	27	nF
C_2	polyester	125 V	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	pF
C_3	polyester	400 V	1.8	1.8	1.8	2.2	2.2	2.2	2.7	2.7	2.7	3.3	3.3	3.3	nF
C_4	ceramic	350 V	0.68	0.68	0.82	0.82	0.82	1.0	1.0	1.2	1.2	1.2	1.5	1.5	nF
C_5	polyester	400 V	330	330	330	390	390	390	470	470	470	560	560	560	pF
C_6	polyester	400 V	390	390	390	390	470	470	470	470	560	560	560	560	pF
C_7	polyester	400 V	0.82	0.82	0.82	0.82	1.0	1.0	1.0	1.0	1.2	1.2	1.2	1.2	nF
C_8	polyester	400 V	1.8	1.8	1.8	1.8	2.2	2.2	2.2	2.2	2.7	2.7	2.7	2.7	nF
C_9	polyester	400 V	3.9	3.9	3.9	3.9	4.7	4.7	4.7	4.7	5.6	5.6	5.6	5.6	nF
C_{10}	polyester	400 V	8.2	8.2	8.2	8.2	10	10	10	10	12	12	12	12	nF
C_{11}	polyester	400 V	15	–	–	–	–	–	–	–	–	–	–	–	nF
C_{12}	polyester	125 V	1.8	1.8	1.8	2.2	2.2	2.2	2.7	2.7	2.7	3.3	3.3	3.3	nF
C_{13}	polyester	125 V	3.9	3.9	3.9	3.9	4.7	4.7	4.7	4.7	5.6	5.6	5.6	5.6	nF
C_{14}	polyester	125 V	8.2	8.2	8.2	8.2	10	10	10	10	12	12	12	12	nF
C_{15}	polyester	125 V	18	18	18	18	22	22	22	22	27	27	27	27	nF
C_{16}	polyester	125 V	39	39	39	39	47	47	47	47	56	56	56	56	nF
C_{17}	polyester	125 V	82	82	82	82	100	100	100	100	120	120	120	120	nF
C_{18}	polyester	125 V	150	–	–	–	–	–	–	–	–	–	–	–	nF
C_{19}	ceramic	350 V	10	10	10	10	10	10	10	10	10	10	10	10	pF
C_{20}	ceramic	350 V	10	10	10	10	10	10	10	10	10	10	10	10	pF
C_{21}	ceramic	350 V	10	10	10	10	10	10	10	10	10	10	10	10	pF
C_{22}	ceramic	350 V	22	22	22	22	22	22	22	22	22	22	22	22	pF
C_{23}	ceramic	350 V	47	47	47	47	47	47	47	47	47	47	47	47	pF
C_{24}	ceramic	350 V	100	–	–	–	–	–	–	–	–	–	–	–	pF
C_{25}	ceramic	350 V	10	10	10	10	10	10	10	10	10	10	10	10	pF
C_{26}	ceramic	350 V	10	10	10	10	10	10	10	10	10	10	10	10	pF
C_{27}	ceramic	350 V	10	10	10	10	10	10	10	10	10	10	10	10	pF
C_{28}	ceramic	350 V	22	22	22	22	22	22	22	22	22	22	22	22	pF
C_{29}	ceramic	350 V	47	47	47	47	47	47	47	47	47	47	47	47	pF
C_{30}	ceramic	350 V	100	–	–	–	–	–	–	–	–	–	–	–	pF
R_1			22	22	27	27	27	33	33	39	39	39	47	47	kΩ

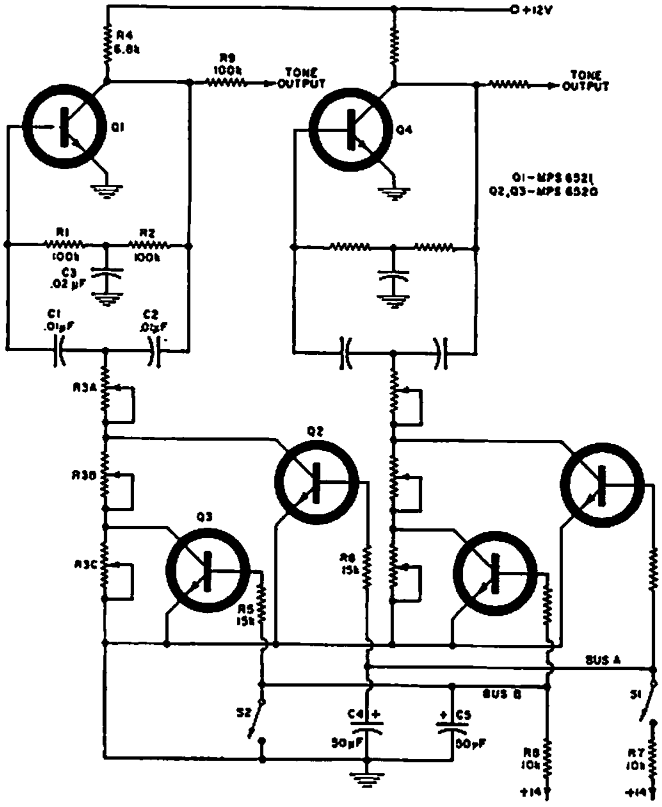
ORGAN TONE GENERATOR—Circuit shown (for C natural) is one of 12 master tone generators in electronic organ for homes or small public rooms. All notes comprising six-octave range of instrument are derived by ZA1001 cold-cathode relaxation oscillators operating in cascade as successive frequency dividers. Final stage, including V13 and V14, is omitted from tone generators for other notes. V1 is half of ECC82 double-triode. Resistors are identical for all 12 tone generators except for R11-R17 whose values must be selected for vibrato and frequency adjustment, and R1 whose values are given in table along with capacitor values. Values are: R2 47K; R3 22K; R4-R10 4.7 meg; R11-R17 1.8 to 22 meg; R18-R23 10 meg; R24, R25 4.7K; R26 15K; R27-R33 220K; L is 45 mH with core K30024 and 850 turns wild-wound, tapped at 210 turns. Report gives complete design and construction data for entire organ.—Electronic Organ with Cold-Cathode Tube Frequency Dividers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 122, 1966.


R1 560Ω
R2 2.2K
R3 2.7K
BAT 6V
S6
IC-1
IC-2
IC-3
IC-4
R4 3.3K
C1 0.05
R15 220Ω
R16 470Ω
R17 560Ω
R18 680Ω
R19 330Ω
R20 680Ω
R21 1K
R9 56K
R5 56K
R6 56K
R7 56K
R8 56K
S1
S2
S3
S4
2'
4'
8'
16'
R10 4.7K
R11 470K
C5 1μF
R15 25K
Q1
Q2
Q3
45Ω
C2 2μF
R12 47K
R13 47K
C3 1μF
C4 1μF
R14 2.2K
S5
IC-1 - HEP 556
IC-2,3,4 - HEP 558
Q1 - HEP 251
Q2,Q3 - HEP 250

IC SINGLE-OSCILLATOR ORGAN—Linear amplifier IC-1 and eight switched-in resistors R15-R21 serve as oscillator for generating eight notes of diatonic scale—do, re, mi, fa, sol, la, ti, do, though not necessarily with perfect tuning to international musical scale unless resistor values are slightly changed. Other three IC's are J-K flip-flops that generate suboctaves by exact frequency division. Q1 is 6-Hz vibrato generator. Stop switches S1-S4, each providing different sound, are used singly or in combinations to provide voicing. Q2-Q3 serve as audio amplifier. Article gives construction details.—"Integrated Circuit Projects," Motorola, Phoenix, Ariz., 1966, p 32—45.

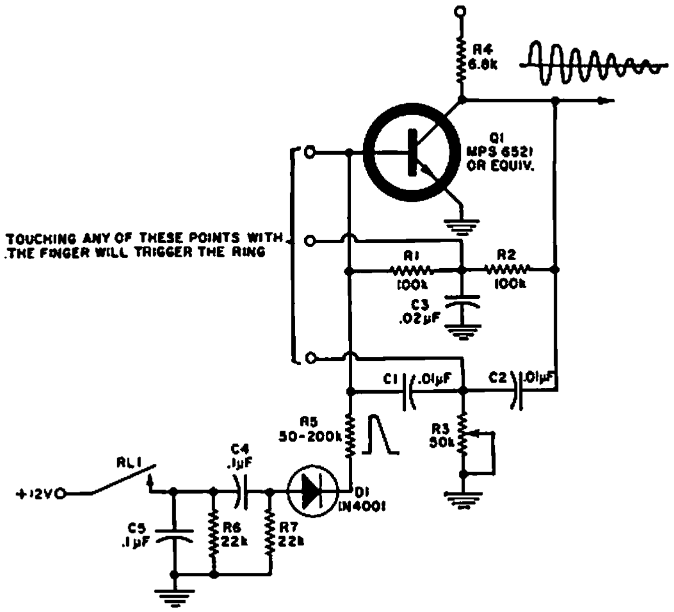

S1
10.5 V
B1
C5
200
C1
C2
C3
2N652
Q1
330 K
R4
R6
6.8K
20 K
R7
10
C6
R1 22K
R2 22K
22 K
R3
C4
100
R5
1 K
R8
5 K
4.7 K
R13
270 K
R11
C8
0.0018
C9
10
R14
1K
C7
10
INPUT MAGNETIC OR CERAMIC PICKUP
100K
R9
R10
20K
2N381
Q2
R12
150
OUTPUT TO AMPLIFIER

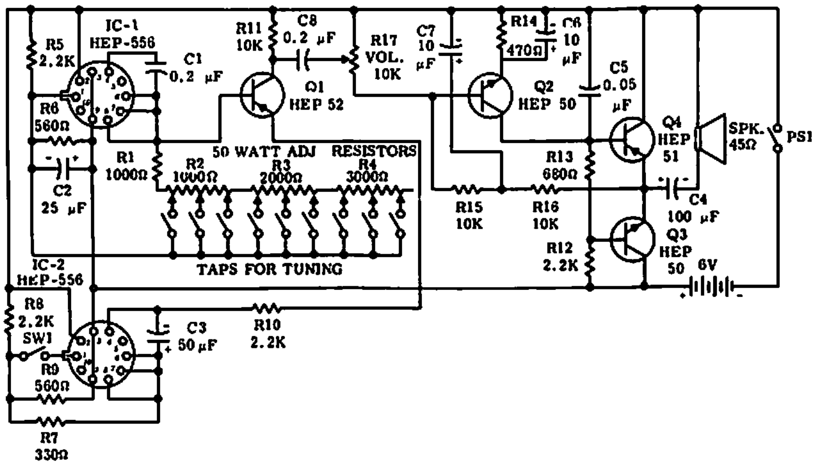
TREMOLO FOR GUITAR—Q1 is 6-Hz phase-shift oscillator acting on voltage amplifier Q2 to vary input signal strength and provide added depth to any musical instrument using pickup.—W. R. Shippee, Simplified Tremolo, *Electronics World*, Oct. 1966, p 89.


+12V
R4
6.8k
R9
100k
TONE OUTPUT
TONE OUTPUT
Q1
Q4
Q1-MPS 6521
Q2,Q3-MPS 6520
R1
100k
R2
100k
C3
.02μF
C1
.01μF
C2
.01μF
R3A
R3B
R3C
Q2
Q3
R6
15k
R5
15k
BUS A
BUS B
S2
S1
C4
50μF
C5
50μF
R8
10k
R7
10k
+14
+14

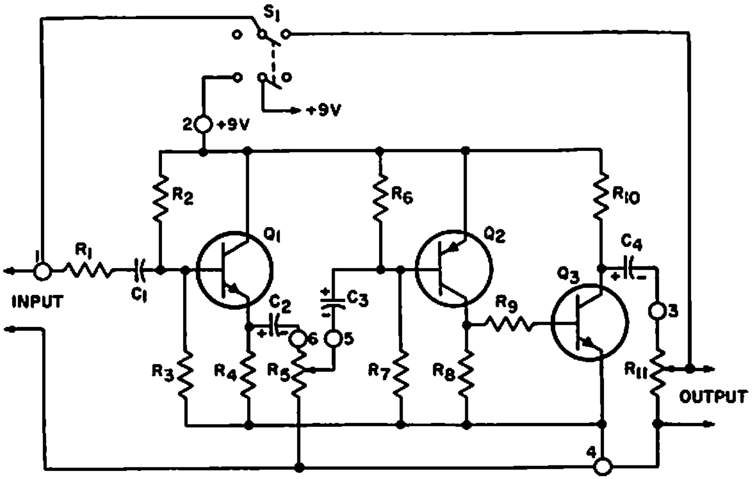
TWIN-T GLIDING-TONE—Used in experimental musical instruments to provide shifts and glides at any intervals within 1.5-octave frequency ranges of multiplicity of twin-T oscillators employed. Only part of circuit is shown, with values given for first oscillator Q1. Article gives design details for achieving desired musical effects.—F. B. Maynard, Twin T's: Designs & Applications, *Electronics World*, Aug. 1968, p 35—37 and 64.

BONGO—Provides ringing function for simulating musical instruments when R3 in basic twin-T oscillator is adjusted until circuit just becomes quiescent. If this is close to cutoff, duration of ringing can be up to 30 sine waves. Can be triggered by positive square waves or by touching indicated terminals. At around 100 Hz, effect sounds like bass drums. Middle frequencies simulate tom-toms and bongos. Above 1 kHz sounds of gongs, resonant wood blocks, and claves are generated. Can also be used for doorbells and signaling devices.—F. B. Maynard, Twin T's: Designs & Applications, *Electronics World*, Aug. 1968, p 35–37 and 64.


R4 6.8k
Q1 MPS 6521 OR EQUIV.
TOUCHING ANY OF THESE POINTS WITH THE FINGER WILL TRIGGER THE RING
R1 100k
R2 100k
C3 .02µF
C1 .01µF
C2 .01µF
R5 50-200k
R3 50k
RL1
+12V
C4 .1µF
D1 1N4001
C5 .1µF
R6 22k
R7 22k


IC-1 HEP-556
R5 2.2K
C1 0.2 µF
R6 560Ω
C2 25 µF
R1 1000Ω
R2 1000Ω
R3 2000Ω
R4 3000Ω
50 WATT ADJ RESISTORS
TAPS FOR TUNING
R11 10K
C8 0.2 µF
Q1 HEP 52
R17 VOL. 10K
C7 10 µF
R14 470Ω
C6 10 µF
Q2 HEP 50
C5 0.05 µF
Q4 HEP 51
SPK. 45Ω
PS1
R13 680Ω
R15 10K
R16 10K
C4 100 µF
R12 2.2K
Q3 HEP 50
6V
IC-2 HEP-556
R8 2.2K
SW1
R9 560Ω
C3 50 µF
R10 2.2K
R7 330Ω

GUITAR—Uses two IC R-C oscillators, one tapped to provide notes over two-octave scale (250 to 1,100 Hz). Other gives fixed-frequency output around 12 Hz which may be turned on and off by SW1, adding a rapid string-plucking sound to instrument. Article gives construction details. Amplifier delivers 200 mW to speaker.—"Integrated Circuit Projects," Motorola, Phoenix, Ariz., 1966, p 80.


S1
+9V
2
R2
R6
R10
Q1
Q2
Q3
C4
R1
C1
INPUT
C2
C3
6
5
R9
3
R3
R4
R5
R7
R8
R11
OUTPUT
4
COMMON

FUZZ BOX—Can be used with guitar or any other instrument whose musical output is amplified. Will change character of sound produced, to give variety of sounds not otherwise available from the instrument. Q2 is biased almost to cutoff and therefore amplifies only half of input signal. R5 changes level of signal at input to Q2 and therefore controls amount of fuzz. Q3 is biased to clip top of signal input and further change character of sound. Circuit requires 1 V input.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 91.

C_1 = 0.01 microfarad, 25 volts or greater

$C_2C_3C_4$ = 5 microfarads, 15 volts, electrolytic

Q_1Q_3 = transistor, RCA SK3020

Q_2 = transistor, RCA SK3005

$R_1 R_2 R_3 R_7$ = 100,000 ohms, 1/2 watt, 10%

R_4 = 3300 ohms, 1/2 watt, 10%

R_5 = potentiometer, 5000 ohms, linear taper

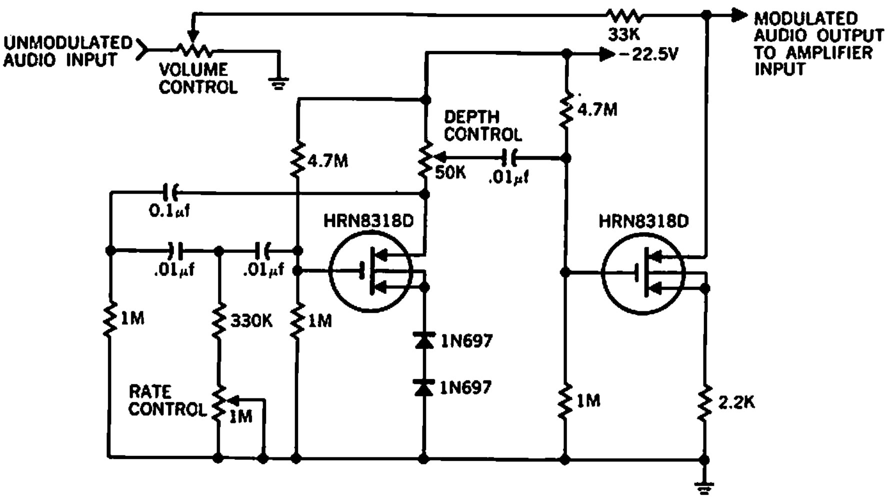
R_6 = 15,000 ohms, 1/2 watt, 10%

$R_8 R_{10}$ = 2700 ohms, 1/2 watt, 10%

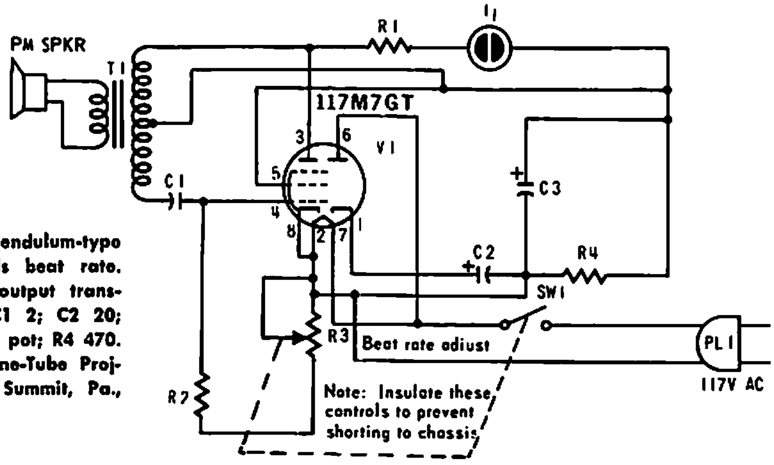
R_9 = 47,000 ohms, 1/2 watt, 10%

R_{11} = potentiometer, 10,000 ohms, linear taper

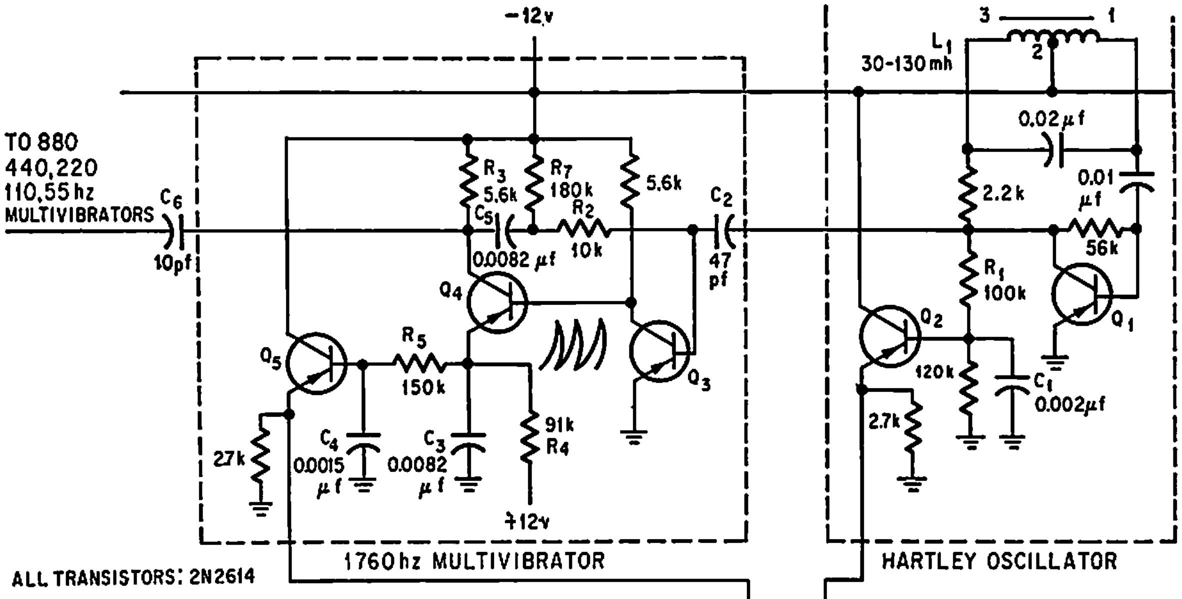
S_1 = switch, double-pole, double-throw


UNMODULATED AUDIO INPUT
VOLUME CONTROL
33K
-22.5V
MODULATED AUDIO OUTPUT TO AMPLIFIER INPUT
DEPTH CONTROL
4.7M
4.7M
50K
.01μf
0.1μf
HRN8318D
HRN8318D
.01μf
.01μf
1M
330K
1M
1N697
1N697
RATE CONTROL
1M
1M
2.2K

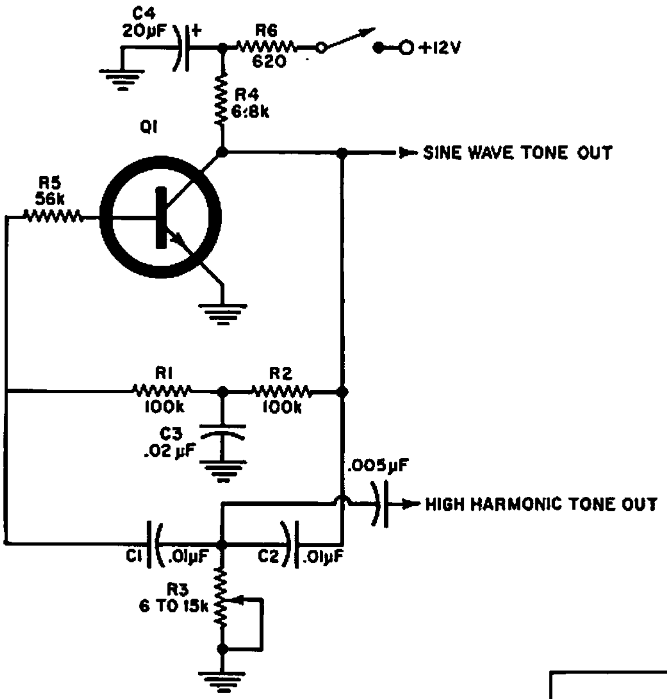
4–8 HZ TREMOLO—Circuit modulates audio input from stringed electrical instrument by using first fet as phase-shift oscillator that controls resistance of second fet. Basic oscillation frequency is determined by setting of rate control pot. When depth control is in full clockwise position, output of subsonic oscillator is shorted to −22.5 V power supply and linear resistance of second fet does not vary, so audio signal is unmodulated.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 10.


PM SPKR
T1
R1
I1
117M7GT
V1
3
6
5
4
8
2
7
1
C1
C3
C2
R4
SW1
R3
Beat rate adjust
PL1
117V AC
R2
Note: Insulate these controls to prevent shorting to chassis

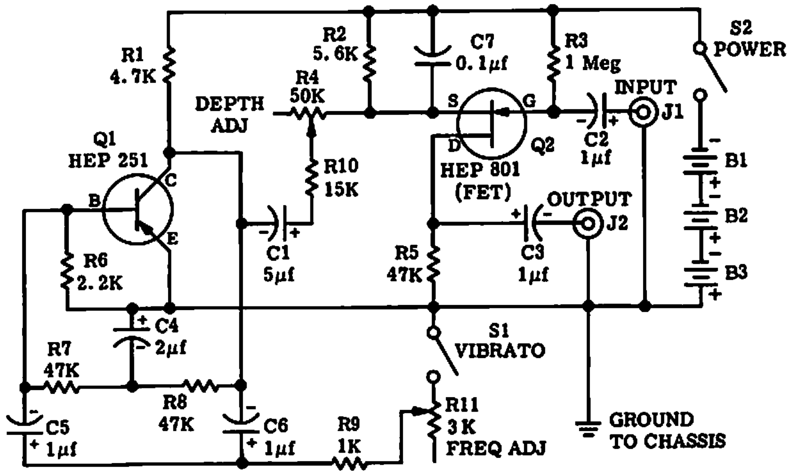
A-C METRONOME—Simulates pendulum-type used with pianos. R3 controls beat rate. T1 is Merit A-2900 universal output transformer; I1 NE-2 pilot lamp; C1 2; C2 20; C3 40; R1-R2 120K; R3 7.5 meg pot; R4 470. —R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 119.


-12v
TO 880 440,220 110,55 hz MULTIVIBRATORS
C6
10pf
R3 5.6k
R7 180k
5.6k
C5
0.0082 μf
R2 10k
C2
47 pf
Q4
Q5
R5 150k
Q3
91k R4
C4 0.0015 μf
C3 0.0082 μf
27k
+12v
1760hz MULTIVIBRATOR
ALL TRANSISTORS: 2N2614
3
1
L1 30-130 mh
2
0.02μf
0.01 μf
2.2k
56k
R1 100k
Q2
Q1
120k
C1 0.002μf
2.7k
HARTLEY OSCILLATOR

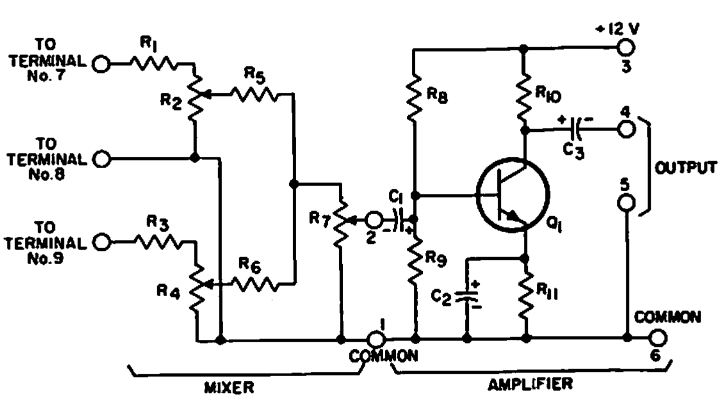
BUZZ-FREE ORGAN—Addition of capacitor C4 to mvbr and modification of Hartley oscillator with R1 and C1 eliminate buzzing sound created by fast flyback of sawtooth voltages in electronic organ. Redesign of circuit also adds richness to music, because all harmonics are generated along with each fundamental. Output of Hartley is stable enough to serve as sync signal along with organ note.—R. F. Woody Jr., Putting Electronic Organs In Tune With Natural Sound, *Electronics*, June 24, 1968, p 100–102.


C4
20µF
+
R6
620
+12V
R4
6.8k
Q1
SINE WAVE TONE OUT
R5
56k
R1
100k
R2
100k
C3
.02 µF
.005µF
HIGH HARMONIC TONE OUT
C1
.01µF
C2
.01µF
R3
6 TO 15k

"SUSTAIN" EFFECT—Twin-T oscillator provides effect heard in pianos, bells, and string instruments, in which tone decreases gradually in intensity. Article has nomogram for choosing twin-T component values to give desired frequency. Voltage stability is sufficiently good that maximum deviation from constant frequency cannot be detected by most persons. Q1 is Motorola MPS6521.—F. B. Maynard, Twin T's: Designs & Applications, *Electronics World,* Aug. 1968, p. 35–37 and 64.


R1
4.7K
R2
5.6K
C7
0.1µf
R3
1 Meg
S2
POWER
R4
50K
DEPTH
ADJ
S
G
D
Q2
HEP 801
(FET)
INPUT
J1
C2
1µf
B1
B2
B3
Q1
HEP 251
B
C
E
R10
15K
OUTPUT
J2
C1
5µf
C3
1µf
R5
47K
R6
2.2K
C4
2µf
S1
VIBRATO
R7
47K
R8
47K
C5
1µf
C6
1µf
R9
1K
R11
3K
FREQ ADJ
GROUND
TO CHASSIS

FET VIBRATO—Gives tremolo or other special effects to guitars, accordions, and reed-type electric chord organs. Connect high-impedance pickup or microphone to input jack J1, and connect output jack J2 to high-impedance input of any audio amplifier system. Twin-tee oscillator Q1 produces 6-Hz sine-wave output, adjustable by R11. Article gives construction and adjustment details.—"Field Effect Transistor Projects," Motorola, Phoenix, Ariz., 1966, p 15–25.


TO
TERMINAL
No.7
R1
R2
R5
TO
TERMINAL
No.8
TO
TERMINAL
No.9
R3
R4
R6
R7
2
C1
1
COMMON
MIXER
+12 V
3
R8
R10
C3
4
5
OUTPUT
Q1
R9
C2
R11
COMMON
6
AMPLIFIER

ORGAN MIXER-AMPLIFIER—Sawtooth input to R3 and pulse input to R1 from single-voice electronic organ are mixed to change character of tone before feeding into audio amplifier stage. Output at terminals 4 and 5 may be fed into hi-fi audio amplifier.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 107.

C_1 = 15 microfarads, 10 volts, electrolytic

C_2 = 100 microfarads, 6 volts, electrolytic

C_3 = 50 microfarads, 15 volts, electrolytic

Q_1 = transistor, RCA SK3020

R_1 R_5 R_6 R_9 = 100,000 ohms, 1/2 watt, 10%

R_2 = potentiometer, 5000 ohms, linear taper

R_3 = 2.2 megohms, 1/2 watt, 10%

R_4 = potentiometer, 250,000 ohms, linear taper

R_7 = potentiometer, 10,000 ohms, linear taper

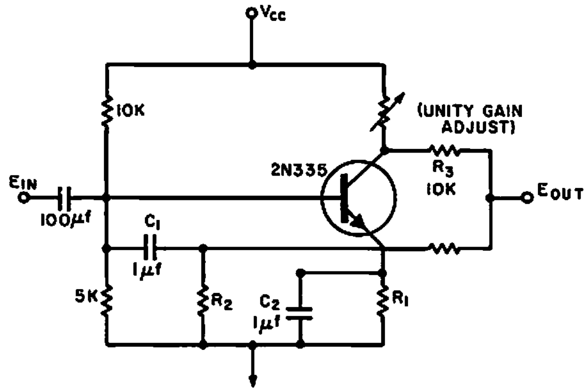
R_8 = 330,000 ohms, 1/2 watt, 10%

R_{10} = 12,000 ohms, 1/2 watt, 10%

R_{11} = 3300 ohms, 1/2 watt, 10%

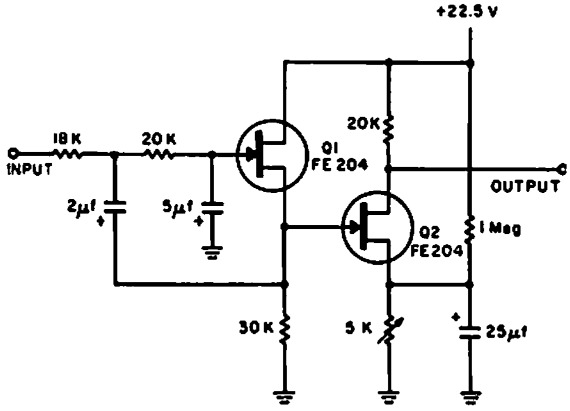
CHAPTER 28

Filter Circuits—Active



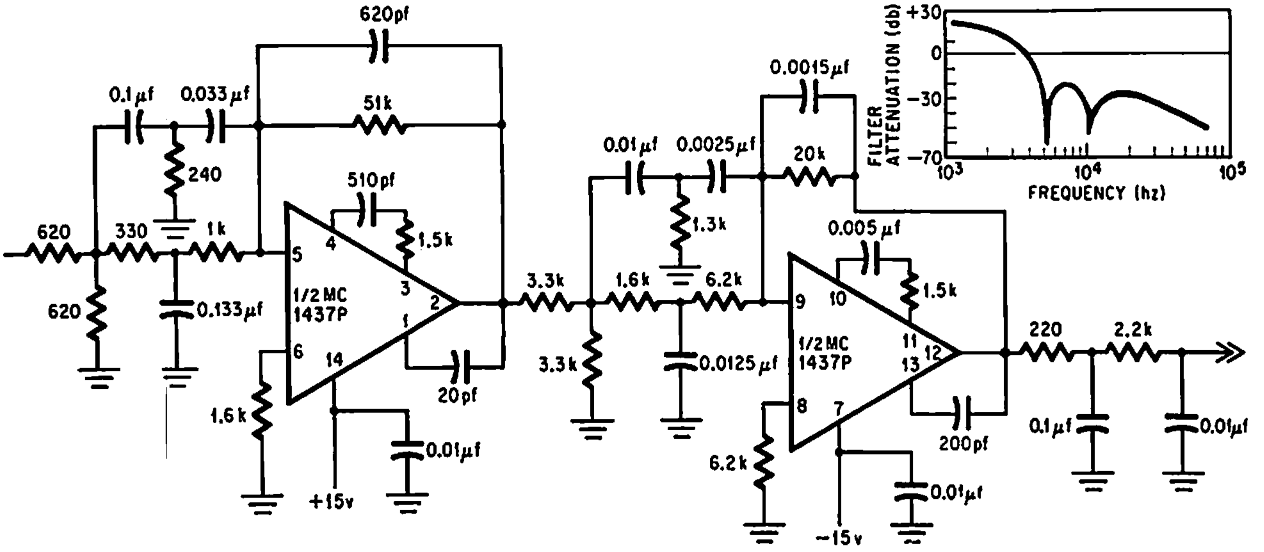
Vcc
10K
(UNITY GAIN ADJUST)
2N335
R3
10K
EIN
100μf
C1
1μf
EOUT
5K
R2
C2
1μf
R1

3–20 DB BANDWIDTH NOTCH FILTER—Adjusting values of R1 and R2 alters bandwidth without affecting notch attenuation. With 1,375 ohms for both, notch bandwidth is much narrower than when R1 is 310 ohms and R2 is 10K. Article gives response curves and phase characteristic for operating range of 100 to 150 Hz.—H. E. Butler, Variable Bandwidth From a Notch Filter, *Electronic Design*, April 27, 1964, p 90.



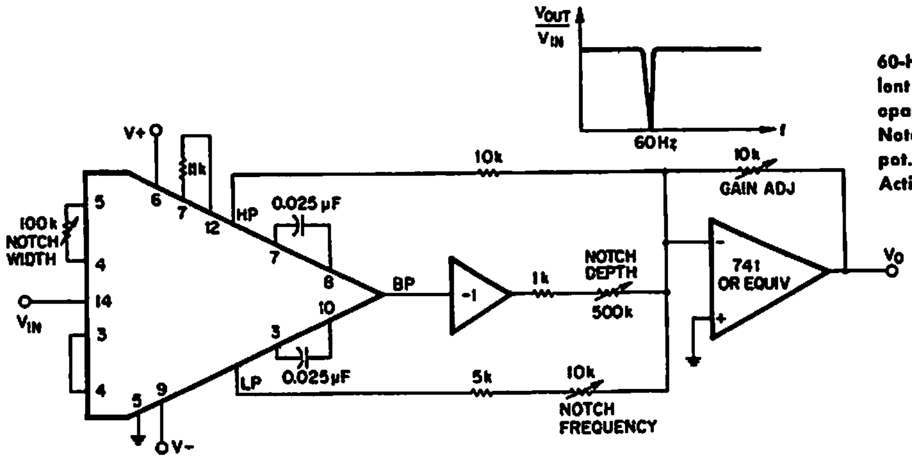
+22.5 V
18 K
20 K
INPUT
20K
Q1
FE 204
OUTPUT
2μf
5μf
Q2
FE204
1 Meg
30 K
5 K
25μf

0–1 HZ ACTIVE FILTER—Low-pass filter with voltage gain to 2.5 has rolloff of 12 dB per decade of frequency and noise (referred to input) of only 15 μV per root cycle, as compared to 140 with ordinary low-noise transistor.—T. F. Prosser, Field Effect Transistor Improves Low Pass Filter Action, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 15.

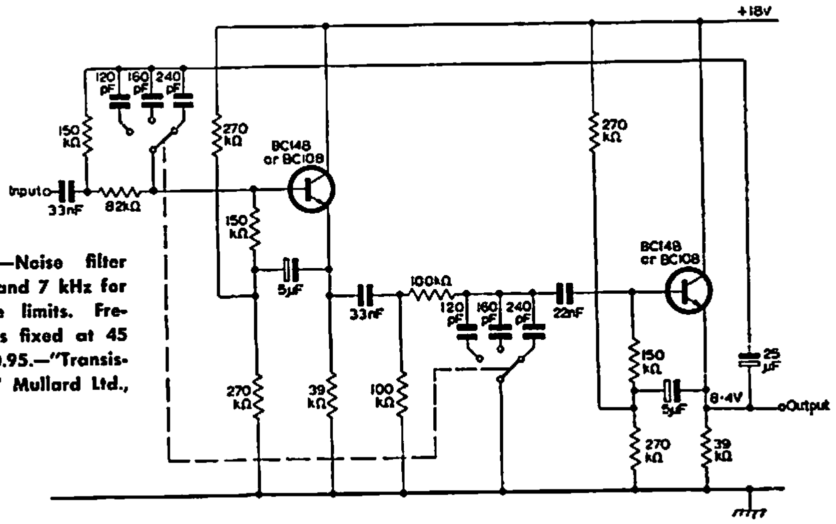


620pf
0.1μf
0.033μf
51k
240
510pf
620
330
1k
5
4
1.5k
620
0.133μf
1/2 MC 1437P
3
2
1
6
14
1.6k
20pf
0.01μf
+15v
0.0015μf
0.01μf
0.0025μf
20k
1.3k
0.005μf
3.3k
1.6k
6.2k
9
10
1.5k
3.3k
0.0125μf
1/2 MC 1437P
11
13
12
8
7
200pf
6.2k
0.01μf
−15v
220
2.2k
0.1μf
0.01μf
FILTER ATTENUATION (db)
+30
0
−30
−70
10^3
10^4
10^5
FREQUENCY (hz)

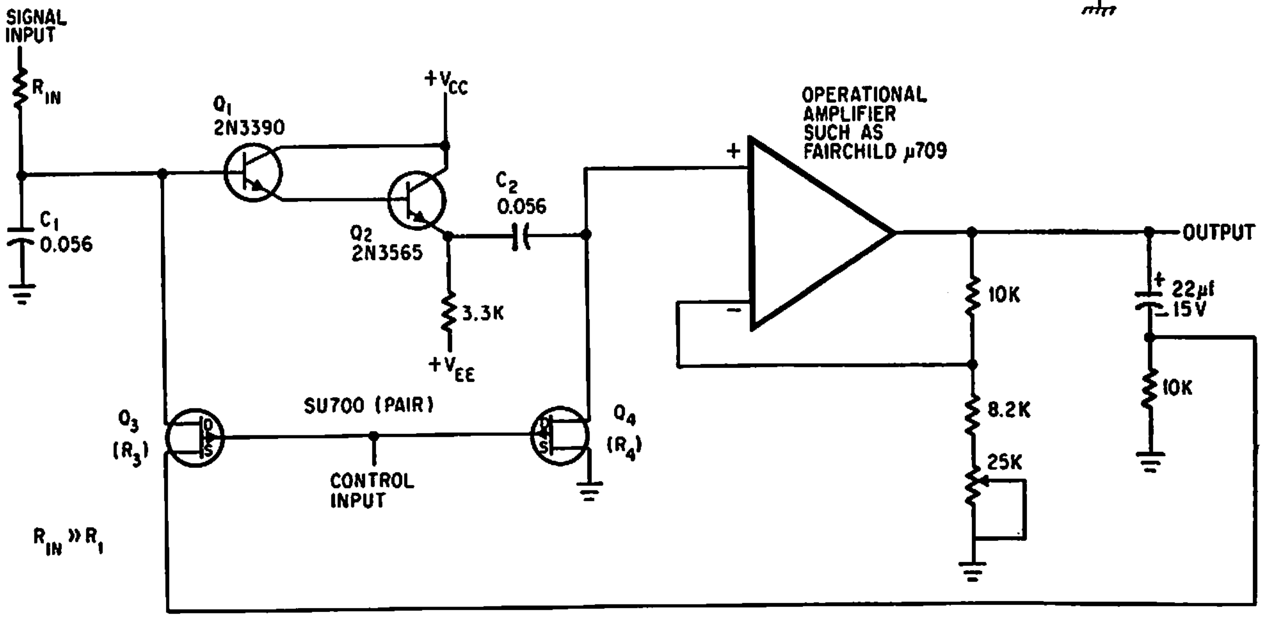
PHASE-LOCKED LOOP—Two-section active filter using opamps was developed for frequency synthesizer requiring d-c voltage gain of 15 V/V, 5-kHz reference frequency at least 70 dB down from d-c gain, 10-kHz second harmonic 60 dB down, and all other harmonics at least 50 dB down. Phase shift at 1 kHz must be less than 50 deg. Article gives design equations.—B. Welling, Active Filters: The Op Amp Saves Time and Money, *Electronics*, Feb. 3, 1969, p 82–90.


VOUT/VIN
60Hz
f
V+
11k
5
6
7
12
HP
0.025 µF
7
8
10
3
0.025µF
LP
100k NOTCH WIDTH
4
14
VIN
3
4
5
9
V-
BP
-1
1k
NOTCH DEPTH
500k
10k
10k GAIN ADJ
741 OR EQUIV
-
+
VO
5k
10k
NOTCH FREQUENCY

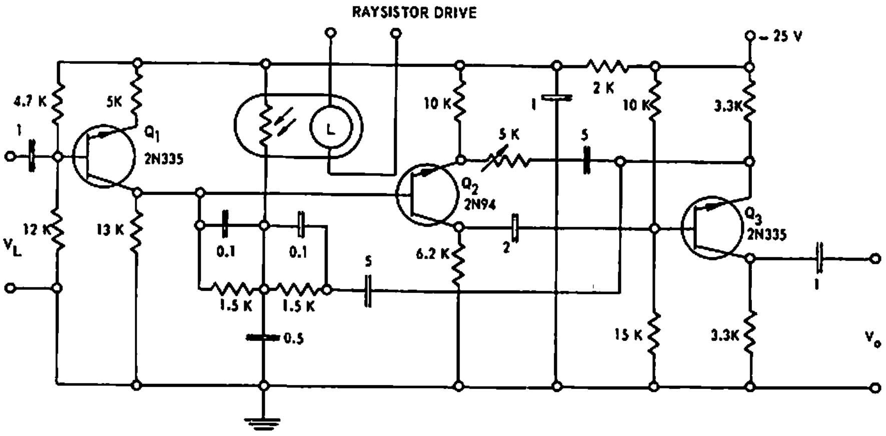
60-HZ NOTCH FILTER—Uses FS-20 or equivalent IC active filter with unity-gain inverting opamp providing adjustable notch depth. Notch frequency may be changed with 10K pot.—G. J. Estep, New Applications for IC Active Filters, *EEE*, Oct. 1969, p 60–63.


+18V
120 pF
160 pF
240 pF
150 kΩ
270 kΩ
BC148 or BC108
Input
33nF
82kΩ
150 kΩ
5µF
33nF
100kΩ
120 pF
160 pF
240 pF
22nF
BC148 or BC108
270 kΩ
270 kΩ
39 kΩ
100 kΩ
150 kΩ
5µF
8·4V
25 µF
Output
270 kΩ
39 kΩ

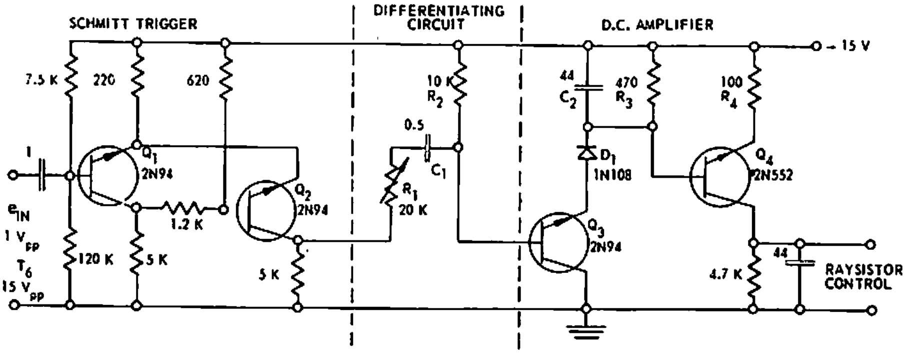
NOISE AND RUMBLE FILTER—Noise filter switch gives choice of 16, 12, and 7 kHz for 3-dB-down frequency response limits. Frequency limit of rumble filter is fixed at 45 Hz. Voltage gain of filter is 0.95.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 138.


SIGNAL INPUT
RIN
C1 0.056
Q1 2N3390
+VCC
Q2 2N3565
C2 0.056
3.3K
+VEE
Q3 (R3)
D
S
SU700 (PAIR)
CONTROL INPUT
D
S
Q4 (R4)
RIN » R1
OPERATIONAL AMPLIFIER SUCH AS FAIRCHILD µ709
+
-
OUTPUT
10K
8.2K
25K
+ 22µf 15V
10K

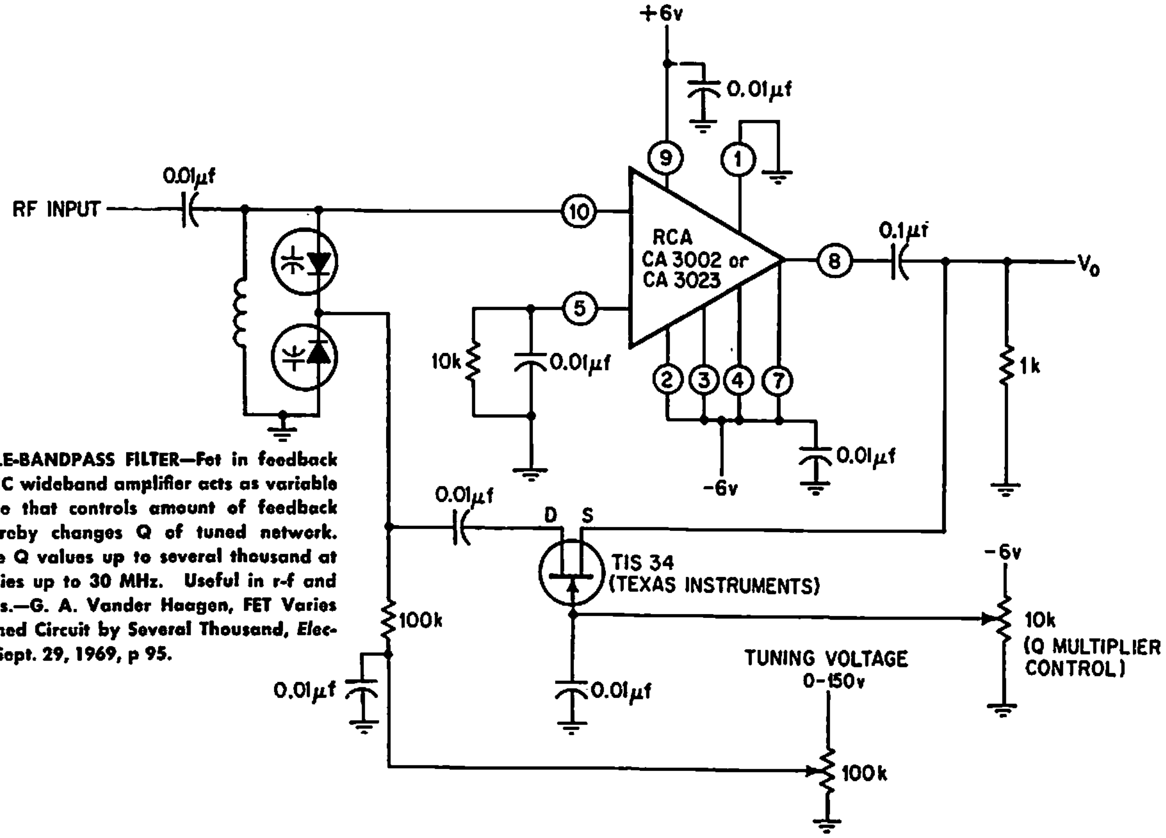
ACTIVE TUNABLE BANDPASS—Uses pair of fet's as tuning element to save money and space. Developed by Philco-Ford for speech bandwidth compression system needed by NASA to reduce transmission power for voice communication from Mars and deep space. Permits transmission of narrow band of encoded information that can be converted into intelligible synthetic speech on earth. Filter frequency is linearly related to control voltage for 20:1 frequency range. Article covers design of low, high, and bandpass filters using active filters with Q up to 100 for frequencies up to several hundred kHz. Bandpass version shown has overall gain of 2.—J. M. Loe, FET's Call The Tune In Active Filter Design, *Electronics*, Oct. 3, 1966, p 98–101.


RAYSISTOR DRIVE
− 25 V
4.7 K
5K
1
Q1
2N335
12 K
VL
13 K
L
0.1
0.1
1.5 K
1.5 K
0.5
5
10 K
Q2
2N94
5 K
6.2 K
2
1
2 K
10 K
5
3.3K
Q3
2N335
1
15 K
3.3K
Vo

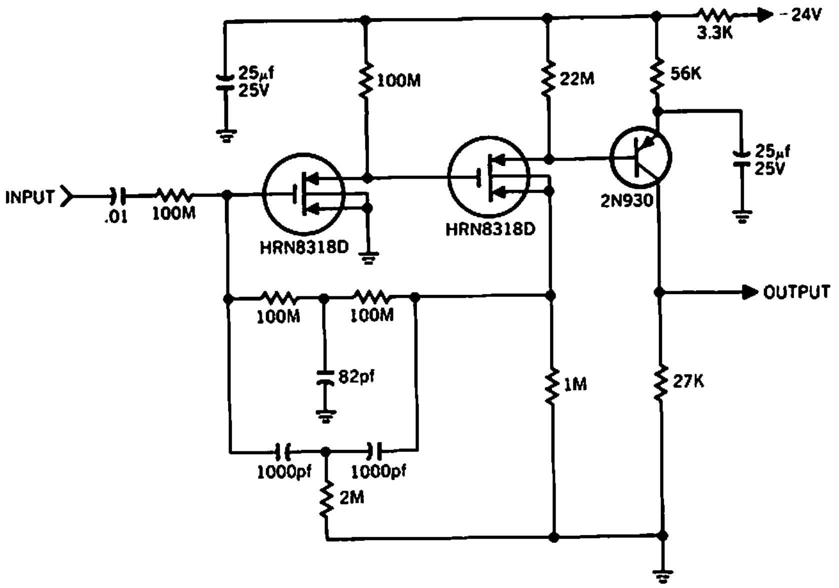
OPTOELECTRONIC CONTROL OF NOTCH FILTER—D-c control voltage applied to lamp of CK1102 Raysistor makes active notch filter track from 800 to 1,200 Hz. To make tracking filter automatically follow applied signal frequency, in same range, use Schmitt trigger, differentiating circuit, and d-c amplifier to provide d-c control voltage of 0 to 1 V whose value varies with applied frequency.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 19.


SCHMITT TRIGGER
DIFFERENTIATING CIRCUIT
D.C. AMPLIFIER
− 15 V
7.5 K
220
620
1
Q1
2N94
1.2 K
Q2
2N94
eIN
1 VPP
T6
15 VPP
120 K
5 K
5 K
10 K
R2
0.5
C1
R1
20 K
44
C2
470
R3
D1
1N108
Q3
2N94
100
R4
Q4
2N552
44
4.7 K
RAYSISTOR CONTROL

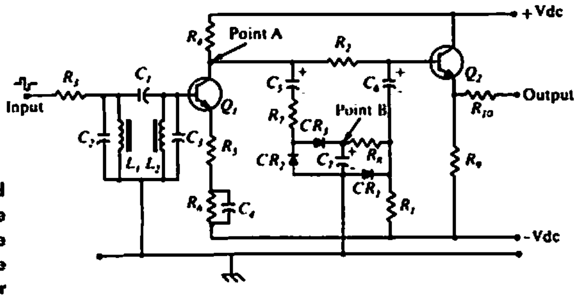
OPTOELECTRONIC TRACKING FILTER CONTROL—Converts input frequency in range of 800 to 1,200 Hz to proportional d-c output voltage from 0 to 1 V for lamp of Raysistor in active notch filter providing automatic tracking in same frequency range.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 20.


+6v
0.01µf
9
1
RF INPUT
0.01µf
10
RCA
CA 3002 or
CA 3023
8
0.1µf
Vo
5
10k
0.01µf
2
3
4
7
0.01µf
-6v
1k
0.01µf
D
S
TIS 34
(TEXAS INSTRUMENTS)
-6v
10k
(Q MULTIPLIER CONTROL)
100k
0.01µf
0.01µf
TUNING VOLTAGE
0-150v
100k

VARIABLE-BANDPASS FILTER—Fet in feedback loop of IC wideband amplifier acts as variable resistance that controls amount of feedback and thereby changes Q of tuned network. Will give Q values up to several thousand at frequencies up to 30 MHz. Useful in r-f and i-f stages.—G. A. Vander Haagen, FET Varies Q of Tuned Circuit by Several Thousand, *Electronics*, Sept. 29, 1969, p 95.

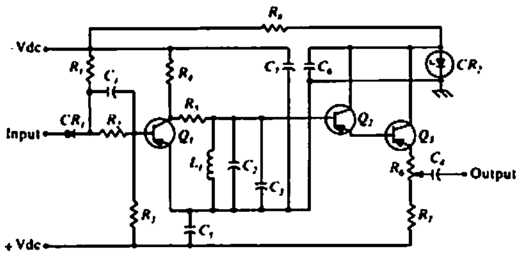

-24V
3.3K
25μf 25V
100M
22M
56K
25μf 25V
INPUT
.01
100M
HRN8318D
HRN8318D
2N930
OUTPUT
100M
100M
82pf
1M
27K
1000pf
1000pf
2M

8-HZ TWIN-T IN MOSFET AMPLIFIER—Filter network in negative feedback loop of two-stage mosfet amplifier gives bandpass with 8-Hz center frequency. Output transistor provides additional gain and relatively low output impedance. Basic circuit can be adapted for detecting large number of discrete audio tones, for power analysis of audio spectrum, or for synthetic reconstruction of speech or music.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 15.


+Vdc
R_6
Point A
R_2
Q_2
Input
R_1
C_1
Q_1
C_5
C_6
Output
R_{10}
R_7
CR_1
Point B
C_2
L_1
L_2
C_3
R_3
CR_2
C_7
R_8
CR_3
R_9
R_4
C_4
R_5
-Vdc

Supplies	+ 6 V dc, – 6 V dc
Q_1	2N336
Q_2	2N333
CR_1	1N137A
CR_2	1N629
CR_3	1N629
R_1	360K
R_2	68K
R_3	82K
R_4	5.6K
R_5	820 Ω
R_6	9.1K
R_7	6.8K
R_8	39K
R_9	16K
C_1	.008 μF
C_2	.093 μF
C_3	.113μF
C_4	2.2 μF, 20 V dc
C_5	1 μF, 20 V dc
C_6	1 μF, 20 V dc
C_7	1 μF, 20 V dc
L_1	1 H
L_2	1 H

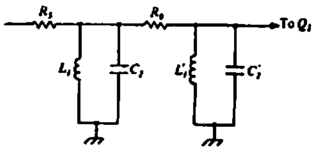
SHARPENING FILTER—Electronic switch and discriminator serve as frequency-sensitive means of sharpening slopes of filter response curve. Can be used to eliminate interference caused by overmodulation of f-m transmitter in subcarrier telemetry systems. Square-wave input from frequency-modulated subcarrier oscillator is converted to sine wave by LC input bandpass filter, amplified by Q1, then converted to positive d-c voltage at point B, proportional to amplitude of signal voltage at point A. When input frequency goes beyond cutoff point of LC filter, voltage at B drops and no longer holds CR1 open; resulting low-impedance path from base of Q2 to ground causes signal voltage to be dropped almost entirely across R2 to give electronic equivalent of narrower filter.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 51.


R_8
-Vdc
R_1
C_1
R_4
C_5
C_4
CR_2
R_3
Input
CR_1
R_2
Q_1
Q_2
Q_3
L_1
C_2
C_3
R_6
C_7
Output
R_5
R_7
C_6
+Vdc

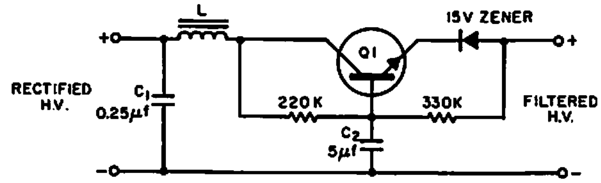
Supplies	– 18 V dc + 12 V dc
Q_1	2N1132
Q_2	2N1132
Q_3	2N1132
CR_1	1N695
Zener CR_2	–
R_6	1K
R_7	500 Ω
R_8	220 Ω
C_1	150 pF
C_4	0.47 μF, 50 V dc
C_5	0.068 μF
C_6	0.068 μF
C_7	0.068 μF

Comp.	1 Kc Filter	10 Kc Filter	100 Kc Filter
R_1	6.8K	6.8K	3.9K
R_2	2.2K	2.2K	8.2K
R_3	22K	22K	39K
R_4	1.2K	1.2K	3.9K
R_5	39K	39K	24K
R_9	10K	—	—
C_2	. 0.068 μF (2)*	0.033 μF	820 pF
L_1	0.25 H (2)*	8 mH	2.5 mH

*1 Kc Filter, Two Filter Stages.

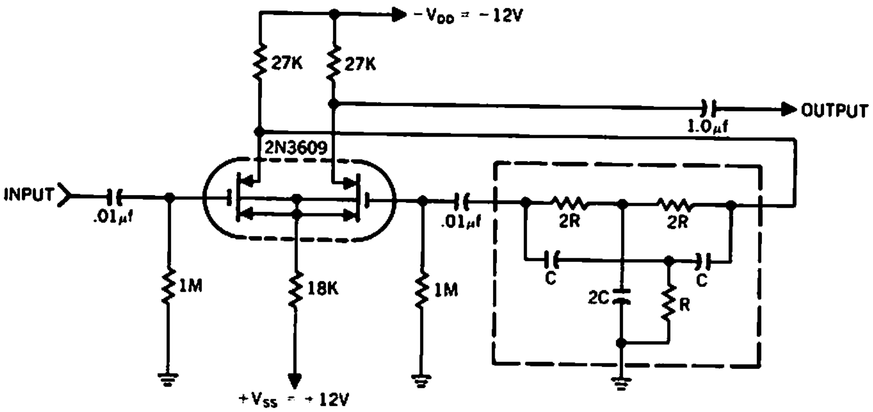

R_3
R_9
To Q_1
L_1
C_2
L_1'
C_2'

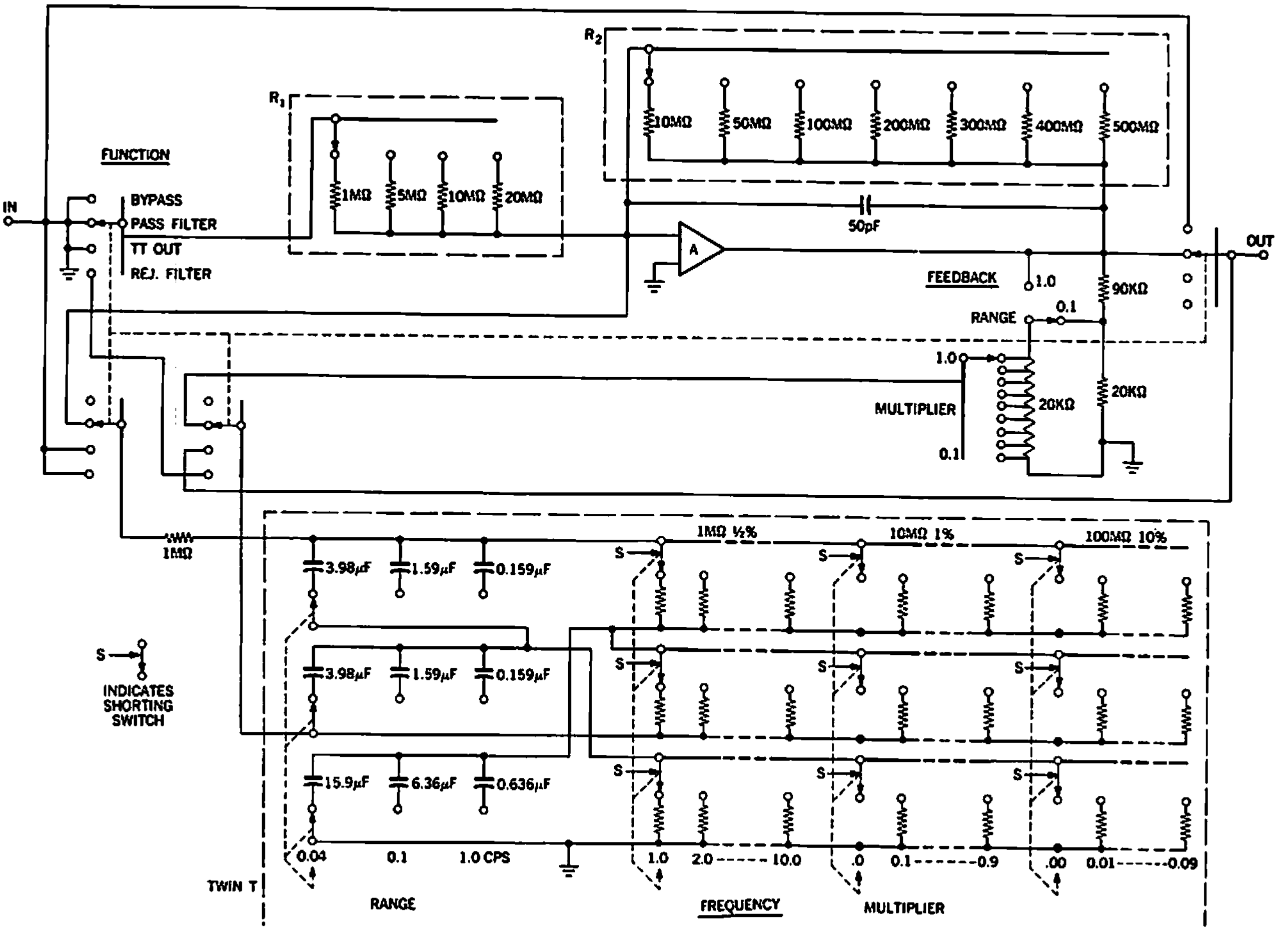
PULSE CONVERSION FILTER—Converts rectangular input signal to highly stable sine-wave output. Q1 applies amplified input signal to filter whose values are given for three different center frequencies. In each case, tuning of tank circuit to desired frequency is done by changing value of C3. Amplitude of sine-wave signal at output of Darlington emitter-follower Q2-Q3 varies with duty cycle of rectangular input waveform; 50% duty cycle gives optimum operation. Circuit can provide coordinated timing signals for several locations.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 54.


L
+
15V ZENER
+
Q1
RECTIFIED H.V.
C1
0.25μf
220K
330K
FILTERED H.V.
C2
5μf
-
-

RIPPLE SUPPRESSION FOR HIGH-VOLTAGE SUPPLY—Capacitance multiplier circuit keeps anode voltage very low for high-voltage photomultiplier. Gives output of 2 kV at 2 mA. Transistor type is not critical.—G. P. Epstein, Photo-Multiplier Filter Adaptable Over Wide Range, *Electronic Design*, April 13, 1964, p 73.

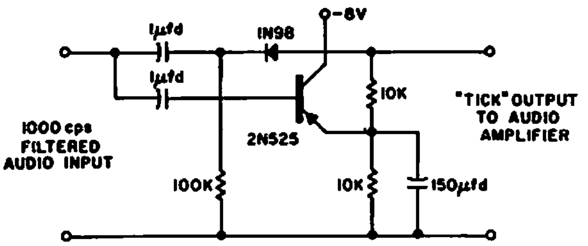
TWIN-T MOSFET—Fet pair acts as differential amplifier with extremely high input impedance. One side of differential amplifier is connected to twin-T filter to give notch filter at frequency determined by values used for R and C. Overall impedance of twin-T network should be above 100K for proper circuit operation.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 17.


-V_DD = -12V
27K
27K
OUTPUT
1.0μf
2N3609
INPUT
.01μf
.01μf
2R
2R
C
C
2C
R
1M
18K
1M
+V_SS = +12V

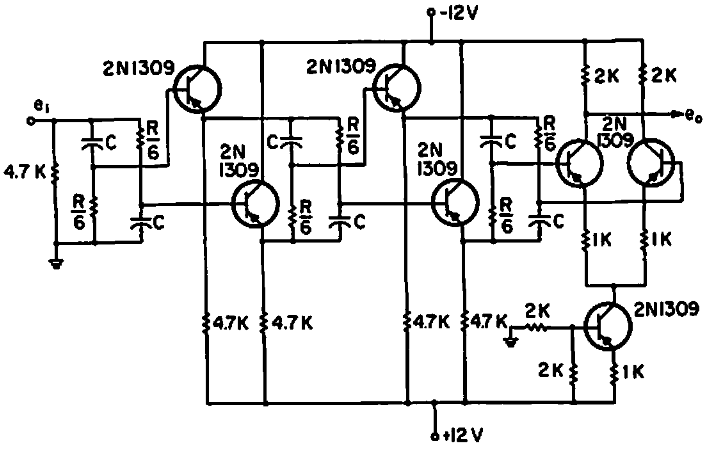

R2
10MΩ
50MΩ
100MΩ
200MΩ
300MΩ
400MΩ
500MΩ
R1
1MΩ
5MΩ
10MΩ
20MΩ
FUNCTION
IN
BYPASS
PASS FILTER
TT OUT
REJ. FILTER
50pF
A
OUT
FEEDBACK
1.0
0.1
RANGE
90KΩ
1.0
MULTIPLIER
20KΩ
20KΩ
0.1
1MΩ
1MΩ ½%
10MΩ 1%
100MΩ 10%
S
3.98μF
1.59μF
0.159μF
3.98μF
1.59μF
0.159μF
15.9μF
6.36μF
0.636μF
S
INDICATES SHORTING SWITCH
0.04
0.1
1.0 CPS
1.0
2.0------10.0
.0
0.1-------0.9
.00
0.01------0.09
TWIN T
RANGE
FREQUENCY
MULTIPLIER

0.04–10.99 HZ TUNABLE TWIN-T—Used in measuring transverse dHS effect in bismuth at liquid helium temperatures. Switching matched sets of fixed capacitors gives three ranges having minimum values of 0.04, 0.1, and 1 Hz. Multiplication by factors between 1.0 and 10.99 in steps of 0.01 is achieved by varying elements of three equal resistance arms. Can be used in feedback line of opamp as pass filter or in input line as rejection filter. Article describes performance and gives details of measurement procedure. Opamp is Philbrick USA-3.—R. D. Brown III, New Methods for Do Haas-Shubnikov Measurements, *IBM Journal*, Nov. 1966, p 462–471.

WWV 1-KHZ TICK-PASSING FILTER—Diode and transistor form biased-base clipper in circuit that passes 1,000-Hz seconds-tick tone in time signals from WWV while rejecting 440 and 600 Hz tones also transmitted. Each tick consists of 5 ms of 1,000-Hz tone. Undesired tones last longer than 5 ms and create back bias on diode, so do not appear in output.—T. E. Fay, Biased Base Clipper Isolates WWV Tick Tone, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 137.

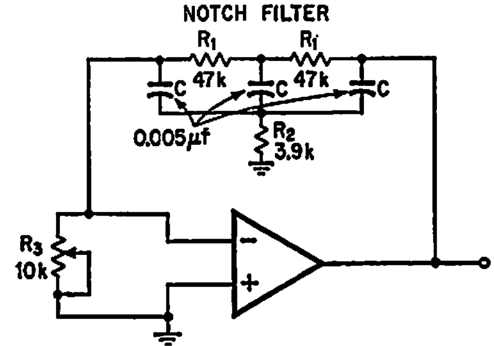


-8V
1μfd
1μfd
IN98
10K
"TICK" OUTPUT TO AUDIO AMPLIFIER
1000 cps FILTERED AUDIO INPUT
2N525
100K
10K
150μfd



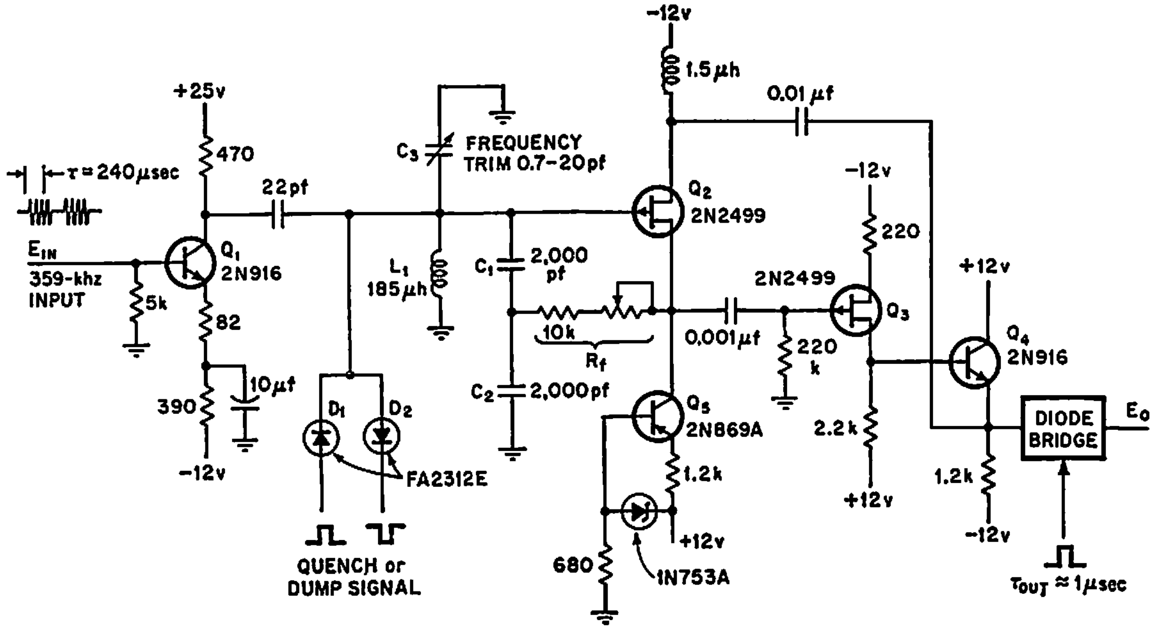
-12V
2N1309
2N1309
e_1
4.7 K
C
R/6
R/6
C
2N 1309
C
R/6
R/6
C
2N 1309
C
R/6
R/6
C
2N 1309
2K
2K
e_o
1K
1K
4.7K
4.7K
4.7K
4.7K
2K
2N1309
2K
1K
+12V

THREE-SECTION ALL-PASS—With 0.01 μF for C and 10K for R (1.67K for R/6), time delay of filter is 100 μs. Article gives design equations and examples of values for other time delays.—T. Mollinga, All-Pass Networks, *EEE*, Oct. 1966, p 84–88.



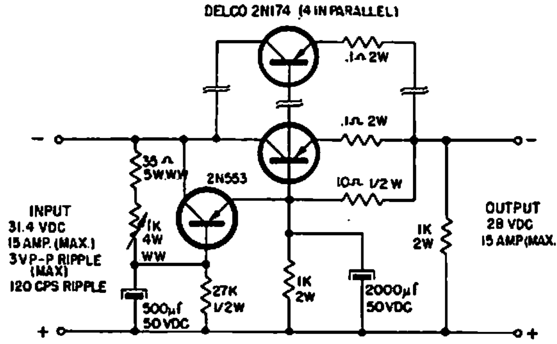
NOTCH FILTER
R_1
R_1
C
47k
C
47k
C
0.005μf
R_2
3.9k
R_3
10k
-
+

SHARP-BANDSTOP NOTCH FILTER—Notch filter alone is useful at low frequencies when bulky inductors are undesirable. Addition of opamp in active network, with R3 adjusted to make amplifier unstable, gives simple oscillator whose frequency corresponds to center frequency of filter (about 10 kHz). Article gives design nomograph for notch filter.—P. V. Wanek, Nomograph Charts a Fast Way to Build a Notch Filter, *Electronics*, September 15, 1969, p 119.

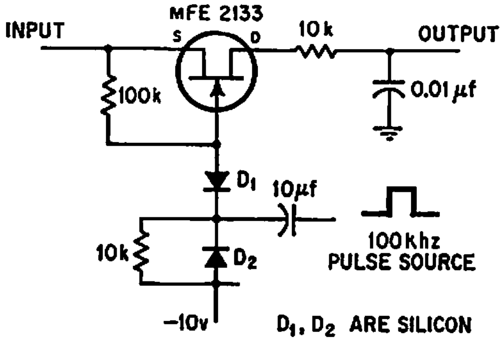


-12v
1.5μh
0.01μf
+25v
470
τ=240μsec
22pf
C_3
FREQUENCY TRIM 0.7-20pf
Q_2
2N2499
-12v
220
E_{IN}
359-khz INPUT
5k
Q_1
2N916
82
L_1
185μh
C_1
2,000 pf
10k
R_f
2N2499
0.001μf
220 k
Q_3
+12v
Q_4
2N916
390
10μf
-12v
D_1
D_2
FA2312E
C_2
2,000pf
Q_5
2N869A
1.2k
2.2k
+12v
1.2k
-12v
DIODE BRIDGE
E_o
+12v
680
1N753A
QUENCH or DUMP SIGNAL
T_{OUT} ≈ 1μsec

359-KHZ ACTIVE BANDPASS—Gated Q multiplier integrates, stores, filters, and analyzes audio tones that may be separated by as little as 80 Hz in phase-modulated communication system. High-Q tank circuit provides loaded Q's greater than 3,000 for integration. Tones are sequentially analyzed by filter, with only the one tone that is tuned to the 359-kHz center frequency providing positive integral during integration period.—R. J. Turner, Q-Multiplier Analyzes Audio-Frequency Tones, *Electronics*, May 25, 1970, p 94.

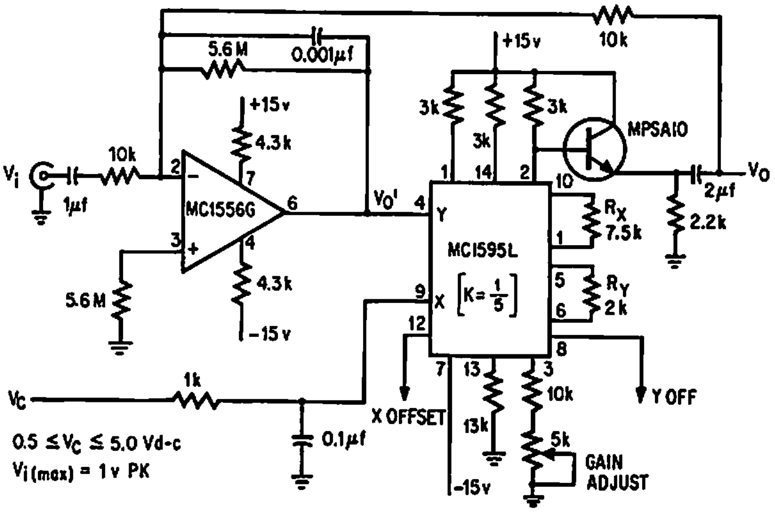

DELCO 2N174 (4 IN PARALLEL)
.1Ω 2W
.1Ω 2W
33 Ω 5W WW
2N553
10Ω 1/2 W
INPUT
31.4 VDC
15 AMP. (MAX.)
3VP-P RIPPLE (MAX)
120 CPS RIPPLE
1K 4W WW
500µf 50VDC
27K 1/2W
1K 2W
2000µf 50VDC
1K 2W
OUTPUT
28 VDC
15 AMP (MAX.)
−
+

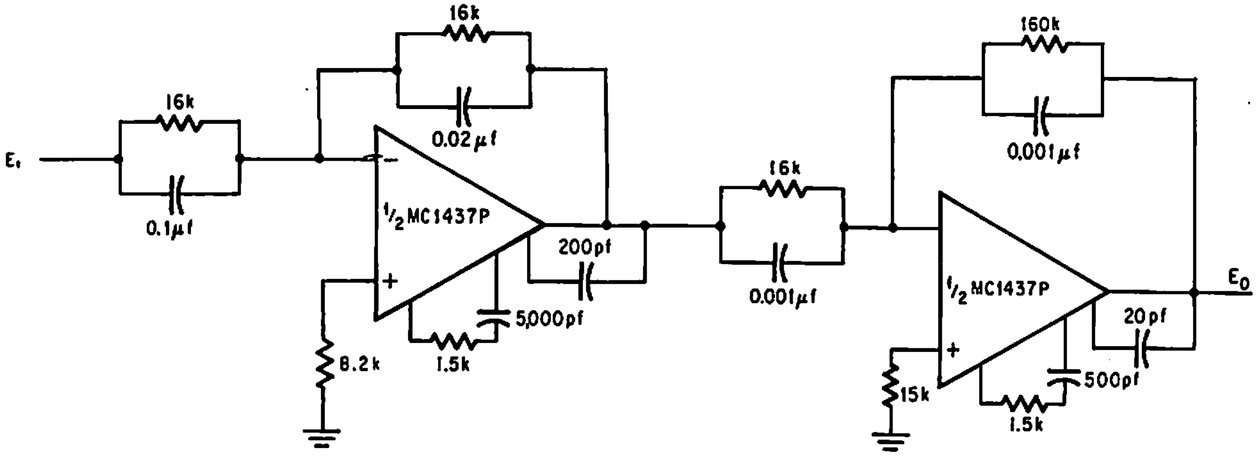
250:1 ELECTRONIC RIPPLE FILTER—Supplements conventional LC filter after that has reduced ripple to a value below 3V p-p, to reduce ripple electronically to 1/250th of that at input. Uses paralleled transistors to dissipate heat. Report gives theory of operation and design considerations.—Electronic Ripple Filter, Delco Radio, Kokomo, Ind., No. 28, 1965.


MFE 2133
INPUT
S
D
10k
OUTPUT
100k
0.01µf
D1
10µf
100Khz PULSE SOURCE
10k
D2
−10v
D1, D2 ARE SILICON

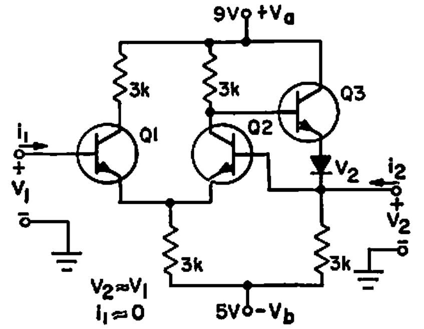
FET CONTROLS R-C FILTER—Switching of fet by pulse width modulated source varies circuit resistance, thereby controlling corner frequency (frequency selectivity) of R-C filter. As duty factor of pulse source is varied from 1 to 0 in circuit shown, effective resistance varies from 10,000 ohms to infinity.—L. L. Hamilton, Pulse-Train Duty Factor Controls RC Filter, *Electronics*, Aug. 4, 1969, p 93.

IC ACTIVE LOW-PASS—Gives transfer function of single-pole low-pass filter whose pole location can be controlled linearly by external d-c voltage Vc. Can be used as adaptive audio filter or voltage-tunable low-pass network. Gives one full decade of control in audio frequency range by varying Vc between 0.5 and 5 V.—E. Renschler and D. Weiss, Try the Monolithic Multiplier as a Versatile A-C Design Tool, *Electronics*, June 8, 1970, p 100–105.

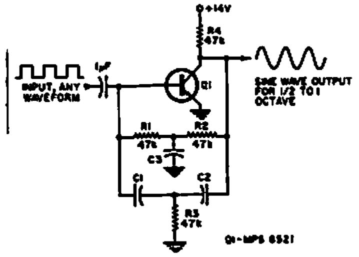

5.6M
0.001µf
10k
+15v
+15v
4.3k
3k
3k
3k
MPSA10
Vi
1µf
10k
MC1556G
2
7
6
3
4
Vo'
4.3k
−15v
5.6M
1
14
2
10
4
Y
MC1595L
[K = 1/5]
9
X
12
Rx 7.5k
1
5
6
Ry 2k
8
2µf
Vo
2.2k
1k
Vc
0.1µf
7
13
3
13k
10k
5k
X OFFSET
Y OFF
GAIN ADJUST
−15v
0.5 ≤ Vc ≤ 5.0 Vd-c
Vi (max) = 1v PK


16k
16k
0.02µf
E1
0.1µf
1/2 MC1437P
−
+
200pf
5,000pf
8.2k
1.5k
16k
0.001µf
160k
0.001µf
1/2 MC1437P
+
20pf
500pf
15k
1.5k
E0

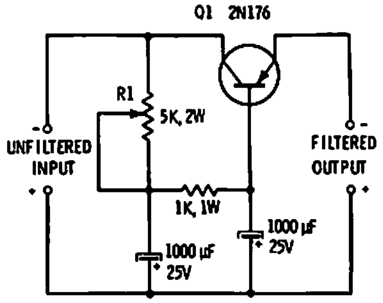
DUAL-OPAMP ACTIVE FILTER—Use of dual IC operational amplifier as active filter takes advantage of isolation between amplifiers to simplify calculations for obtaining desired transfer function. Article gives design equations. Compensating networks are added to both amplifiers to avoid instability with different d-c gains. First-stage gain is unity and second is 10, so amplifier is compensated for gain of 10.—B. Wolling, Active Filters: The Op Amp Saves Time and Money, *Electronics*, Feb. 3, 1969, p 82–90.


9V +Va
3k
3k
Q3
Q1
Q2
i_1
+
V_1
V_2
i_2
+
V_2
3k
3k
$V_2 \approx V_1$
$I_1 \approx 0$
5V -Vb

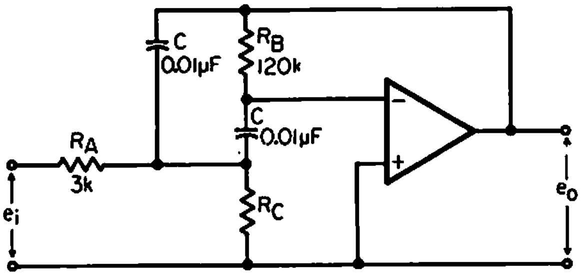
UNITY GAIN—Basic circuit fulfills standard conditions for active very low frequency filter, wherein V2 = V1 and input current is zero. Zener diode V2 serves only for biasing.—J. L. Hogin, Active Filters, *Electronics World*, April 1969, p 58–60.


+14V
R4
47k
1μF
INPUT, ANY WAVEFORM
Q1
SINE WAVE OUTPUT FOR 1/2 TO 1 OCTAVE
R1
47k
R2
47k
C3
C1
C2
R3
47k
Q1-MPS 6521

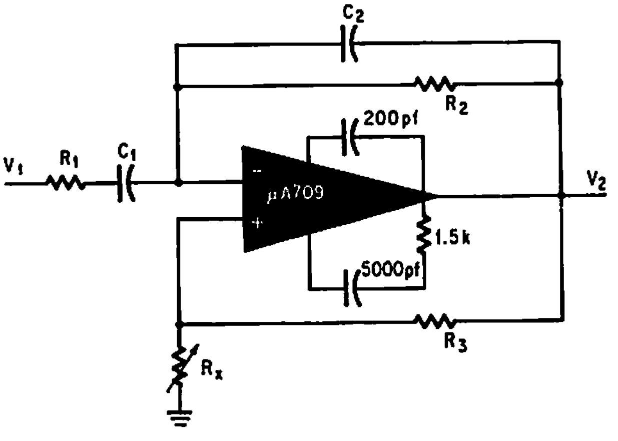
TWIN-T ACTIVE FILTER—Circuit is adjusted well into active region by choice of resistor values, to serve as active bandpass network. Useful for wave-shaping, as when producing flute or tibia voices from square waves in electronic organ. Bandpass is equivalent to about 1 octave of frequency. Article gives nomogram for selecting filter elements for any center frequency.—F. B. Maynard, Twin T's: Designs & Applications, *Electronics World*, Aug. 1968, p 35–37 and 64.


Q1 2N176
R1
5K, 2W
-
UNFILTERED INPUT
+
-
FILTERED OUTPUT
+
1K, 1W
1000 μF 25V
1000 μF 25V

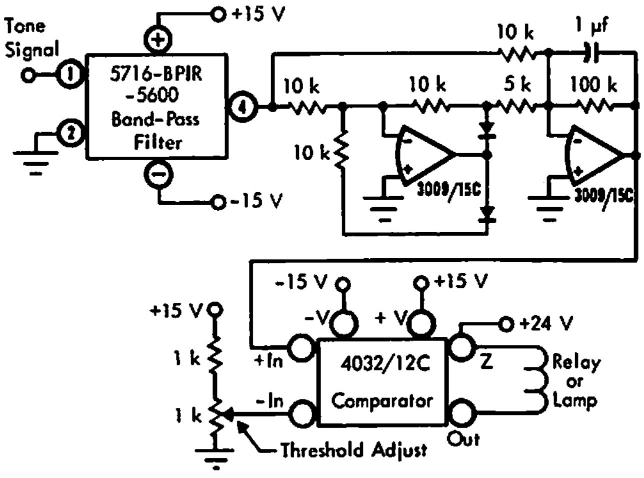
ELECTRONIC FILTER—Filtering action is comparable to that of 10,000-μF capacitor, reducing ripple in transistor power supply d-c output of 25 V to only a few millivolts. Current rating is 0.5 A.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 8.


C
0.01μF
R_B
120k
C
0.01μF
R_A
3k
R_C
e_i
e_o
-
+

ACTIVE ADJUSTABLE BANDPASS—Requires only low-cost opamp and five discrete components. Values of Rc from 1,100 to 406 ohms give center frequency range of 1.6 to 2.4 kHz, without changing gain of 26 dB or bandwidth of 260 Hz for 3 dB down. Article gives procedure for designing filter for other parameters.—L. Robinson, Active Bandpass Filter with Adjustable Center Frequency and Constant Bandwith, *EEE*, Feb. 1968, p 124.

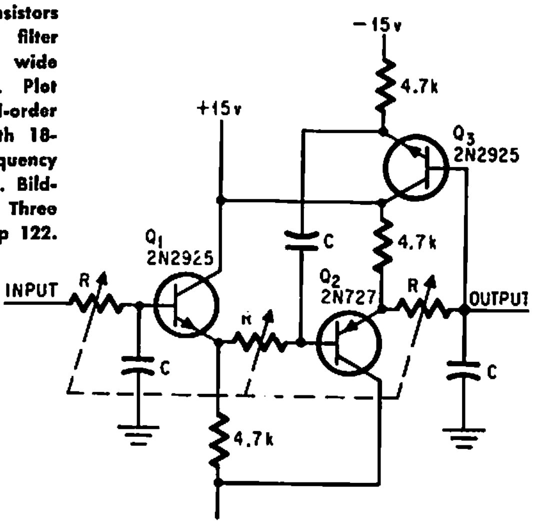

C_2
R_2
200pf
V_1
R_1
C_1
μA709
-
+
V_2
1.5k
5000pf
R_3
R_x

IC BANDPASS FILTER—Fairchild μA709 opamp provides both gain and frequency selectivity without use of inductors. Rx varies Q of circuit independently of center frequency determined by values of R-C inductor-synthesizing feedback elements. Filter is useful for f-m recording in range from 1 to 1,000 Hz and other applications where bulk and weight of inductor would create problems. For Q of 20, voltage gain is 7. Article gives transfer function equation.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.

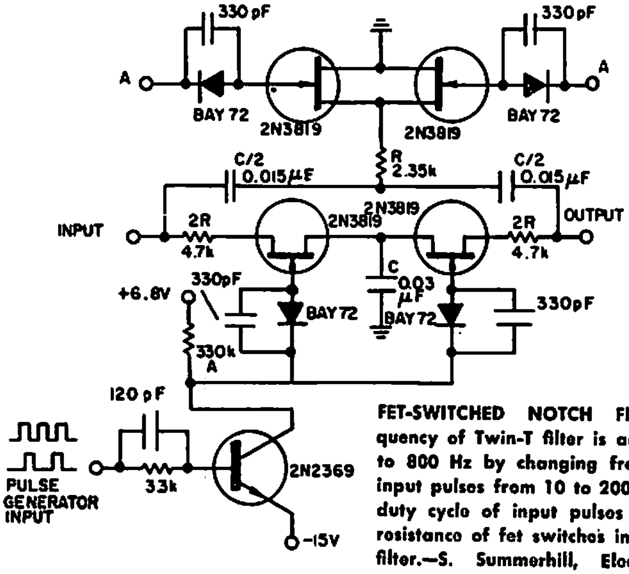

Tone Signal
1
2
+
+15 V
5716-BPIR -5600 Band-Pass Filter
-
-15 V
4
10 k
10 k
10 k
5 k
10 k
1 μf
100 k
3009/15C
3009/15C
-15 V
+15 V
+15 V
-V
+ V
+24 V
1 k
+In
4032/12C Comparator
Z
Relay or Lamp
1 k
-In
Out
Threshold Adjust

TONE SIGNALING SYSTEM—Uses Burr-Brown active bandpass filter module to detect and indicate presence of 560-Hz signal tone at 0.1 V rms. Precision rectifier with gain of 10 and time constant of 0.1 s converts desired a-c signal into d-c signal for comparison with reference voltage. Relay or lamp is actuated whenever d-c signal exceeds preset input threshold.—Burr-Brown Computer Designed Active Filters, Burr-Brown Research, PDS-203A, 1968, p 10.

SHARP CUTOFF—Three identical RC networks and three inexpensive unity-gain transistors serve as sharp-cutoff low-frequency filter whose response can be shifted over wide range by adjusting ganged resistors R. Plot of output voltage vs frequency is third-order Butterworth curve, maximally flat with 18-dB-per-octave rolloff after cutoff frequency determined by values of R and C.—P. Bildstein, Third-Order Active Filter Uses Three Transistors, *Electronics*, Oct. 14, 1968, p 122.

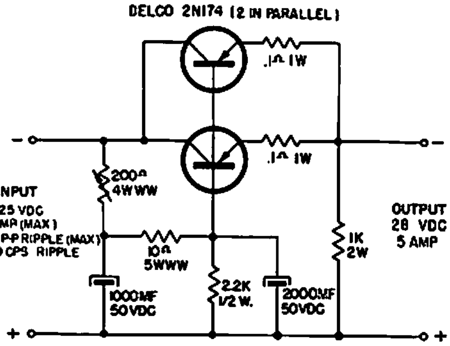


−15v
4.7k
+15v
Q3
2N2925
C
4.7k
Q1
2N2925
Q2
2N727
INPUT
R
R
R
OUTPUT
C
C
4.7k
−15v



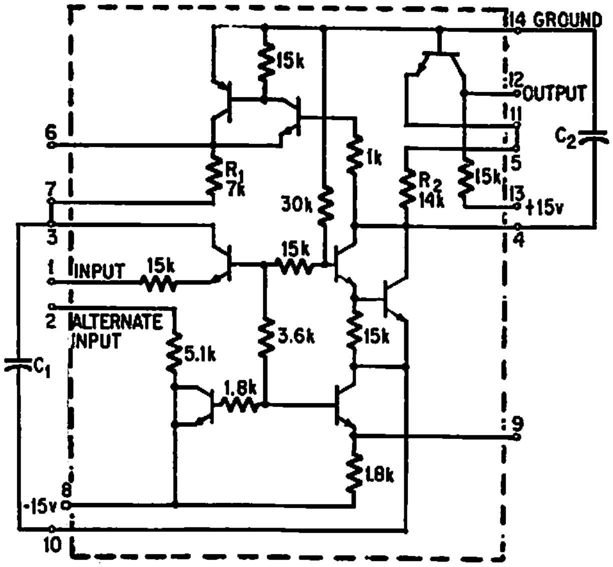
330 pF
330 pF
A
A
BAY 72
2N3819
2N3819
BAY 72
C/2
0.015µF
R
2.35k
C/2
0.015µF
INPUT
2R
4.7k
2N3819
2N3819
2R
4.7k
OUTPUT
C
0.03 µF
330pF
+6.8V
BAY72
BAY72
330pF
330k
A
120 pF
PULSE GENERATOR INPUT
33k
2N2369
−15V

FET-SWITCHED NOTCH FILTER—Notch frequency of Twin-T filter is adjustable from 30 to 800 Hz by changing frequency of 2.5-µs input pulses from 10 to 200 kHz. Change in duty cycle of input pulses changes effective resistance of fet switches in resistive arms of filter.—S. Summerhill, Electronically Tuned Notch Filter uses FET as a Resistor, *Electronic Design*, March 15, 1970, p 212 and 214.



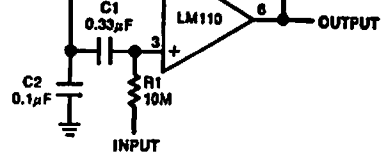
DELCO 2N174 (2 IN PARALLEL)
.1Ω 1W
.1Ω 1W
INPUT
31.25 VDC
5AMP (MAX)
3V P-P RIPPLE (MAX)
120 CPS RIPPLE
200Ω
4W WW
10Ω
5W WW
1000MF
50VDC
2.2K
1/2 W.
2000MF
50VDC
1K
2W
OUTPUT
28 VDC
5 AMP

60:1 ELECTRONIC RIPPLE FILTER—If conventional LC filter has reduced power supply ripple below 3 V p-p, this simple electronic filter will reduce this residual ripple to 1/60th of its value. Thus, if power supply has 60-mV p-p ripple initially, ripple at output of electronic filter will be only about 1 mV p-p. Report covers theory and design.—Electronic Ripple Filter, Delco Radio, Kokomo, Ind., No. 28, 1965.



14 GROUND
15k
12 OUTPUT
11
6
C2
1k
R1
7k
R2
14k
15k
5
7
30k
13 +15v
3
4
15k
1 INPUT 15k
2 ALTERNATE INPUT
5.1k
3.6k
15k
C1
1.8k
9
1.8k
8
−15v
10

OPTIMUM ACTIVE FILTER—IC version, presented as example of detailed design procedures given for 24 different active filter designs, uses biasing arrangement that minimizes sensitivity to thermal and supply voltage variations. Can be tuned from d-c through 40 kHz, with any Q up to about 2,000, with no tendency to oscillate. Frequency response curve corresponds to that of ideal R-L-C- filter.—J. W. Mullaney, Active Filters: Part II—Varying the Approach, *Electronics*, July 21, 1969, p 86–93.



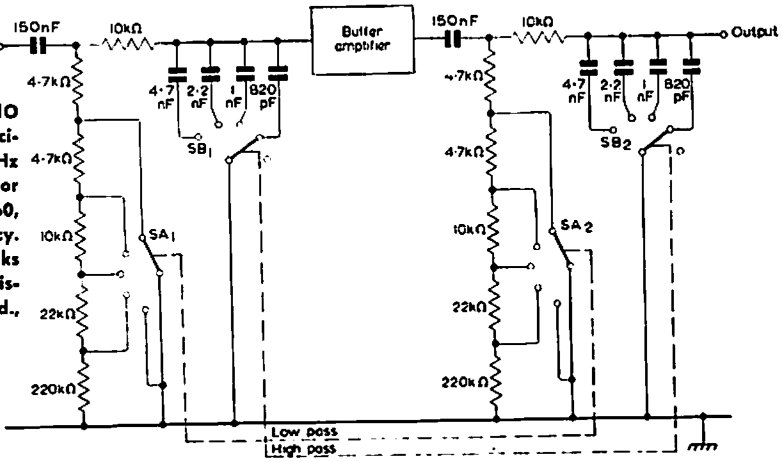
R2
1K
C1
0.33µF
LM110
6
OUTPUT
3
C2
0.1µF
R1
10M
INPUT

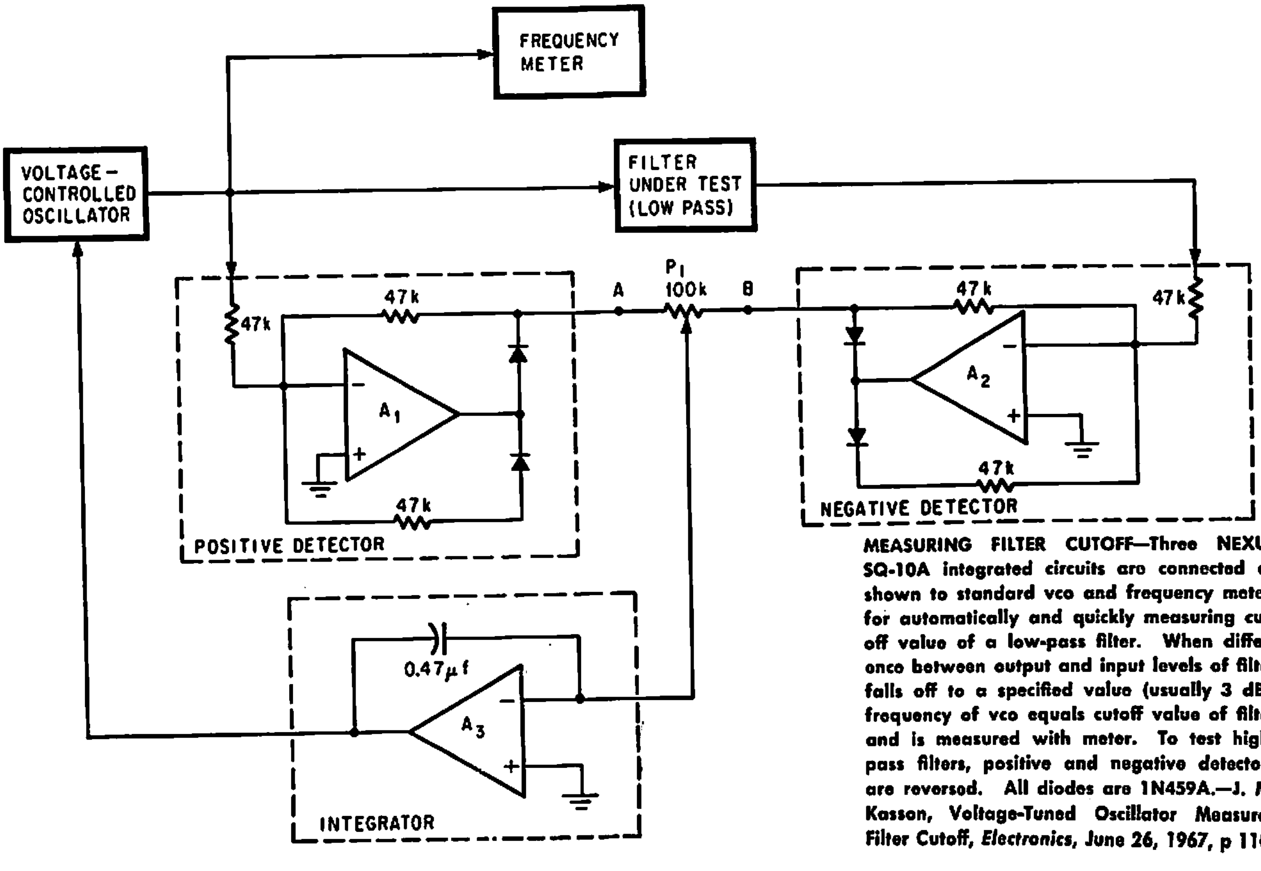
20-MHZ BANDWIDTH—IC uses super-gain transistors in follower requiring 10-nA bias current and giving 30-µs slew.—Bandpass Filter (National Semiconductor ad), *Electronic News*, June 8, 1970, p 11.

CHAPTER 29

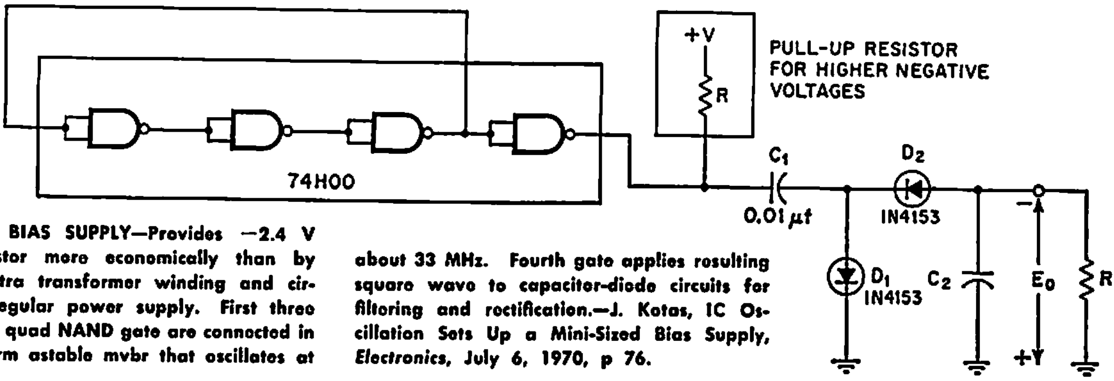
Filter Circuits—Passive

COMBINATION LOW-PASS HIGH-PASS AUDIO FILTER—High-pass selector switch (for capacitors) gives choice of 11, 9, 4.5, and 3.2 kHz for cutoff frequency. Low-pass switch (for divider resistors) gives choice of 40, 80, 160, and 720 Hz for lower cutoff frequency. Unity-gain buffer in series with RC networks prevents interaction between filters.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 136.

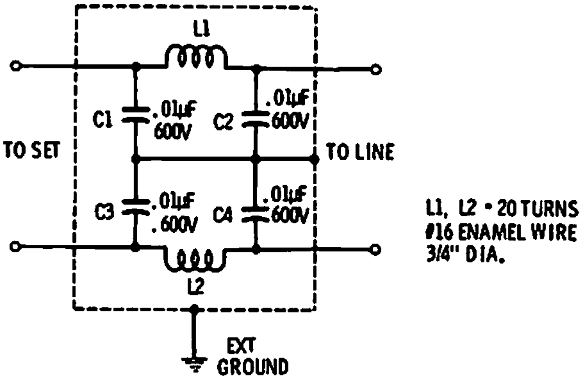

Input
150nF
10kΩ
4·7kΩ
4·7kΩ
10kΩ
22kΩ
220kΩ
4·7 nF
2·2 nF
1 nF
820 pF
SB1
SA1
Buffer amplifier
150nF
10kΩ
Output
4·7kΩ
4·7kΩ
10kΩ
22kΩ
220kΩ
4·7 nF
2·2 nF
1 nF
820 pF
SB2
SA2
Low pass
High pass


FREQUENCY METER
VOLTAGE-CONTROLLED OSCILLATOR
FILTER UNDER TEST (LOW PASS)
47k
47k
A1
47k
POSITIVE DETECTOR
A
P1
100k
B
47k
47k
A2
47k
NEGATIVE DETECTOR
0.47μf
A3
INTEGRATOR

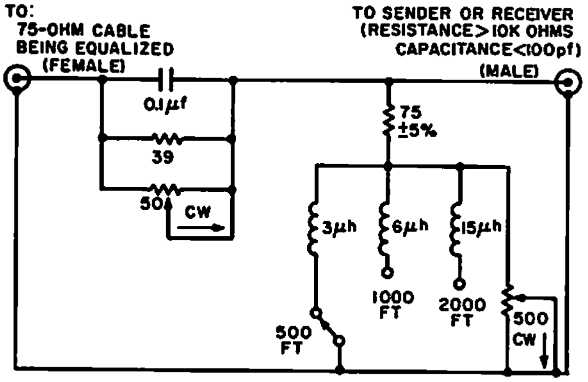
MEASURING FILTER CUTOFF—Three NEXUS SQ-10A integrated circuits are connected as shown to standard vco and frequency meter, for automatically and quickly measuring cutoff value of a low-pass filter. When difference between output and input levels of filter falls off to a specified value (usually 3 dB), frequency of vco equals cutoff value of filter and is measured with meter. To test high-pass filters, positive and negative detectors are reversed. All diodes are 1N459A.—J. M. Kasson, Voltage-Tuned Oscillator Measures Filter Cutoff, *Electronics*, June 26, 1967, p 110.


74H00
+V
R
PULL-UP RESISTOR FOR HIGHER NEGATIVE VOLTAGES
C1
0.01 µf
D2
IN4153
D1
IN4153
C2
−
E0
+V
RL

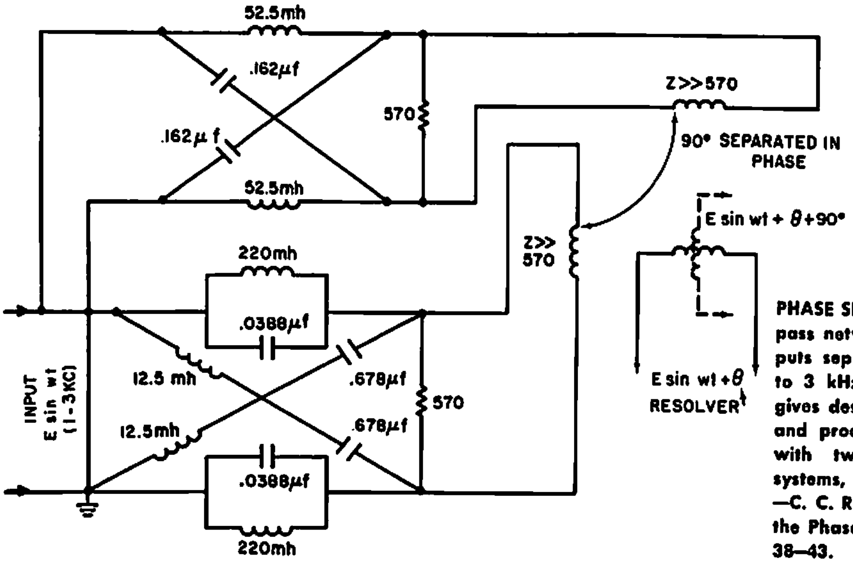
NEGATIVE BIAS SUPPLY—Provides −2.4 V for transistor more economically than by placing extra transformer winding and circuitry in regular power supply. First three gates in IC quad NAND gate are connected in loop to form astable mvbr that oscillates at about 33 MHz. Fourth gate applies resulting square wave to capacitor-diode circuits for filtering and rectification.—J. Kotas, IC Oscillation Sets Up a Mini-Sized Bias Supply, *Electronics*, July 6, 1970, p 76.


L1
C1
.01µF 600V
C2
.01µF 600V
TO SET
TO LINE
C3
.01µF .600V
C4
.01µF 600V
L2
EXT GROUND
L1, L2 • 20 TURNS #16 ENAMEL WIRE 3/4" DIA.

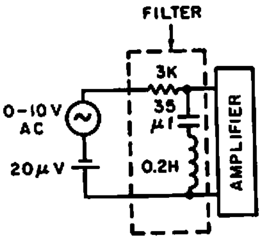
POWER-LINE INTERFERENCE FILTER—Used in a-c line to tv or radio receiver to suppress interference traveling over power line from nearby fluorescent lamp, electronic mixer, neon sign, or other source of rfi. Metal housing of filter should be grounded. For tv set, wind coils with No. 14 enamel wire. Use line cord at line side, and outlet for set.—J. P. Shields, "Novel Electronic Circuits," H. W.. Sams & Co., Indianapolis, Ind., 1968, p 59.


TO: 75-OHM CABLE BEING EQUALIZED (FEMALE)
TO SENDER OR RECEIVER (RESISTANCE>10K OHMS CAPACITANCE<100pf) (MALE)
0.1µf
39
50
CW
75 ±5%
3µh
6µh
15µh
1000 FT
2000 FT
500 FT
500 CW

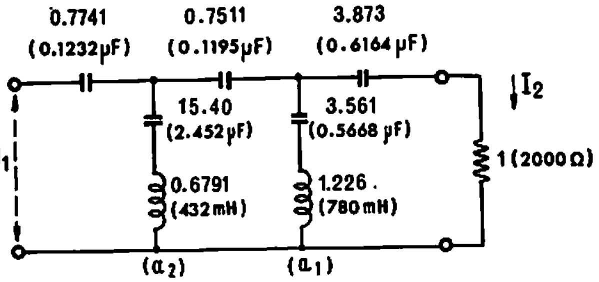
75-OHM COAX EQUALIZER—Passive filter network compensates for amplitude attenuation and phase retardation at video frequencies in four different lengths of cable. When used at both ends, provides 5 dB gain at 5 kHz and slight loss below 200 kHz. If used only at one end, other end must be terminated in resistance within 25% of 75-ohm nominal cable impedance.—A. H. Turner, Equalizer for 75-Ohm Cables Reduces Phase Retardation, *Electronic Design*, March 30, 1964, p 71.


52.5mh
.162µf
570
.162µ f
52.5mh
Z>>570
90° SEPARATED IN PHASE
Z>> 570
E sin wt + θ+90°
220mh
.0388µf
12.5 mh
.678µf
570
12.5mh
.678µf
.0388µf
220mh
INPUT E sin wt (1-3KC)
E sin wt +θ
RESOLVER

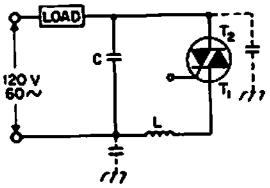
PHASE SPLITTER—Combines simple unipole all-pass network with duopole filter to give outputs separated by 90 deg, operating from 1 to 3 kHz, with tolerance of 5 deg. Article gives design equations for each type of filter and procedures for combining them for use with two-phase resolvers, single-sideband systems, and phase modulation applications. —C. C. Routh, All-Pass Filters Accurately Split the Phase, *Electronic Design*, Jan. 18, 1965, p 38–43.


FILTER
3K
35 μf
0.2H
0-10 V AC
20μV
AMPLIFIER

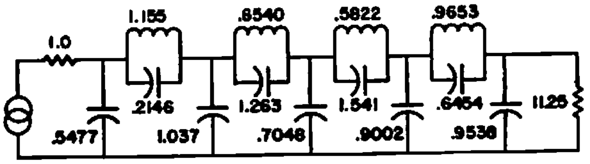
SUPPRESSING 60-HZ PICKUP—Simple LC filter improves performance of sensitive d-c amplifiers for microvolt d-c signals in the presence of 60-Hz power-line pickup up to 10 V. —R. L. Nuttall and D. C. Ginnings, Is 60-Cycle Pickup Degrading the Performance of your DC Amplifiers? *Electronic Design*, Dec. 20, 1965, p 34–35.


0.7741
(0.1232μF)
0.7511
(0.1195μF)
3.873
(0.6164μF)
15.40
(2.452μF)
3.561
(0.5668 μF)
0.6791
(432mH)
1.226
(780mH)
U1
I2
1(2000Ω)
(α2)
(α1)

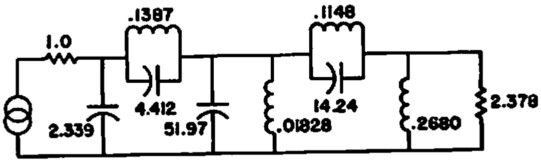
HIGH-PASS RLC—Provides attenuation of 52 dB below 245 Hz and only 0.044 dB above 500 Hz when inserted between voltage generator and 2,000-ohm resistance. Article gives design procedure.—P. Allemandou, Transfer Functions of RLC Filters, *IEEE Transactions on Circuit Theory*, Dec. 1968, p 483–485.


LOAD
C
T2
T1
120 V 60~
L

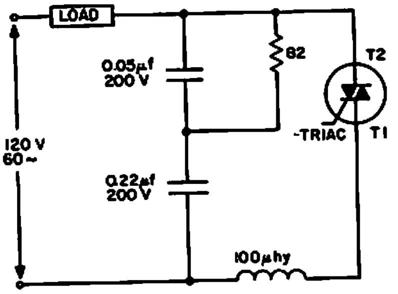
SUPPRESSING SCR AND TRIAC RFI—Single L-C low-pass filter having resonant frequency of 50 kHz gives about 40 dB of noise suppression at low end of broadcast band, for suppressing conducted rfi generated each time triac T2 (or scr) fires in resistive circuit such as lamp dimmer. At each firing, occurring 120 times per second with full-wave phase control, load current jumps from zero in fraction of microsecond and generates almost infinite spectrum of energy. For loads between 150 and 1,000 W, L can be 100 μH and C 0.1 μF.—J. H. Galloway, RF Filter Considerations for Triac and SCR Circuits, General Electric, Syracuse, N.Y., No. 201.19, 1966.


1.0
1.155
.8540
.5822
.9653
.2146
1.263
1.541
.6454
1125
.5477
1.037
.7048
.9002
.9538

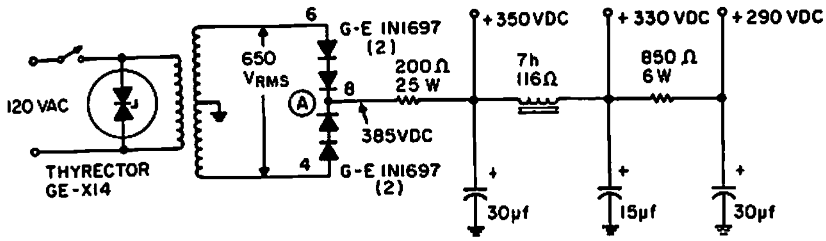
NINTH-ORDER LOW-PASS—When predistorted for average dissipation factor of 0.005, passband loss varies between 5.23 and 5.5 dB over passband of 0 to 1.0 frequencies.—W. N. Tuttle, Simplified Procedures for Approximation and Predistortion in Filter Synthesis by Digital Computer, *IEEE Transactions on Circuit Theory*, Dec. 1968, p 488–492.


1.0
.1387
.1148
2.339
4.412
51.97
.01828
14.24
.2680
2.378

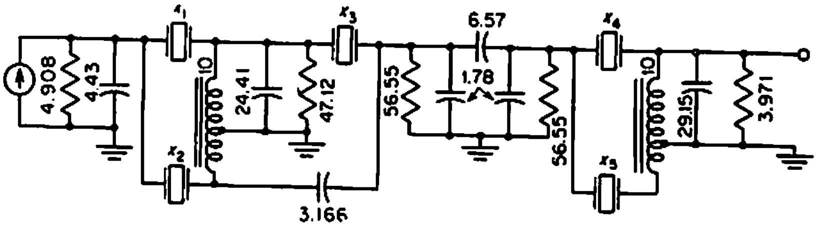
COMPUTER-DESIGNED BANDPASS—Values shown are for sixth-order symmetrical bandpass filter predistorted for average dissipation factor of 0.02. Attenuation is 7.45 dB for bandwidth of 10% above and 9% below center frequency.—W. N. Tuttle, Simplified Procedures for Approximation and Predistortion in Filter Synthesis by Digital Computer, *IEEE Transactions on Circuit Theory*, Dec. 1968, p 488–492.


LOAD
0.05μf 200 V
82
T2
TRIAC
T1
120 V 60~
0.22μf 200 V
100μhy

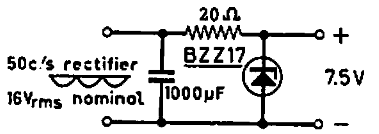
DAMPED R-F FILTER—Suppresses broadcast-band conducted rfi created by step-function action of triac. Upper resistor and capacitor provide damping required for proper operation under light load conditions, as for 60-W lamp dimmer.—"SCR Manual," 4th Edition, General Electric, 1967, p 334–335.


6
G-E IN1697
(2)
650 VRMS
A
8
200Ω
25 W
385VDC
4
G-E IN1697
(2)
120 VAC
THYRECTOR GE-X14
+350VDC
7h
116Ω
+330 VDC
850 Ω
6 W
+290 VDC
30μf
15μf
30μf

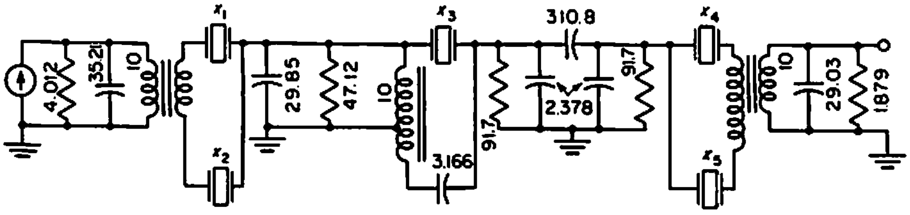
SILICON RECTIFIERS FOR TUBES—Gives procedures for substituting silicon rectifiers for vacuum, gas, or mercury rectifier tube. Arrangement shown is for 5U4GB. Only other change is addition of thyrector across primary to absorb line transients. Silicon rectifiers will give about 10% higher output voltage, which is usually not objectionable. To reduce supply voltage, place resistor (around 200 ohms at 25 W) in series with each pair of rectifiers.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 192.


x_1
x_3
6.57
x_4
4.908
4.43
10
24.41
47.12
56.55
1.78
56.55
10
29.15
3.971
x_2
x_5
3.166

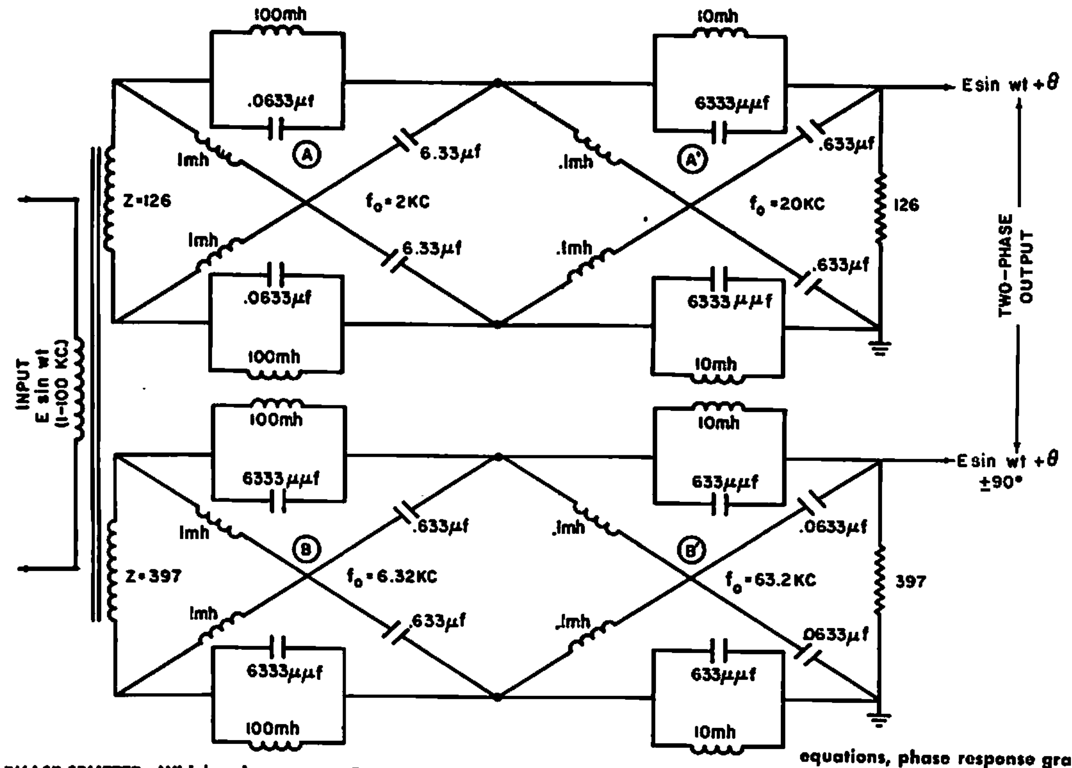
10-MHZ FIVE-CRYSTAL NARROW-BAND—Bandwidth for 3 dB down is 20 kHz, using AT-cut crystals and autotransformers having 10-μH inductance, Q of 150, and unity coupling. Article gives design equations for Chebyshev-type response and 1-dB passband ripple.—D. S. Humpherys, Network Synthesis of Narrow-Band Crystal Filters, *Electro-Technology*, Nov. 1965, p 36–43.


20Ω
BZZ17
50c/s rectifier
16Vrms nominal
1000μF
+
7.5V
−

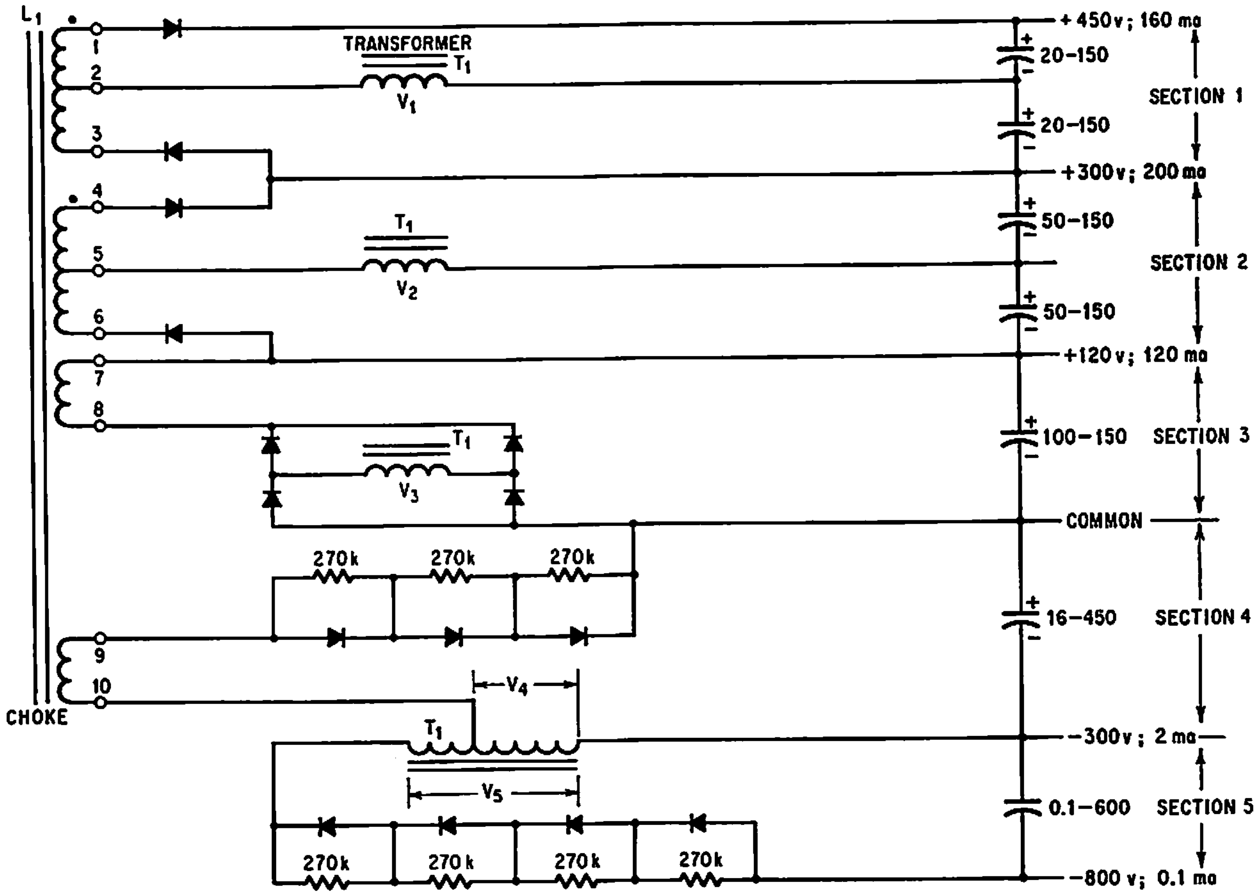
ZENER REPLACES CAPACITOR—Use of zener in place of output capacitor in smoothing filter gives smoothing comparable to that of 1,000-μF capacitor. Load current may vary from 0 to 300 mA.—Zener Diodes and Their Applications, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1966.


x_1
x_3
310.8
x_4
4.012
35.21
10
29.85
47.12
10
91.7
2.378
91.7
10
29.03
1.879
x_2
3.166
x_5

10-MHZ CRYSTAL FILTER—Design is based on left-half-plane reflection zeros, with hybrid transformers at each end for impedance transformations. Bandwidth is 20 kHz for 3 dB down, using AT-cut crystals and autotransformers having 10-μH inductance.—D. S. Humpherys, Network Synthesis of Narrow-Band Crystal Filters, *Electro-Technology*, Nov. 1965, p 36–43.


100mh
.0633μf
lmh
Ⓐ
6.33μf
f_o=2KC
lmh
6.33μf
.0633μf
100mh
10mh
6333μμf
.lmh
Ⓐ'
.633μf
f_o=20KC
.lmh
.633μf
6333μμf
10mh
126
Z=126
Esin wt+θ
TWO-PHASE OUTPUT
INPUT E sin wt (1-100 KC)
100mh
6333μμf
lmh
Ⓑ
.633μf
f_o=6.32KC
lmh
.633μf
6333μμf
100mh
10mh
633μμf
.lmh
Ⓑ'
.0633μf
f_o=63.2KC
.lmh
.0633μf
633μμf
10mh
Z=397
397
Esin wt +θ ±90°

CASCADED PHASE-SPLITTER—Wideband operation from 1 to 100 kHz is obtained by cascading all-pass filters in both channels. Outputs are separated by 90 deg, as required for use with resolvers, ssb systems, and phase modulation systems. Article gives design equations, phase response graphs, and logical design procedures.—C. C. Routh, All-Pass Filters Accurately Split the Phase, *Electronic Design*, Jan. 18, 1965, p 38–43.

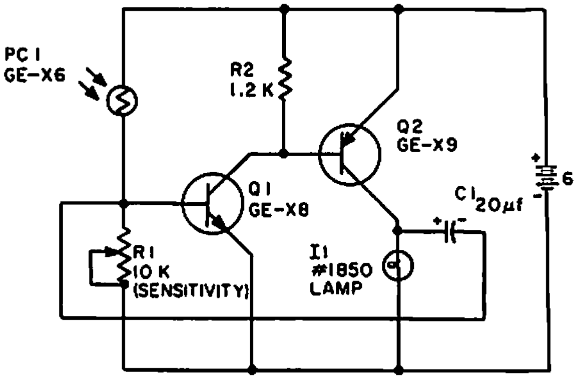

L1
CHOKE
1
2
3
4
5
6
7
8
9
10
TRANSFORMER
T1
V1
T1
V2
T1
V3
270k
270k
270k
V4
T1
V5
270k
270k
270k
270k
+450v; 160 ma
20-150
20-150
SECTION 1
+300v; 200 ma
50-150
SECTION 2
50-150
+120v; 120 ma
100-150
SECTION 3
COMMON
16-450
SECTION 4
-300v; 2 ma
0.1-600
SECTION 5
-800 v; 0.1 ma

ALL DIODES = 1N1763

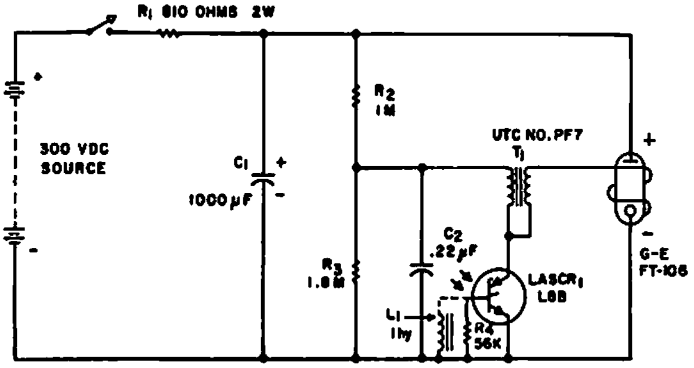
FIVE D-C OUTPUTS WITH ONE CHOKE—Weight-reducing design requires only one multiple-winding choke. Primary winding of transformer T1 (not shown) connects to a-c line, and secondary windings T1 supply required a-c voltages for the five choke-input rectifier sections. Article gives detailed procedures for calculating and winding sections of choke to give desired d-c output voltages and current.—A. G. Lloyd, Choking Up On LC Filters, *Electronics*, Aug. 21, 1967, p 93–97.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

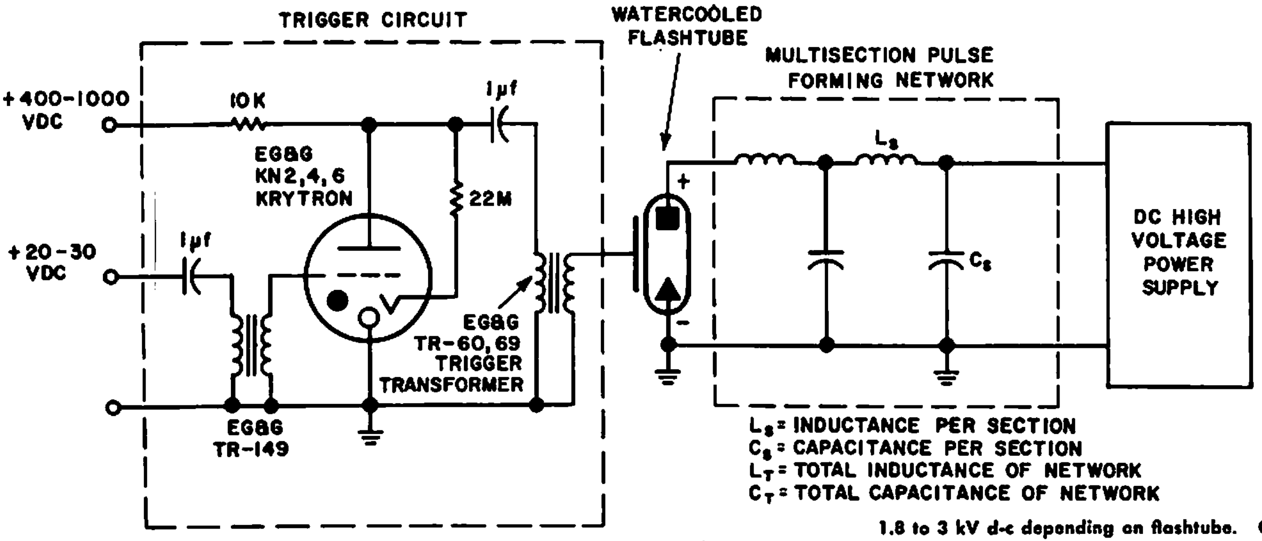
CHAPTER 30
Flash Circuits


PC I
GE-X6
R2
1.2 K
Q2
GE-X9
Q I
GE-X8
C I 20µf
6V
R I
10 K
(SENSITIVITY)
I1
#1850
LAMP

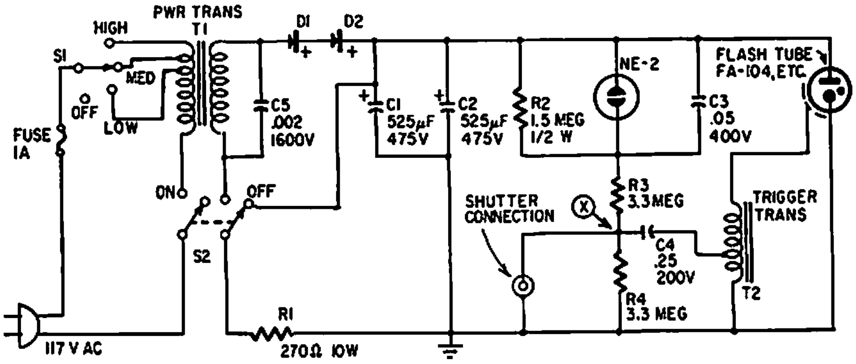
PHOTOCELL-CONTROLLED FLASH—Can be used as target for light gun, to give flash each time light-source gun is accurately aimed. Will flash continuously for steady light. Sensitivity control should be adjusted until flashing justs stops when not illuminated by desired light source.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 78.


R1 810 OHMS 2W
300 VDC
SOURCE
C1
1000µF
R2
1M
R3
1.8M
C2
.22µF
L1
1hy
R4
56K
UTC NO. PF7
T1
LASCR1
L8B
G-E
FT-106

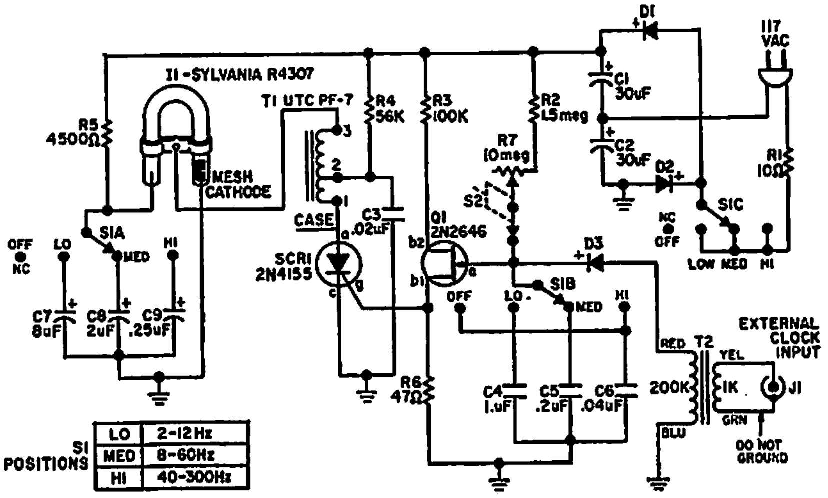
LASCR SLAVE FLASH—Developed for multiple-light-source high-speed photography. Uses standard flash gun, modified to use lascr in place of camera contacts or trip switch. Response is few ms, giving perfect sync between master and slave. For high ambient light levels that could trip lascr, 1-H choke L1 is added to serve as low impedance to ambient light but high impedance to flash.—E. K. Howell, The Light Activated SCR, General Electric, Syracuse, N.Y., No. 200.34, 1965.


TRIGGER CIRCUIT
+400-1000 VDC
10K
1µf
EG&G
KN2,4,6
KRYTRON
22M
+20-30 VDC
1µf
EG&G
TR-60,69
TRIGGER
TRANSFORMER
EG&G
TR-149
WATERCOOLED
FLASHTUBE
MULTISECTION PULSE
FORMING NETWORK
L_s
C_s
DC HIGH
VOLTAGE
POWER
SUPPLY
L_s = INDUCTANCE PER SECTION
C_s = CAPACITANCE PER SECTION
L_T = TOTAL INDUCTANCE OF NETWORK
C_T = TOTAL CAPACITANCE OF NETWORK

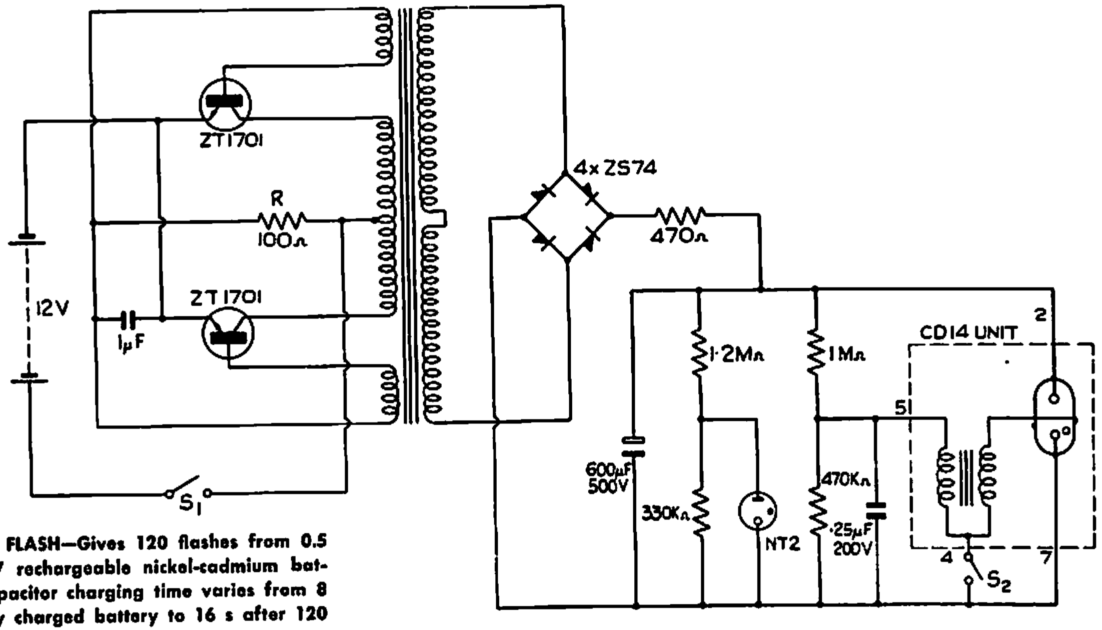
EXTERNAL TRIGGERING OF WATER-COOLED FLASHTUBE—Application of 20 to 30 V d-c to trigger circuit using Krytron four-element gas-filled cold-cathode switch tube generates 10-µs pulse at 5,000 V d-c and 2,500 A peak current (for KN-4) for primary of trigger transformer, to trigger water-cooled flashtube by applying 25 to 30 kV to external electrode. Operating voltage of flashtube, applied through pulse-forming network, ranges from 1.8 to 3 kV d-c depending on flashtube. Can be used for optical pumping of high-energy lasers, photography, and other applications requiring high-energy sources.—Linear Water-Cooled Xenon Flashtubes, EG&G, Boston, Mass., No. 1004, 1968.


HIGH
PWR TRANS
T1
D1
D2
S1
MED
OFF
LOW
FUSE 1A
C5 .002 1600V
C1 525µF 475V
C2 525µF 475V
R2 1.5 MEG 1/2 W
NE-2
FLASH TUBE FA-104,ETC.
C3 .05 400V
ON
OFF
S2
SHUTTER CONNECTION
R3 3.3MEG
C4 .25 200V
R4 3.3 MEG
TRIGGER TRANS
T2
R1
270Ω 10W
117 V AC

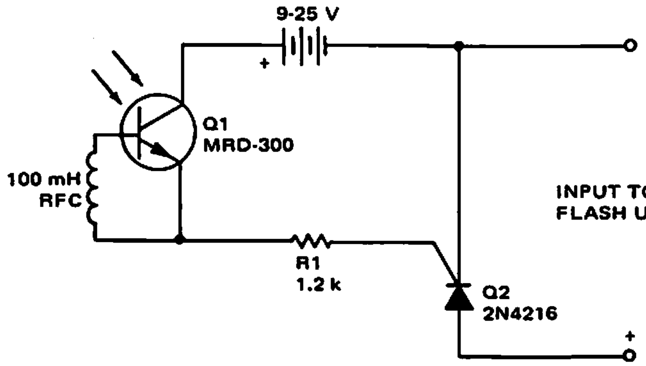
A-C FLASHTUBE SUPPLY—Circuit is typical of most small and low-cost electronic photoflash units, in which shutter of camera closes firing or triggering circuit that discharges capacitor through step-up transformer to produce single high-voltage pulse that ignites flashtube. One serious drawback is that discharge of C4 may soon burn out shutter contacts and give user harmless but unpleasant shock that may cause him to drop expensive camera.—L. E. Greenlee, SCR Trigger for Your Photoflash, *Radio-Electronics*, Nov. 1965, p 40–41.


D1
117 VAC
T1-SYLVANIA R4307
T1 UTC PF-7
R5 4500Ω
R4 56K
R3 100K
R2 1.5meg
C1 30uF
C2 30uF
D2
R1 10Ω
MESH CATHODE
3
2
1
R7 10meg
S2
CASE
C3 .02uF
SCR1 2N4155
a
c
g
Q1 2N2646
b2
b1
e
S1A
OFF NC
LO
MED
HI
C7 8uF
C8 2uF
C9 .25uF
D3
S1B
S1C
NC OFF
LOW MED HI
R6 47Ω
C4 1.uF
C5 .2uF
C6 .04uF
RED
T2
200K
YEL
1K
J1
GRN
BLU
EXTERNAL CLOCK INPUT
DO NOT GROUND
S1 POSITIONS
LO 2-12Hz
MED 8-60Hz
HI 40-300Hz

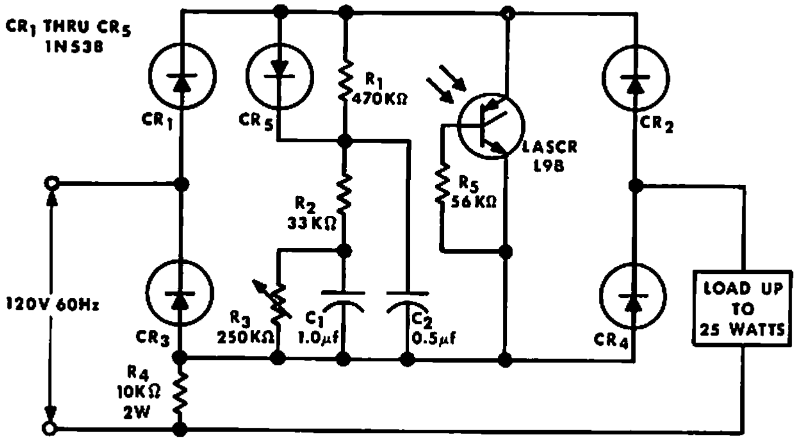
LOW-COST STROBE—Uses ujt relaxation oscillator as clock for driving high-voltage trigger and xenon flashtube discharge circuit, with conventional 300-V voltage-doubling power supply. Switch S1 gives choice of three flash ranges: 2-12 Hz, 8-60 Hz, and 4-300 Hz. R7 adjusts flash rate within each range. Article gives construction details, calibration procedure, and suggestions for use.—S. Tennen, Pennypincher's Stroboscope, *Elementary Electronics*, Mar.–Apr. 1970, p 29–33 and 99.


ZT1701
R
100Ω
ZT1701
12V
1µF
S1
4×ZS74
470Ω
1·2MΩ
1MΩ
CD14 UNIT
2
5
600µF 500V
330KΩ
NT2
470KΩ
·25µF 200V
4
7
S2

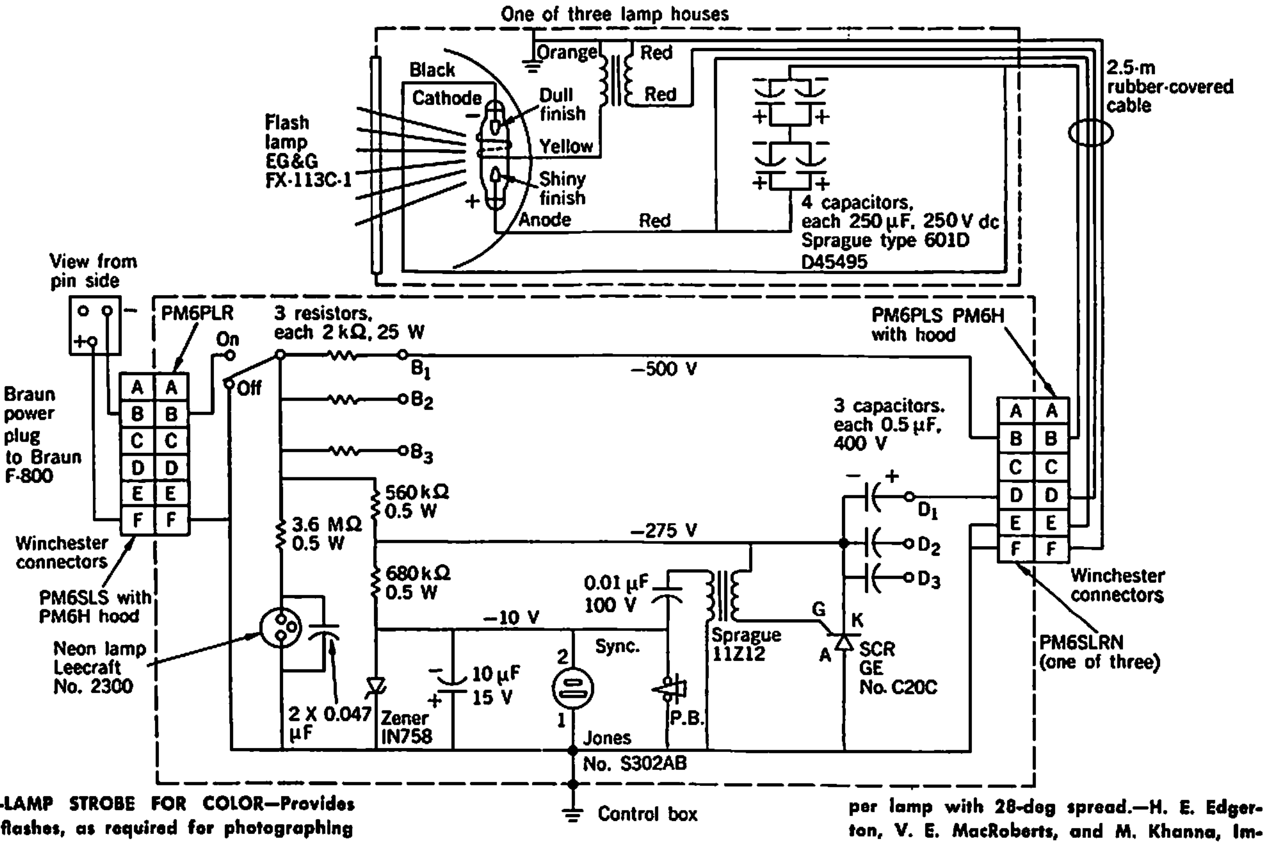
50-JOULE FLASH—Gives 120 flashes from 0.5 A-hr 12-V rechargeable nickel-cadmium battery. Capacitor charging time varies from 8 s for fully charged battery to 16 s after 120 flashes. Battery drives two-transistor inverter operating at about 1.5 kHz, with oscillation accomplished by saturating transformer. Secondary voltage is rectified for charging 600-µF capacitor to about 400 V. Neon then glows to indicate that unit is ready for use. Closing camera flash contacts S2 discharges 0.25-µF capacitor through pulse transformer, and resulting high-voltage pulse makes CD14 flash unit turn on so large capacitor discharges through it. Guide number is 40 for Kodachrome II. Report gives design equations and transformer winding data.—A 50-Joule Photographic Flash Unit Using Silicon Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 21, 1965.


9-25 V
+
Q1
MRD-300
100 mH
RFC
INPUT TO STROBE
FLASH UNIT
R1
1.2 k
Q2
2N4216
+

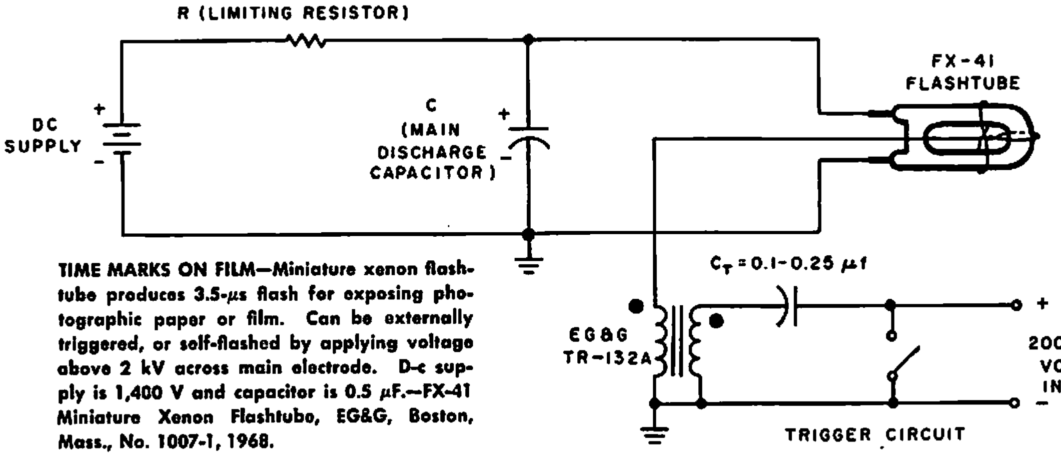
STROBELIGHT SLAVE—Serves as switch for triggering additional electronic strobe without using interconnecting wires. Unaffected by ambient light. Will trigger reliably up to about 20 ft from master strobe. Range can be increased by using lens or parabolic reflector to concentrate light on phototransistor.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6—42.


CR1 THRU CR5
1N538
CR1
CR5
R1
470KΩ
LASCR
L9B
CR2
R5
56KΩ
R2
33KΩ
120V 60Hz
R3
250KΩ
C1
1.0μf
C2
0.5μf
CR3
CR4
LOAD UP TO 25 WATTS
R4
10KΩ
2W

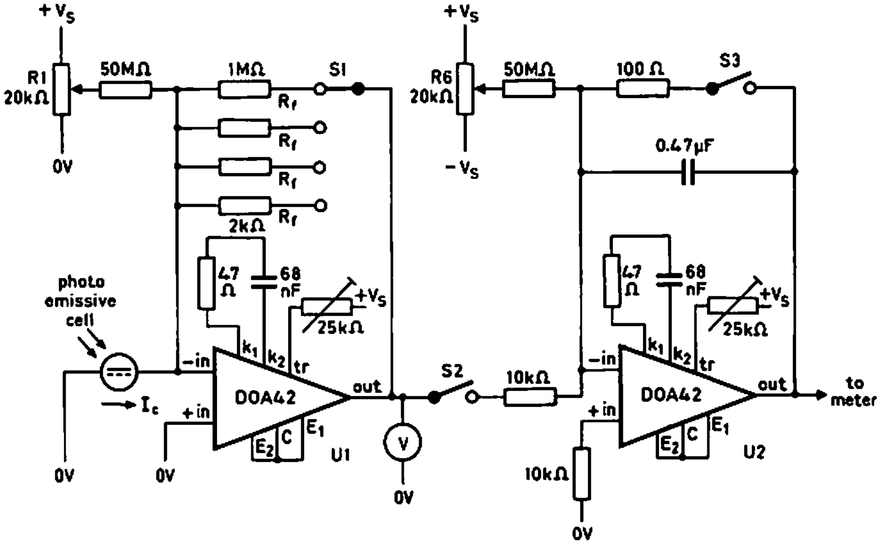
FLASH-ACTUATED SWITCH—Random flash of light fires lascr, turning on load. C1 and C2 then begin discharging. Setting of R3 determines how long flash-actuated switch remains on. Switch can turn on at any phase angle, but will turn off only at current zero, so rfi is negligible.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 19.


One of three lamp houses
Orange
Red
Red
Black
Cathode
Dull finish
Yellow
Shiny finish
Anode
Red
Flash lamp EG&G FX-113C-1
4 capacitors, each 250 μF, 250 V dc Sprague type 601D D45495
2.5-m rubber-covered cable
View from pin side
PM6PLR
On
Off
3 resistors, each 2 kΩ, 25 W
B1
B2
B3
–500 V
PM6PLS PM6H with hood
Braun power plug to Braun F-800
A B C D E F
3 capacitors, each 0.5 μF, 400 V
560 kΩ 0.5 W
3.6 MΩ 0.5 W
–275 V
D1
D2
D3
Winchester connectors
680 kΩ 0.5 W
PM6SLS with PM6H hood
0.01 μF 100 V
Sprague 11Z12
G
K
A
SCR GE No. C20C
Winchester connectors
PM6SLRN (one of three)
Neon lamp Leecraft No. 2300
–10 V
Sync.
10 μF 15 V
P.B.
2 X 0.047 μF
Zener 1N758
Jones No. S302AB
Control box

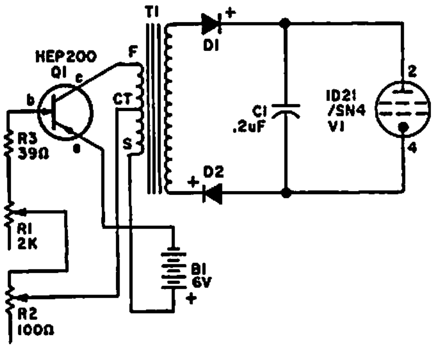
THREE-LAMP STROBE FOR COLOR—Provides 65-μs flashes, as required for photographing wing tips of hummingbirds in color without blur. Circuit is powered by Braun F800 unit. Stored energy is 31 joules per lamp, with light output of 1,500 beam candela seconds per lamp with 28-deg spread.—H. E. Edgerton, V. E. MacRoberts, and M. Khanna, Improvements in Electronics for Nature Photography, *IEEE Spectrum*, July 1969, p 89—94.


R (LIMITING RESISTOR)
DC SUPPLY
+
-
C (MAIN DISCHARGE CAPACITOR)
+
-
FX-41 FLASHTUBE
EG&G TR-132A
C_T = 0.1-0.25 µf
+
200-300 VOLTS DC INPUT
-
TRIGGER CIRCUIT

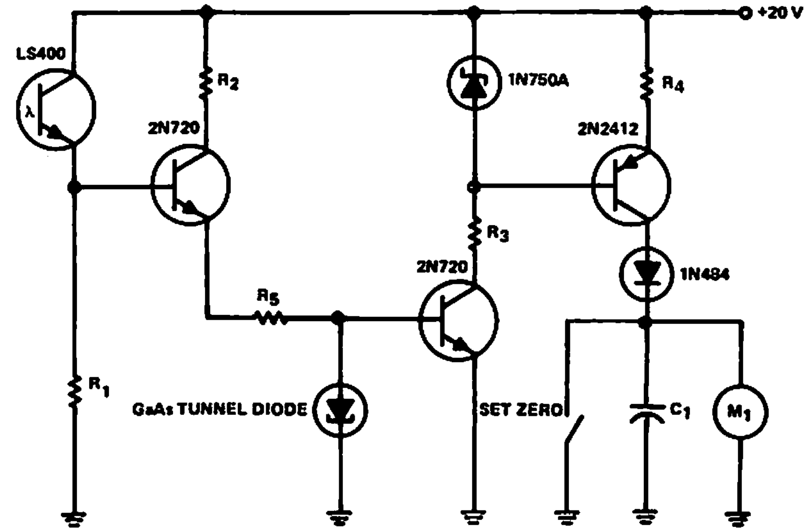
TIME MARKS ON FILM—Miniature xenon flashtube produces 3.5-µs flash for exposing photographic paper or film. Can be externally triggered, or self-flashed by applying voltage above 2 kV across main electrode. D-c supply is 1,400 V and capacitor is 0.5 µF.—FX-41 Miniature Xenon Flashtube, EG&G, Boston, Mass., No. 1007-1, 1968.


$+V_S$
R1 20kΩ
0V
50MΩ
1MΩ
S1
R_f
R_f
R_f
R_f
2kΩ
47 Ω
68 nF
$+V_S$
25kΩ
photo emissive cell
I_c
-in
+in
k_1
k_2
tr
DOA42
out
E_2
C
E_1
U1
0V
0V
V
0V
S2
10kΩ
$+V_S$
R6 20kΩ
$-V_S$
50MΩ
100 Ω
S3
0.47µF
47 Ω
68 nF
$+V_S$
25kΩ
-in
+in
k_1
k_2
tr
DOA42
out
E_2
C
E_1
U2
10kΩ
0V
to meter

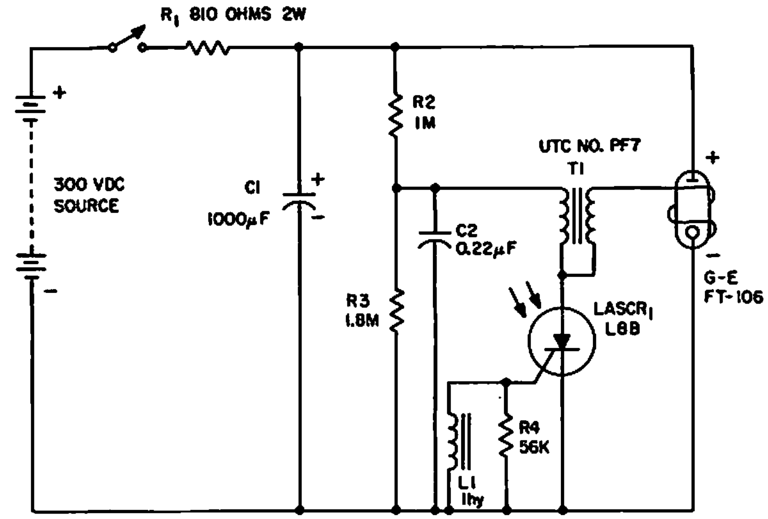
MEASURING FLASH ENERGY—With S2 open, Philips DOA42 IC opamp at left measures photocell current in four ranges, keeping voltage across photocell lower than a few millivolts so relationship between current flow and light intensity is linear. To measure total light energy, as from flash lamps, S2 is closed and S3 open, for integrating output of first amplifier. Supply voltages are +15 and −15 V.—J. Ph. Korthals Altes, Measurement of Light Intensity, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 85.


T1
D1
+
HEP200
Q1
F
c
b
e
CT
S
R3 39Ω
C1 .2uF
1D21 /SN4 V1
2
4
D2
+
R1 2K
B1 6V
+
R2 100Ω

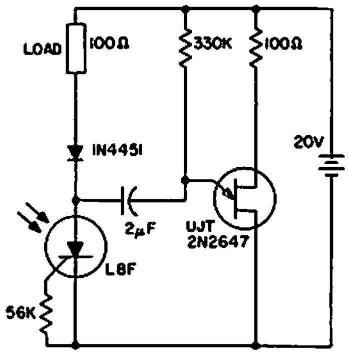
STROBOSCOPE—Audio oscillator Q1 generates variable-frequency output whose frequency is determined by settings of R1 and R2. T1 is power transformer used in reverse, with 6.3-V secondary in oscillator circuit, so step-up ratio of oscillator output is about 18.5:1. Diodes rectify stepped-up voltage to charge C1 to point where it fires Strobotron V1. Article gives construction details. Used for studying rotating objects, by adjusting flash rate until motion appears to be stopped.—S. Daniels, Stop Light Stroboscope, *Science and Electronics*, Jan. 1970, p 37–39.


+20 V
LS400
λ
R_2
2N720
1N750A
R_4
2N2412
R_3
2N720
1N484
R_5
R_1
GaAs TUNNEL DIODE
SET ZERO
C_1
M_1

TIMING DURATION OF LIGHT PULSES—Uses LS400 npn planar silicon photocell for sensing flash of light. Duration of flash in seconds is equal to one-tenth of reading of vtvm M1 in volts. Range of measurable light pulse widths is 1 µs to 1 s. Values are: C1 100 µF Mylar; R1 4.7K; R2 1K; R3 1.5K; R4 3.6K; R5 500.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, CC101, 1968, p 27402.

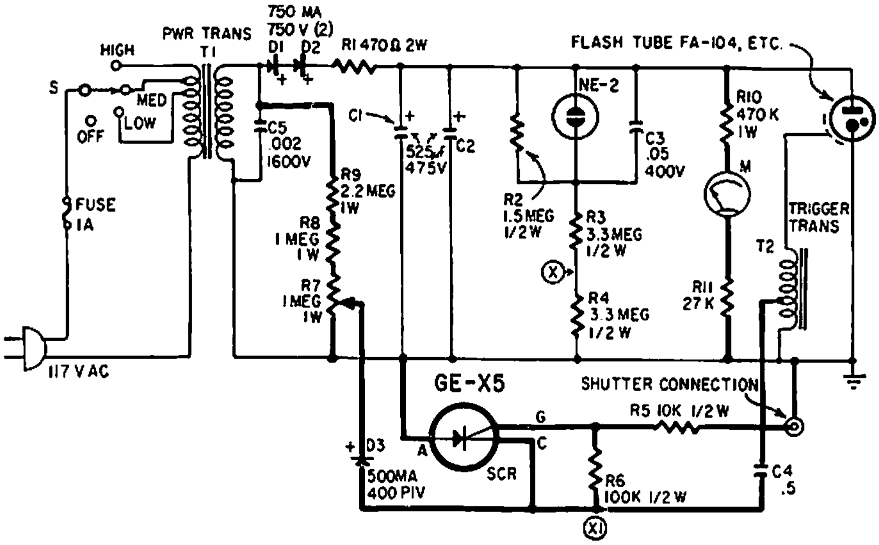

R₁ 810 OHMS 2W
300 VDC SOURCE
+
-
C1 1000μF
R2 1M
R3 1.8M
C2 0.22μF
UTC NO. PF7 T1
LASCR₁ L8B
R4 56K
L1 1hy
G-E FT-106

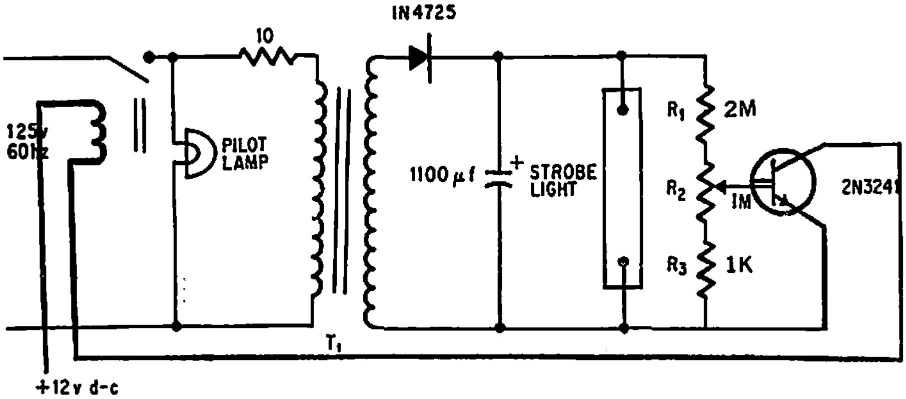
LASCR SLAVE FLASH—With S1 closed, C1 charges to 300 V and C2 charges to 200 V. When master flashgun is fired by contacts on camera, its light output triggers light-activated scr, which then discharges C2 into primary of T1 to trigger slave and discharge C1. Resonant action between C2 and T1 reverse-biases lascr for positive turnoff. Response time is few microsec, giving perfect master-slave sync. Choke L1 prevents triggering by high ambient light.—"SCR Manual," 4th Edition, General Electric, 1967, p 299–300.


LOAD
100Ω
330K
100Ω
1N4451
20V
2μF
UJT 2N2647
L8F
56K

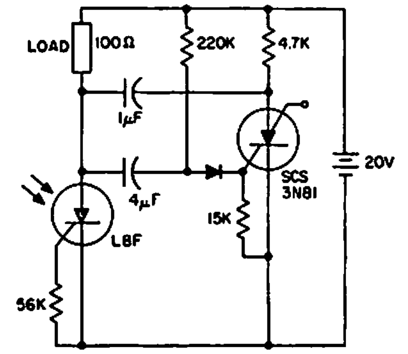
LIGHT-TRIGGERED ONE-SHOT—Ujt triggers about 0.6 s after pulse of light turns on type L8F lascr. If pulse of light is then ended, lascr turns off. If light is still on, ujt operates as relaxation oscillator but will turn lascr off the first time it fires after light is removed. High resistance of dark lascr then prevents ujt from oscillating.—"SCR Manual," 4th Edition, General Electric, 1967, p 297.

SCR-TRIGGERED PHOTOFLASH—Improved circuit uses scr to give more reliable triggering of flashtube without discharging C4 through shutter contacts. Maximum current through contacts is less than 1 mA, which practically eliminates pitting. Voltmeter indicates actual voltage across storage capacitors with far greater accuracy than neon flasher. Article gives construction details.—L. E. Greenlee, SCR Trigger for Your Photoflash, *Radio-Electronics*, Nov. 1965, p 40–41.


S
HIGH
MED
LOW
OFF
PWR TRANS T1
FUSE 1A
117 VAC
750 MA 750 V (2)
D1 D2
R1 470Ω 2W
C5 .002 1600V
R9 2.2 MEG 1W
R8 1 MEG 1W
R7 1 MEG 1W
C1
525μf 475V
C2
NE-2
C3 .05 400V
R2 1.5 MEG 1/2W
R3 3.3 MEG 1/2 W
X
R4 3.3 MEG 1/2 W
FLASH TUBE FA-104, ETC.
R10 470 K 1W
M
R11 27 K
T2
TRIGGER TRANS
GE-X5
A
G
C
SCR
SHUTTER CONNECTION
R5 10K 1/2 W
R6 100K 1/2 W
C4 .5
D3 500MA 400 PIV
X1

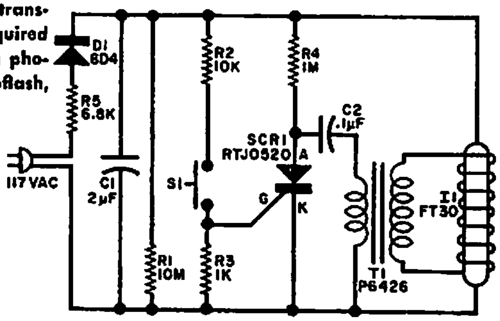

125v 60Hz
10
PILOT LAMP
1N4725
1100μf
STROBE LIGHT
R₁ 2M
R₂ 1M
R₃ 1K
2N3241
T₁
+12v d-c

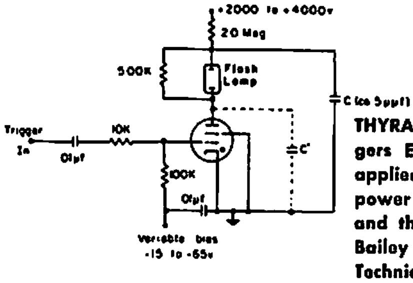
REGULATING PHOTOFLASH SUPPLY—Transistor and relay keep electrolytic capacitor voltage at correct charging level of 300 V, to prevent overcharging that shortens capacitor life. When voltage drops to about 290 V, relay drops out and charging starts again.—T. Lamb, Transistor and Relay Regulate High Voltages, *Electronics*, July 22, 1968, p 70.


LOAD
100Ω
220K
4.7K
1μF
4μF
SCS
3N81
20V
15K
L8F
56K

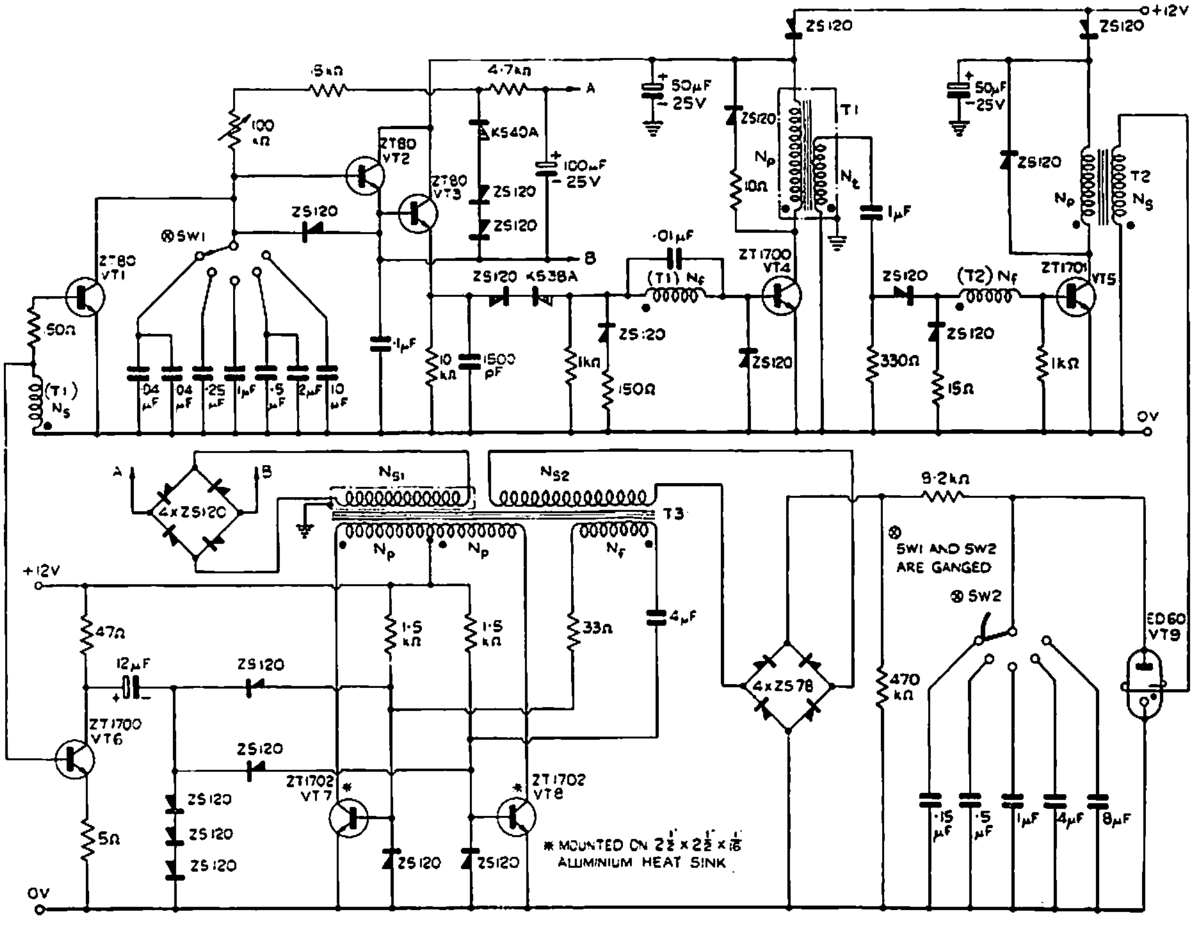
FLASH-DURATION SENSOR—With no light, scs conducts. When flash of light turns on lascr, scs goes off and 4-μF capacitor is charged. After about 0.6 s, scs turns on. If lascr is now dark, it goes off. If flash lasts longer than 0.6 s, lascr remains in conducting state. —"SCR Manual," 4th Edition, General Electric, 1967, p 298.

SIMPLE SCR PHOTOFLASH—Closing S1 discharges C2 through primary of trigger transformer when scr fires, to produce required high voltage across secondary for firing photographic flashtube.—Electronic Photoflash, *Popular Electronics*, April 1970, p 92.


D1
6D4
R5
6.8K
117VAC
C1
2μF
R1
10M
R2
10K
S1
R3
1K
R4
1M
C2
.1μF
SCR1
RTJ0520
A
G
K
T1
P6426
I1
FT30


+2000 to +4000v
20 Meg
500K
Flash
Lamp
C (to Suppl)
Trigger
In
.01μf
10K
100K
.01μf
C'
Variable bias
-15 to -65v

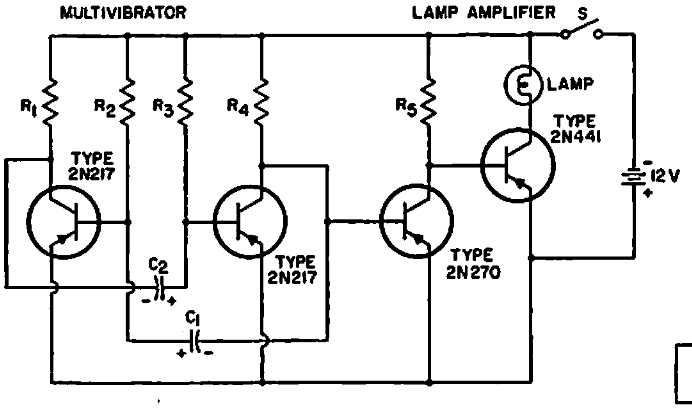
THYRATRON TRIGGER—2D21 thyratron triggers EG&G flashtube when input trigger is applied to control grid. 20-meg resistor in power supply lead ensures that both flashtube and thyratron are cut off after firing.—D. N. Bailey and D. M. Hercules, Flash Photolysis—A Technique for Studying Fast Reactions, *Journal of Chemical Education*, Feb. 1965.


+12V
ZS120
·5kΩ
4·7kΩ
A
B
50μF
25V
100 kΩ
ZT80
VT2
ZT80
VT3
KS40A
ZS120
ZS120
100μF
25V
T1
Np
10Ω
Nt
1μF
ZS120
ZS120
50μF
25V
ZS120
T2
Np
Ns
⊗SW1
ZT80
VT1
·01μF
ZS120
KS38A
(T1) Nf
ZT1700
VT4
ZS120
(T2) Nf
ZT1701
VT5
50Ω
(T1)
Ns
·04 μF
·04 μF
·25 μF
1μF
·5 μF
2μF
10 μF
·1μF
10 kΩ
1500 pF
1kΩ
ZS120
150Ω
ZS120
330Ω
ZS120
15Ω
1kΩ
0V
4xZS120
Ns1
Ns2
T3
Np
Np
Nf
8·2kΩ
⊗ SW1 AND SW2 ARE GANGED
⊗ SW2
ED60
VT9
+12V
47Ω
12μF
ZS120
1·5 kΩ
1·5 kΩ
33Ω
4μF
4xZS78
470 kΩ
ZT1700
VT6
ZS120
ZT1702
VT7
ZT1702
VT8
ZS120
ZS120
ZS120
5Ω
ZS120
ZS120
* MOUNTED ON 2½"×2½"×1/16" ALUMINIUM HEAT SINK
·15 μF
·5 μF
1μF
4μF
8μF
0V

WIDE-RANGE PORTABLE STROBE—Switch gives choice of five repetition rates per second: 1—5, 3—15, 10—50, 30—150, 150—500. Draws maximum of 1.5 A from 12-V battery. Timing circuit VT1-VT4 drives flash tube trigger VT5 which produces 4-kV pulse at transformer secondary. Blocking oscillator VT1 also drives VT6 for switching off inverter VT7-VT8, to prevent self-retriggering of flash tube before gas deionizes on fastest range. Report gives winding data for all transformers.—A Wide Range Stroboscope Using Silicon Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 27, 1964.

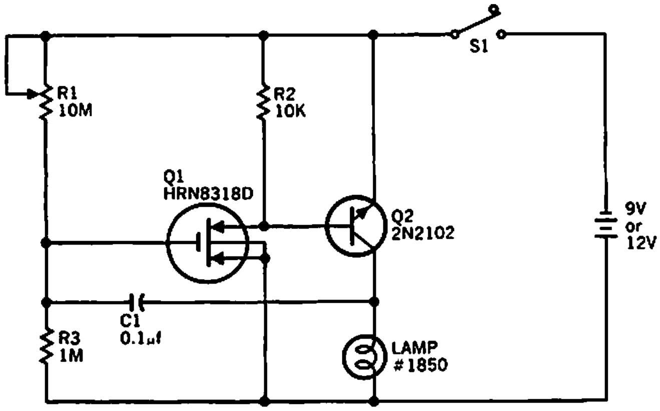
CHAPTER 31

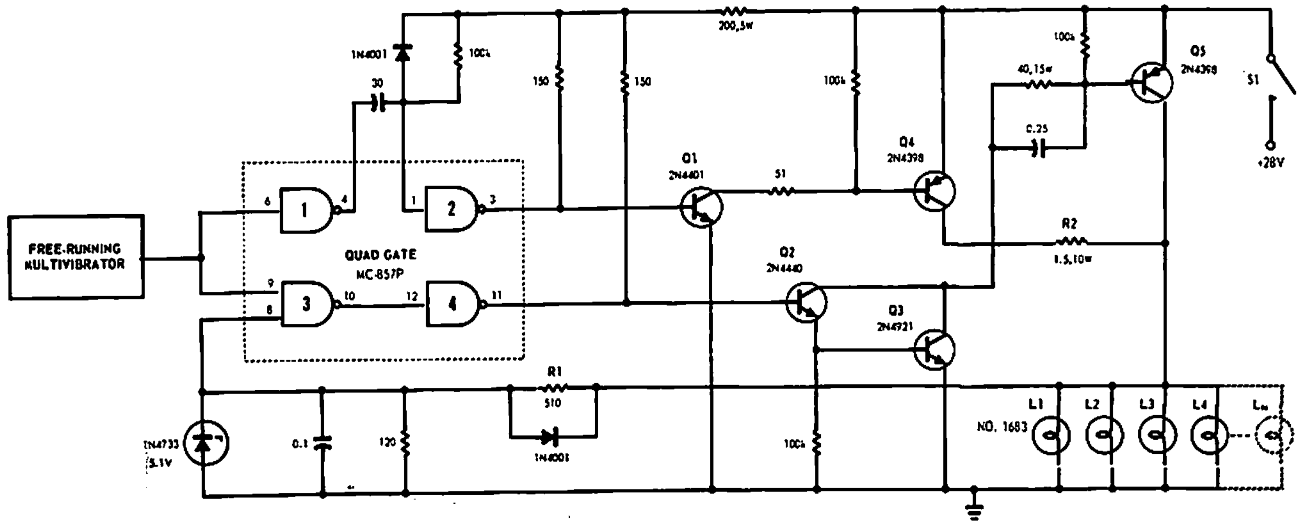
Flasher Circuits


MULTIVIBRATOR
LAMP AMPLIFIER
S
R1
R2
R3
R4
R5
LAMP
TYPE 2N441
TYPE 2N217
TYPE 2N217
TYPE 2N270
- 12V +
C2
- +
C1
+ -

ONCE-PER-SECOND FLASHER—Will handle lamps up to 1 A at 12 V. Ideal for portable use. Lamp flashes at frequency of mvbr using pair of 2N217 transistors. Values: C1 25 μF; C2 100 μF; lamp 12 V at 1 A; R1, R4 2K; R2, R3 100K; R5 120.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 535.

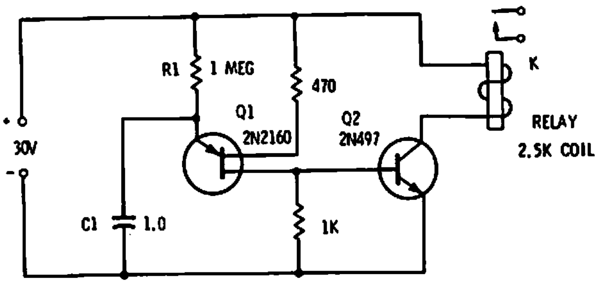
MOSFET FLASHER—Combination of npn transistor and p-channel mosfet gives extremely long duty cycles for flasher, reducing average power dissipation and increasing battery life. Time constant is determined by C1, R1, and R3. If common junction of these three timing components is connected to photocell, flasher will operate only when photocell is dark.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 45.


S1
R1 10M
R2 10K
Q1 HRN8318D
Q2 2N2102
9V or 12V
C1 0.1μf
R3 1M
LAMP #1850

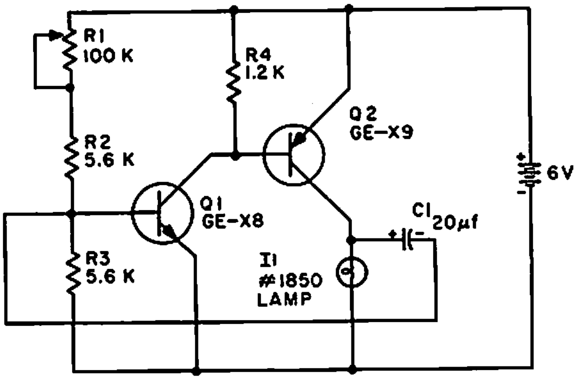

FREE-RUNNING MULTIVIBRATOR
QUAD GATE MC-857P
1
2
3
4
6
4
1
3
9
8
10
12
11
1N4001
100k
30
150
150
200,5W
100k
Q1 2N4401
51
Q4 2N4398
100k
40,15W
0.25
Q5 2N4398
S1
+28V
R2 1.5,10W
Q2 2N4440
Q3 2N4921
R1 510
1N4001
1N4733 5.1V
0.1
120
100k
L1
L2
L3
L4
Ln
NO. 1683

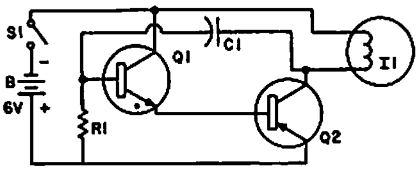
LONG-LIFE FLASHER—Circuit senses load current, withholding full load current until lamp filaments are warm or shorts are removed. Circuit automatically resets when defects are corrected. Maximum pulse current is limited to about 20 A by R2. Normal flashing cycle is 1 s.—R. A. Phillips, Lamp Flasher Outwits Shorts and Surges, *EDN*, Feb. 1, 1970, p 54–55.

1-KW BLINKER—Ujt Q1 operates as relaxation oscillator at frequency determined by R1, which may be potentiometer. Each ujt output pulse energizes relay through amplifier stage Q2, to apply power to lamp through relay contacts. Gives about one flash per second with values shown.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 90.


R1
1 MEG
470
Q1
2N2160
Q2
2N497
+
30V
-
C1
1.0
1K
K
RELAY
2.5K COIL

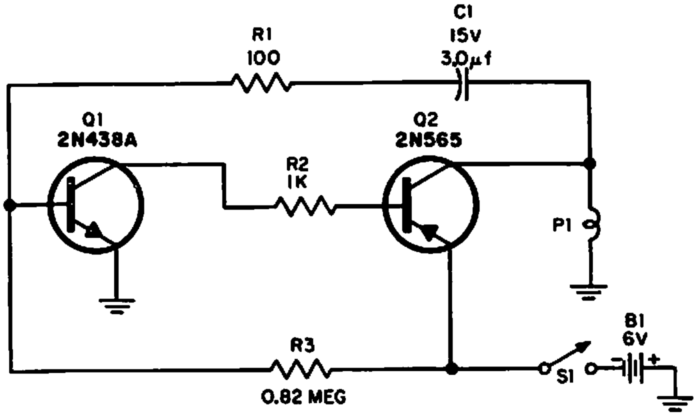
K • POTTER BRUMFIELD LM5-2500 OR EQUIV


R1
100 K
R4
1.2 K
Q2
GE-X9
R2
5.6 K
Q1
GE-X8
6V
C1
20μf
R3
5.6 K
I1
#1850
LAMP


S1
B
6V
Q1
C1
I1
R1
Q2

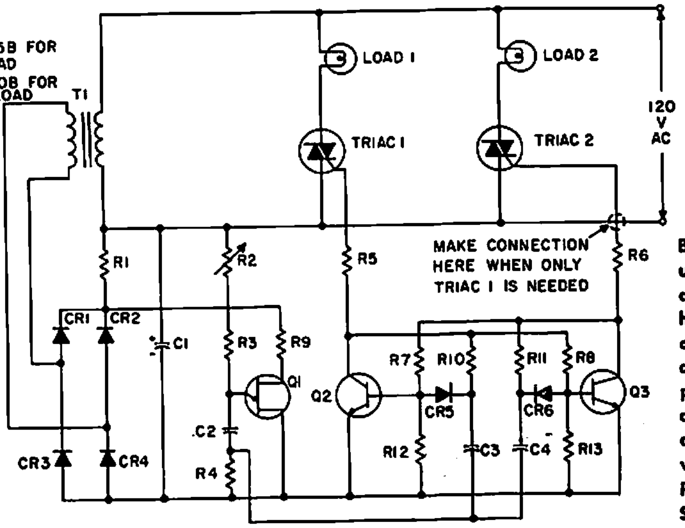
AUTO BREAKDOWN FLASHER—Will flash 6-V automotive lamp to full brilliance for use as warning light when breakdown occurs on turnpike. Operates from 6-V lantern battery. Uses relaxation oscillator, in which Q1 is 2N170, Q2 is 2N155, C1 is 50 μF, and R1 is 47K.—High Powered Flasher, *Elementary Electronics*, Jan.–Feb. 1968, p 14.

BICYCLE FLASHER—Two-stage direct-coupled flasher is connected as free-running mvbr operating from 600-V dry-cell pack. Can readily be mounted on bicycle for night safety. R1 controls both duration of flash and interval between flashes. Can also be used for identifying car at night in large parking lot, or identifying house for guests arriving after dark.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 78.

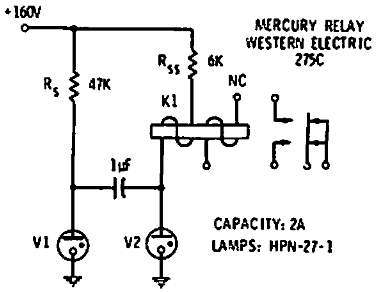

C1
15V
3.0μf
R1
100
Q1
2N438A
Q2
2N565
R2
1K
P1
R3
0.82 MEG
S1
B1
6V

TINY FLASHER—No. 47 lamp at P1 flashes about once a second. Increase size of C1 to get brighter flash.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 64.

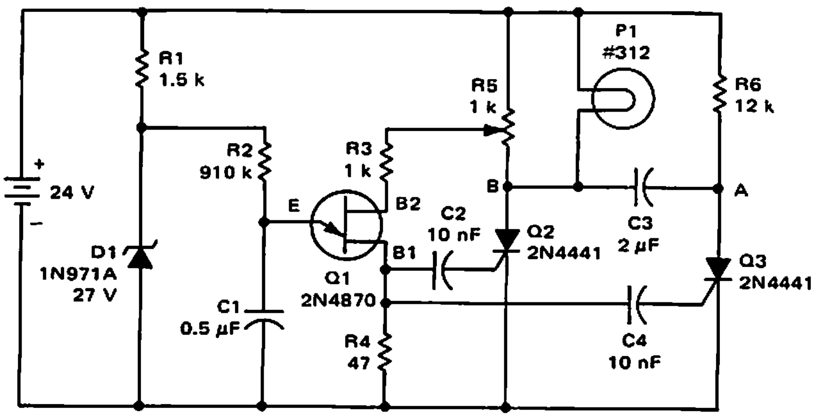
T1-120:12.6 STEPDOWN
TRIAC 1-TRIAC 2: GE SC45B FOR 1KW LOAD
: GE SC40B FOR 600W LOAD
CR1-CR4: GE A13F
CR5,CR6: GE 1N4009
Q1: GE 2N2646 UJT
Q2,Q3: GE 2N3416
C1: 500μF 25V ELECTROLYTIC
C2: .2μF
C3, C4: .05μF
R1: 56Ω 2W
R2: 2MEG TRIMMER
R3: 1 MEG
R4: 100Ω
R5,R6: 33Ω
R7, R8, R9: 680Ω
R10, R11, R12, R13: 10K


T1
LOAD 1
LOAD 2
TRIAC 1
TRIAC 2
120 V AC
MAKE CONNECTION HERE WHEN ONLY TRIAC 1 IS NEEDED
R1
R2
R5
R6
CR1
CR2
C1
R3
R9
Q1
Q2
R7
R10
CR5
R11
CR6
R8
Q3
C2
R4
CR3
CR4
R12
C3
C4
R13

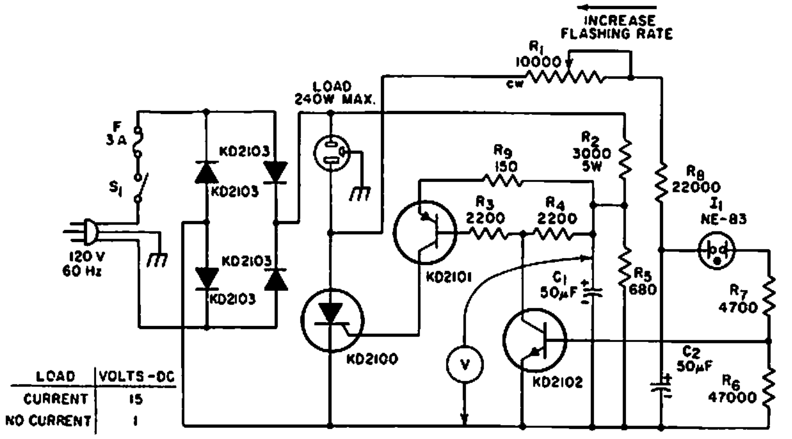
BASIC A-C TWO-LAMP FLASHER—Free-running ujt oscillator Q1 triggers flip-flop Q2-Q3 that alternately fires two triacs each capable of handling 1-kW lamp load. For on-off flashing of one lamp, omit second triac and make connection as indicated. A-c flasher is more popular than d-c version when handling hundreds of watts of power. R2 determines frequency of Q1. Synchronization of flashing with Q1 minimizes rfi.—A. A. Adem, Flashers, Ring Counters and Chasers, General Electric, Syracuse, N.Y., No. 200.48, 1966, p 2.


+160V
MERCURY RELAY
WESTERN ELECTRIC
275C
R_S
47K
R_{SS}
6K
NC
K1
1µf
V1
V2
CAPACITY: 2A
LAMPS: HPN-27-1

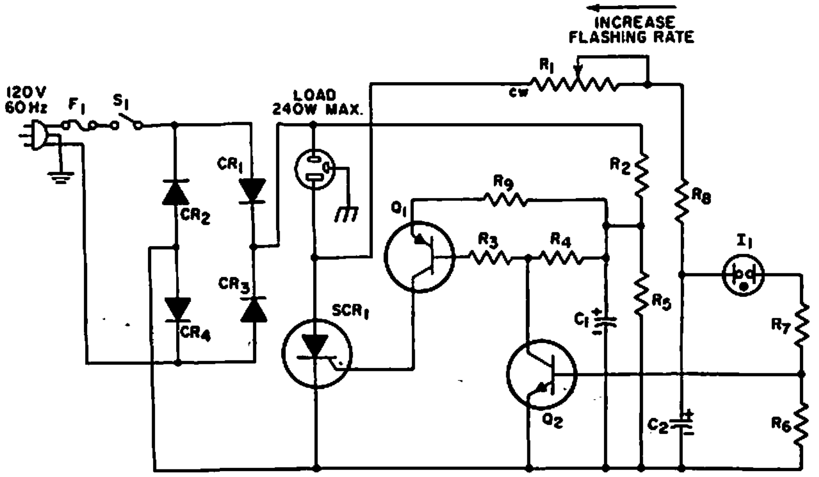
RELAY CONTROL FOR 3-HZ FLASHER—Neon-lamp mvbr is here used to keep mercury relay de-energized five times longer than it is energized, to give flash rate of 3 Hz for lamp connected to relay contacts.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 65.


R1
1.5 k
R2
910 k
R3
1 k
R4
47
R5
1 k
R6
12 k
P1
#312
+
24 V
−
D1
1N971A
27 V
C1
0.5 µF
E
B2
B1
Q1
2N4870
C2
10 nF
B
Q2
2N4441
C3
2 µF
A
Q3
2N4441
C4
10 nF

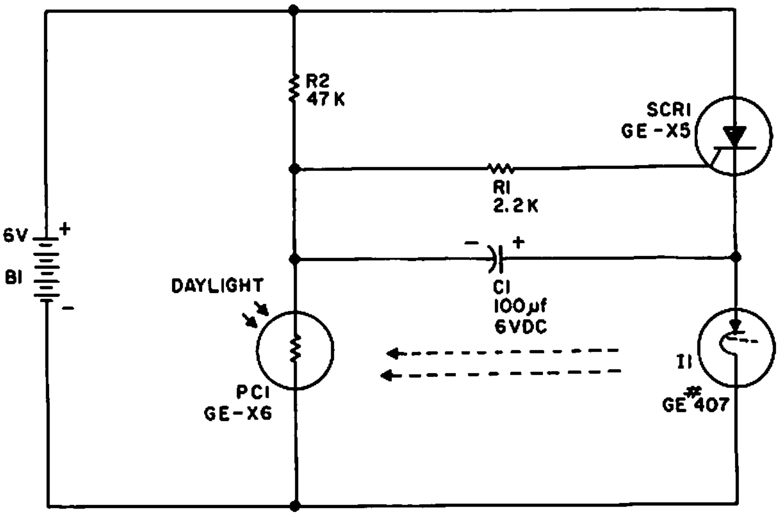
HIGH-RELIABILITY FLASHER—Basic flip-flop is modified so only one scr can come on at any time, to prevent circuit latchup. Duration of flash is adjustable from 10% to 50% of duty cycle; about 30% gives maximum visibility along with 40% saving in power over maximum duty cycle. Developed for boats, aircraft, and emergency vehicles.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–35.


INCREASE
FLASHING RATE
R_1
10000
CW
LOAD
240W MAX.
F
3A
S_1
120 V
60 Hz
KD2103
KD2103
KD2103
KD2103
R_9
150
R_2
3000
5W
R_8
22000
I_1
NE-83
R_3
2200
R_4
2200
KD2101
C_1
50µF
R_5
680
R_7
4700
KD2100
V
KD2102
C_2
50µF
R_6
47000
LOAD | VOLTS-DC
CURRENT | 15
NO CURRENT | 1

240-W WITH 0.5-S FLASHES—R1 adjusts intervals between flashes having fixed duration. For warning signals, typical adjustment is 40 flashes per minute, each lasting about 0.5 s and with 1-s OFF time. With buzzer as load, can serve as metronome.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 69.

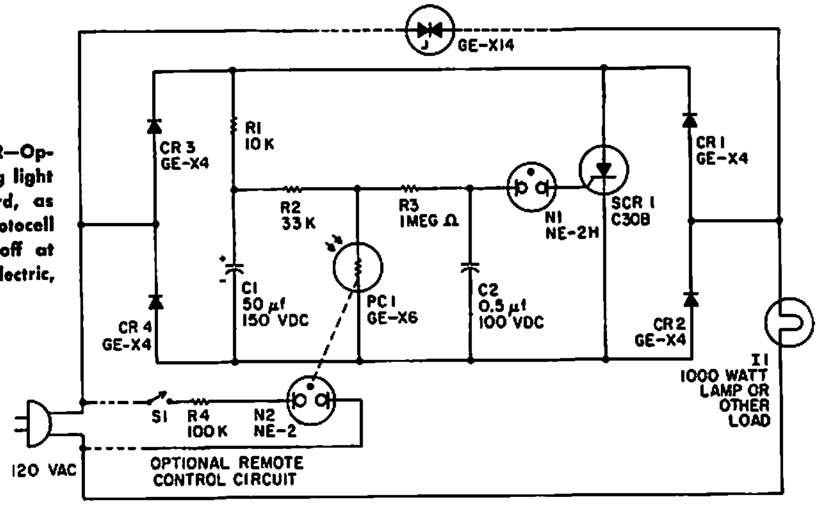

INCREASE
FLASHING RATE
R_1
CW
120V
60Hz
F_1
S_1
LOAD
240W MAX.
CR_1
CR_2
CR_3
CR_4
R_2
R_8
R_9
Q_1
R_3
R_4
R_5
I_1
C_1
SCR₁
R_7
Q_2
C_2
R_6

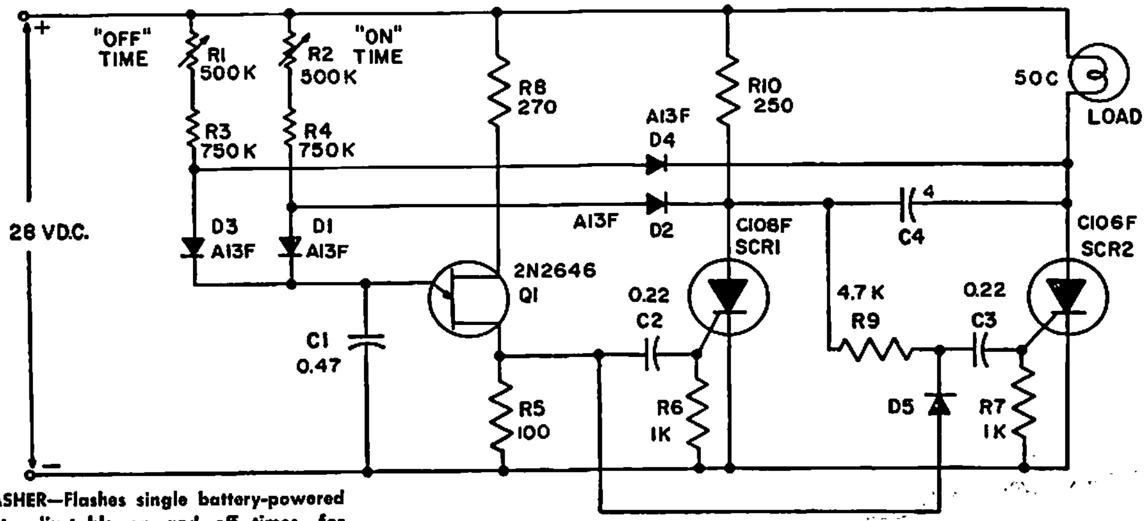
240-W FLASHER—Time of each ON pulse is fixed at about 0.5 s, and duration of OFF time is adjustable with R1 to provide desired number of flashes per minute. Can be used for Christmas-tree lights, advertising signs, warning signals, or for driving alarm bell having clapper hitting gong. Values: C1, C2 50 µF; diodes SK3016; F1 3A; I1 NE-83; Q1 SK3005; Q2 SK3020; R1 10K; R2 3K; R3, R4 2.2K; R5 680; R6 47K; R7 4.7K; R8 22K; R9 150; SCR1 KD2100.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 159.


R2
47 K
SCR1
GE-X5
R1
2.2 K
6V
+
B1
−
DAYLIGHT
− +
C1
100μf
6VDC
PC1
GE-X6
I1
GE #407

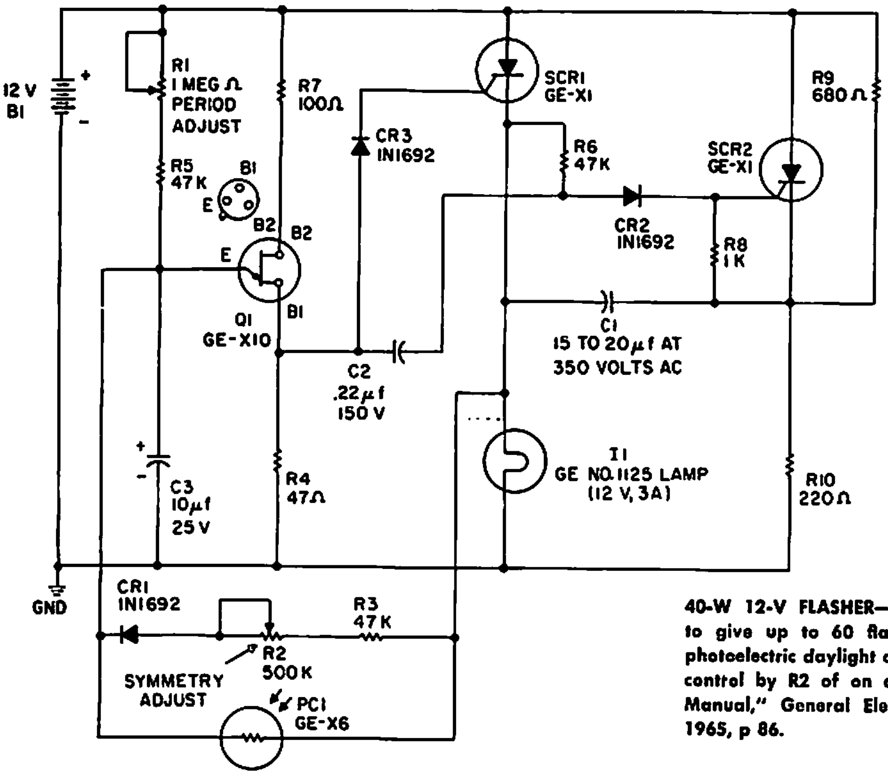
DAYLIGHT-OFF FLASHER FOR BUOYS—Photoelectric switch turns on 6-V single-lamp scr flasher at night and shuts it off at dawn, to conserve battery power and lamp light. For use in isolated locations at which a-c line power is not available. Gives about 12 flashes per minute. Mount photocell to receive as much light from flashing lamp as possible without interfering with visibility of lamp, so flashes lower resistance of photocell. Uses flasher-type lamp having built-in bimetallic switch that opens when lamp heats up (1 or 2 s) and closes again after 0.5 s of lamp cooling.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 84.

1-KW DAYLIGHT-CONTROLLED FLASHER—Operates from a-c line, for use as warning light on tower, pier, or construction hazard, as well as for advertising signs. Photocell starts flasher at sunset and turns it off at dawn.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 88.

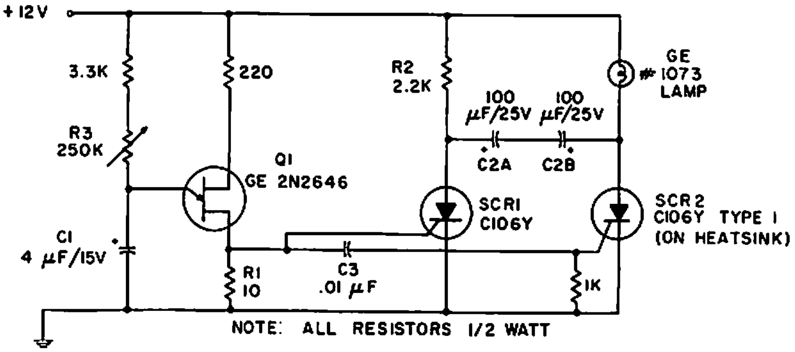

GE-X14
R1
10 K
CR3
GE-X4
CR1
GE-X4
R2
33 K
R3
1MEG Ω
N1
NE-2H
SCR 1
C30B
C1
50 μf
150 VDC
PC1
GE-X6
C2
0.5 μf
100 VDC
CR4
GE-X4
CR2
GE-X4
I1
1000 WATT
LAMP OR
OTHER
LOAD
S1
R4
100K
N2
NE-2
120 VAC
OPTIONAL REMOTE
CONTROL CIRCUIT


+
"OFF"
TIME
R1
500K
R2
500K
"ON"
TIME
R3
750K
R4
750K
R8
270
R10
250
A13F
D4
50C
LOAD
A13F
D2
4
C4
28 VDC.
D3
A13F
D1
A13F
C108F
SCR1
C106F
SCR2
2N2646
Q1
0.22
C2
4.7 K
R9
0.22
C3
C1
0.47
R5
100
R6
1K
D5
R7
1K
−

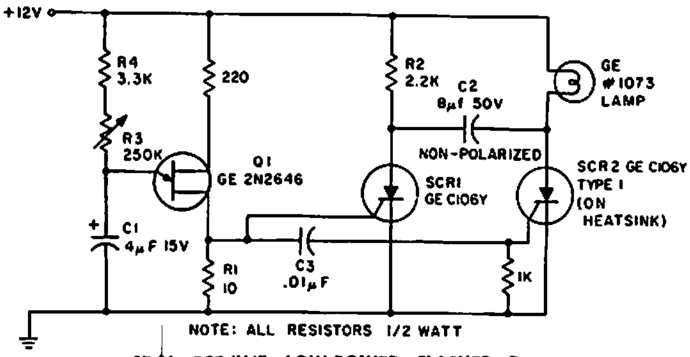
D-C FLASHER—Flashes single battery-powered lamp at adjustable on and off times, for automotive or portable traffic hazard warnings. Uses capacitor-commutated scr flip-flop. SCR2 should be selected so lamp current is within its rating, but SCR1 can be lower rating. Network R9-C3-D5 insures that only SCR1 will be turned on when power is first applied.—A. A. Adem, Solid-State Flashers for Light Displays, *Electronics World*, Aug. 1967, p 83–84.


12 V
B1
R1
1 MEG Ω
PERIOD
ADJUST
R7
100Ω
SCR1
GE-X1
R9
680Ω
CR3
1N1692
R6
47K
SCR2
GE-X1
R5
47 K
B1
E
B2
B2
E
CR2
1N1692
R8
1 K
Q1
GE-X10
B1
C1
15 TO 20μf AT
350 VOLTS AC
C2
.22μf
150 V
I1
GE NO.1125 LAMP
(12 V, 3A)
C3
10μf
25V
R4
47Ω
R10
220Ω
GND
CR1
1N1692
R3
47 K
R2
500 K
SYMMETRY
ADJUST
PC1
GE-X6

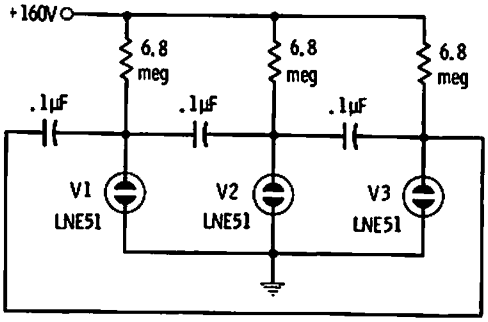
40-W 12-V FLASHER—R1 controls flash rate to give up to 60 flashes per minute, with photoelectric daylight control and independent control by R2 of on and off times.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 86.


+12V
3.3K
220
R2
2.2K
GE
#1073
LAMP
100
μF/25V
100
μF/25V
C2A
C2B
R3
250K
Q1
GE 2N2646
SCR1
C106Y
SCR2
C106Y TYPE I
(ON HEATSINK)
C1
4 μF/15V
R1
10
C3
.01 μF
1K
NOTE: ALL RESISTORS 1/2 WATT

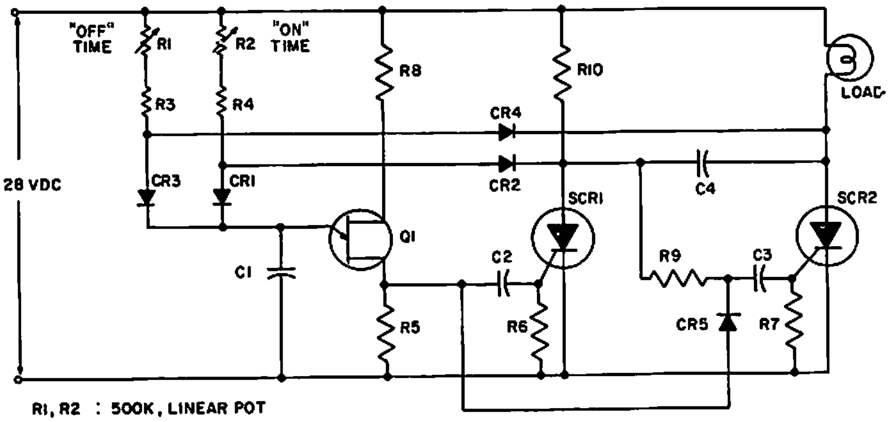
BARRICADE FLASHER—Uses two scr's to drive single lamp at flash rate adjustable by R3 in range of 36 to 160 flashes per minute. Circuit is self-starting when power from 12-V battery is applied, and operates reliably even for fluctuating (noisy) battery supplies. May also be used in autos and boats.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 38.


+12V
R4
3.3K
220
R2
2.2K
C2
8μf 50V
GE
#1073
LAMP
R3
250K
Q1
GE 2N2646
NON-POLARIZED
SCR1
GE C106Y
SCR2 GE C106Y
TYPE I
(ON
HEATSINK)
C1
4μF 15V
R1
10
C3
.01μF
1K
NOTE: ALL RESISTORS 1/2 WATT

12-V SCR/UJT LOW-POWER FLASHER—Provides 36 to 160 flashes per minute, depending on setting of R3. Ujt Q1 operates as relaxation oscillator, delivering train of trigger pulses to two scr gates.—"SCR Manual," 4th Edition, General Electric, 1967, p 160.


+160V
6.8
meg
6.8
meg
6.8
meg
.1μF
.1μF
.1μF
V1
LNE51
V2
LNE51
V3
LNE51

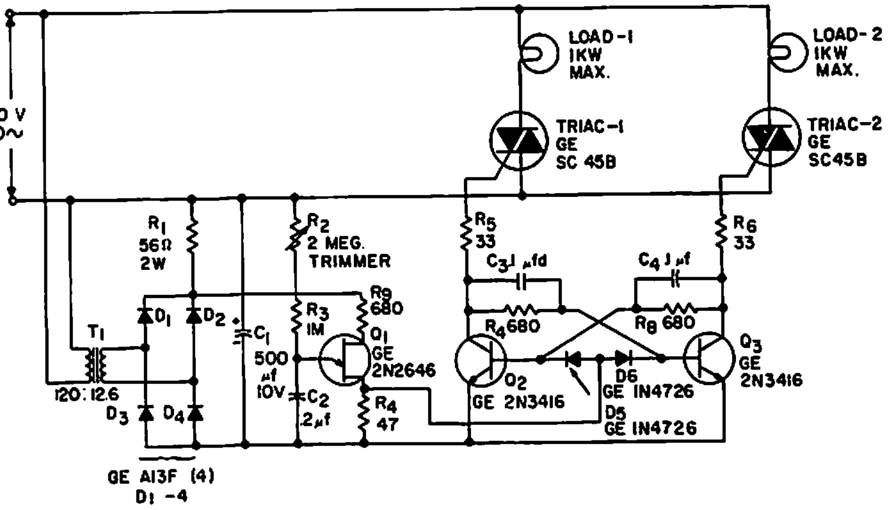
NEON SEQUENTIAL FLASHER—Flashing sequence will either be 1:2:3 or 3:2:1, but starting sequence is not predictable.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 47.


"OFF" TIME
R1
R2
"ON" TIME
R8
R10
LOAD
R3
R4
CR4
CR2
C4
28 VDC
CR3
CR1
SCR1
SCR2
Q1
C1
C2
R9
C3
R5
R6
CR5
R7

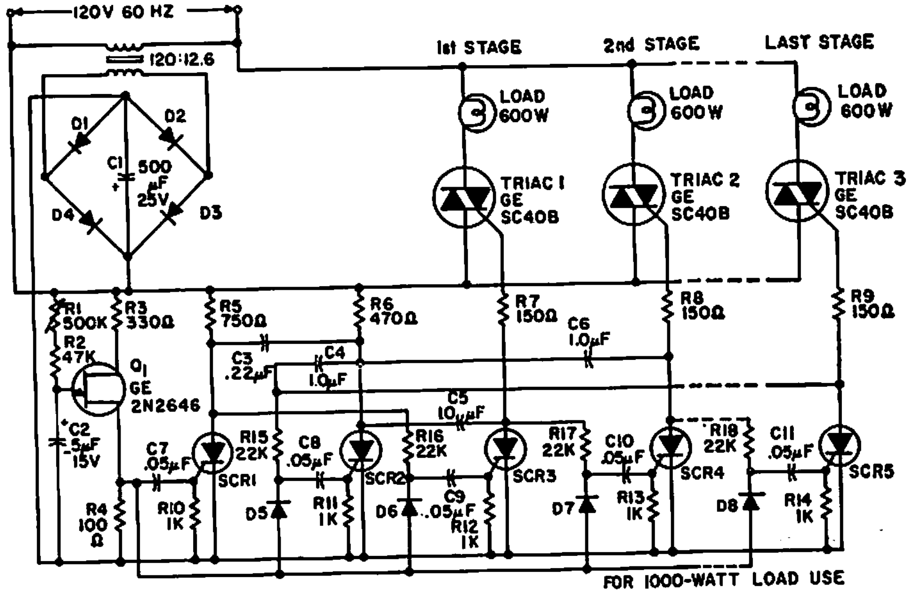
R1, R2 : 500K, LINEAR POT
R3, R4 : 750K 1/2 W
R5 : 100Ω 1/2 W
R6, R7 : 1K, 1/2 W
R8 : 270Ω 1/2 W
R9 : 4.7K, 1/2 W
R10 : 250Ω, 5W
C1 : .47μF 50V
C2, C3 : .22μF 50V

C4 : 4 μF, 50 VOLTS NON-POLARIZED
Q1 : GE 2N2646 UJT
SCR1, SCR2 : GE C106F
CR1 - CR5 : GE A13F
LOAD : GE 50C 1.4A LAMP

SCR FLIP-FLOP D-C FLASHER—Has independent adjustments for on and off times of single lamp load. Circuit is capacitor-commutated scr flip-flop, with network R9-C3-CR5 added to ensure triggering of only one scr when power is first applied.—A. A. Adem, Flashers, Ring Counters and Chasers, General Electric, Syracuse, N.Y., No. 200.48, 1966, p 3.


LOAD-1 1KW MAX.
LOAD-2 1KW MAX.
120 V 60~
TRIAC-1 GE SC 45B
TRIAC-2 GE SC45B
R1 56Ω 2W
R2 2 MEG. TRIMMER
R5 33
R6 33
C3 .1 μfd
C4 .1 μf
R9 680
R3 1M
Q1 GE 2N2646
R4 680
R8 680
Q3 GE 2N3416
T1
120:12.6
D1
D2
D3
D4
C1 500 μf 10V
C2 .2μf
R4 47
Q2 GE 2N3416
D6 GE 1N4726
D5 GE 1N4726
GE A13F (4) D1-4

1-KW FLIP-FLOP FLASHER—Flashing rate, determined by ujt Q1, can be adjusted from about 0.1 to 10 s with R2, to drive triacs through flip-flop Q2-Q3.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 16.


120V 60 HZ
120:12.6
1st STAGE
2nd STAGE
LAST STAGE
LOAD 600W
LOAD 600W
LOAD 600W
D1
D2
C1 500 μF 25V
D4
D3
TRIAC 1 GE SC40B
TRIAC 2 GE SC40B
TRIAC 3 GE SC40B
R1 500K
R3 330Ω
R5 750Ω
R6 470Ω
R7 150Ω
R8 150Ω
R9 150Ω
R2 47K
Q1 GE 2N2646
C3 .22μF
C4 1.0μF
C6 1.0μF
C5 10μF
C2 5μF 15V
C7 .05μF
R15 22K
C8 .05μF
R16 22K
R17 22K
C10 .05μF
R18 22K
C11 .05μF
SCR1
SCR2
SCR3
SCR4
SCR5
R4 100 Ω
R10 1K
D5
R11 1K
D6
C9 .05μF
R12 1K
D7
R13 1K
D8
R14 1K

FOR 1000-WATT LOAD USE GE SC45B TRIACS.

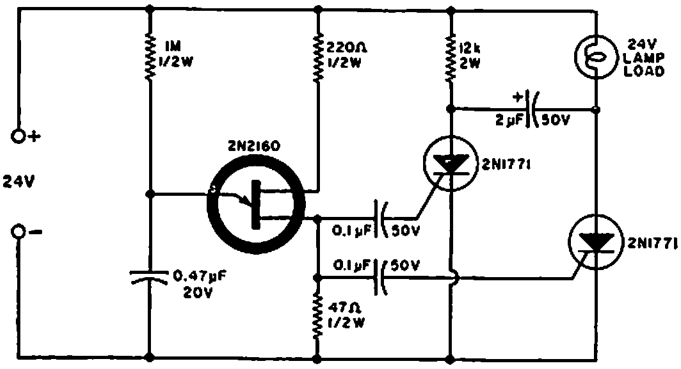
ALL SCR'S GE C106Y
ALL DIODES GE A13 F

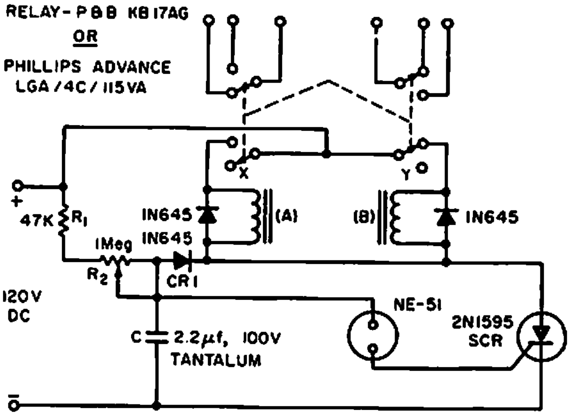
ALL RESISTORS 1/2 W

ADDITIONAL STAGES MAY BE INSERTED BETWEEN DOTTED LINES.

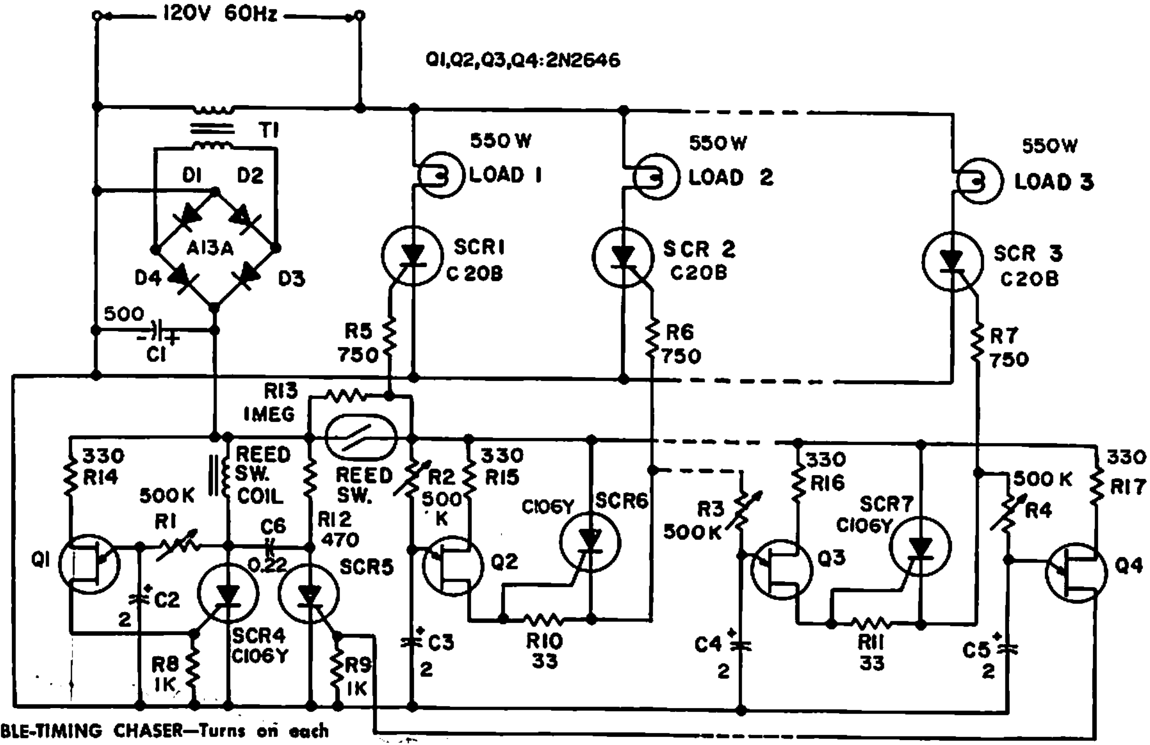
CHASER—Turns on lamps sequentially, at equal intervals, with each one staying on until all are on. Circuit then turns all of them off and starts again with first lamp. Used chiefly in advertising signs.—A. A. Adem, Solid-State Ring Counters and Chasers for Light Displays, *Electronics World*, Sept. 1967, p 84–85.

24-V LAMP FLASHER—With components shown, gives about 60 flashes per minute. To vary flashing rate, use 0.5-meg pot and 0.5-meg resistor in place of 1M resistor.—D. Cooper, SCR's and Triacs—the Revolution Continues, *Electronics World*, Aug. 1968, p 25–28.

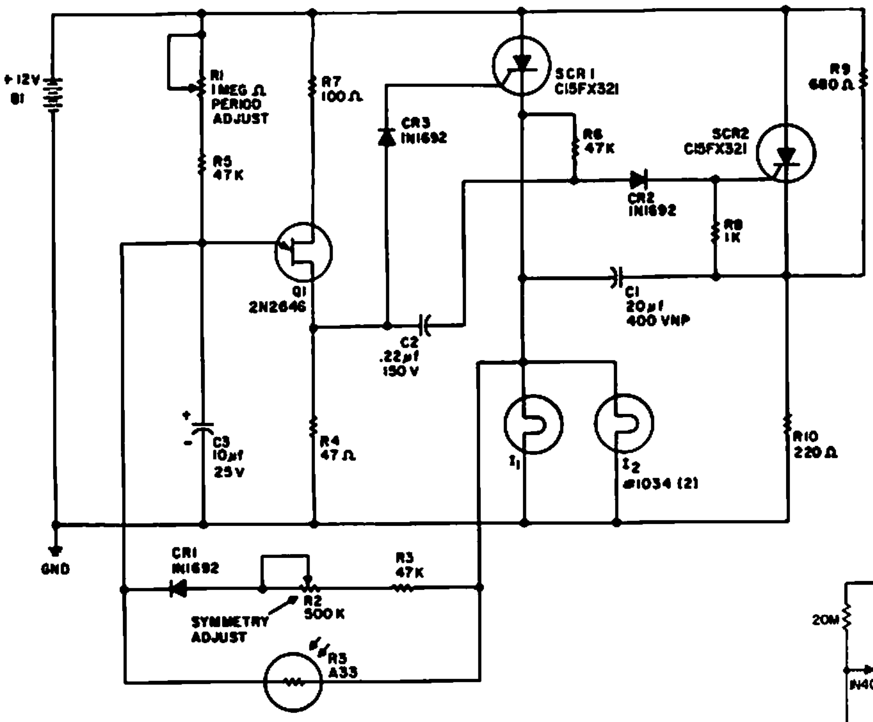

+
24V
−
1M 1/2W
2N2160
0.47µF 20V
220Ω 1/2W
0.1µF 50V
0.1µF 50V
47Ω 1/2W
12k 2W
+
2µF 50V
2N1771
24V LAMP LOAD
2N1771


RELAY-P&B KB17AG
OR
PHILLIPS ADVANCE LGA/4C/115VA
X
Y
(A)
(B)
+
47K R1
1N645
1N645
1N645
1Meg
R2
CR1
120V DC
C 2.2µf, 100V TANTALUM
NE-51
2N1595 SCR
−

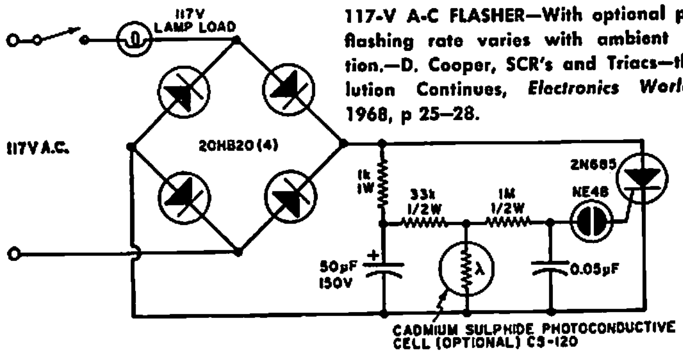
POWER FLIP-FLOP—Combination of scr and dual-coil latching relay provides variable-frequency on-off switching cycle. Extra contacts on relay can be used to drive warning flasher or, with unequal resistance paths for charging capacitor, provide asymmetrical flip-flop action. Values shown give operating frequency range of 12 to 180 cycles per minute. This range permits use as metronome or as interval timer.—V. P. Holec, SCR Relay Circuit Makes Flip-Flop or Interval Timer, *Electronic Design*, June 7, 1965, p 39–40.


120V 60Hz
Q1,Q2,Q3,Q4:2N2646
T1
D1
D2
A13A
D4
D3
500
C1
550W LOAD 1
550W LOAD 2
550W LOAD 3
SCR1 C20B
SCR 2 C20B
SCR 3 C20B
R5 750
R6 750
R7 750
R13 1MEG
330 R14
500K R1
REED SW. COIL
C6 0.22
R12 470
REED SW.
R2 500K
330 R15
C106Y
SCR6
R3 500K
330 R16
SCR7 C106Y
500 K R4
330 R17
Q1
C2 2
SCR4 C106Y
SCR5
R8 1K
R9 1K
Q2
C3 2
R10 33
Q3
C4 2
R11 33
C5 2
Q4

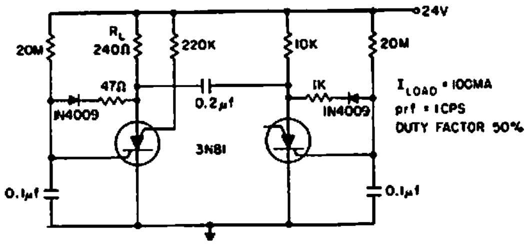
ADJUSTABLE-TIMING CHASER—Turns on each lamp in turn, with separately adjustable time delay in each lamp stage (R1, R2, R3, R4). All lamps stay on until end of sequence, when all go out and process repeats. Used chiefly in advertising signs. Any number of lamp stages can be used. Additional stages may be inserted between dashed lines.—A. Adem, Solid-State Ring Counters and Chasers for Light Displays, *Electronics World*, Sept. 1967, p 84–85.


+12V
B1
R1
1MEG Ω
PERIOD
ADJUST
R5
47K
R7
100Ω
CR3
1N1692
SCR1
C15FX32I
R6
47K
SCR2
C15FX32I
R9
680Ω
CR2
1N1692
R8
1K
Q1
2N2646
C1
20μf
400 VNP
C2
.22μf
150V
C3
10μf
25V
R4
47Ω
I1
I2
#1034 (2)
R10
220Ω
GND
CR1
1N1692
R3
47K
R2
500K
SYMMETRY
ADJUST
R3
A33

40 W WITH DAYLIGHT-OFF CONTROL—Operates from 12-V battery and gives up to 60 flashes per minute as determined by setting of R1. R2 gives independent control of on and off times. Photocell R3 shuts off flasher during daylight, increasing battery life.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 5.

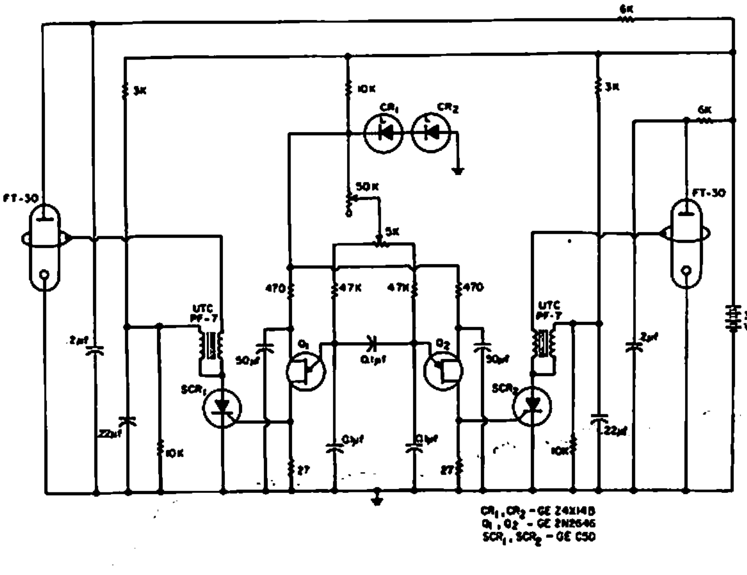

117V
LAMP LOAD
117V A.C.
20HB20 (4)
1k
1W
33k
1/2W
1M
1/2W
2N685
NE48
50μF
150V
λ
0.05μF
CADMIUM SULPHIDE PHOTOCONDUCTIVE
CELL (OPTIONAL) CS-120

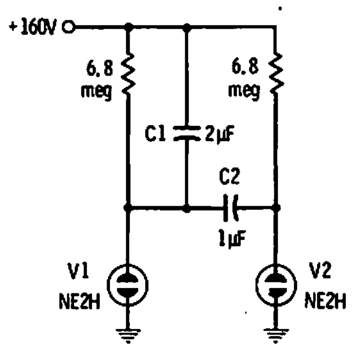
117-V A-C FLASHER—With optional photocell, flashing rate varies with ambient illumination.—D. Cooper, SCR's and Triacs—the Revolution Continues, *Electronics World*, Aug. 1968, p 25–28.


24V
20M
RL
240Ω
220K
10K
20M
47Ω
0.2μf
1K
1N4009
1N4009
3N81
0.1μf
0.1μf
ILOAD = 100MA
prf = 1CPS
DUTY FACTOR 50%

1-HZ FLASHER—Generates one flash per second with 100 mA through 240-ohm lamp load RL without need for electrolytics. When one scs triggers on, 0.2-μF commutating capacitor turns off other one and charges its gate capacitor to negative voltage through 20 meg until retriggering occurs. Circuit efficiency is 88%. 20-meg resistors can be made variable for changing frequency or duty factor.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.

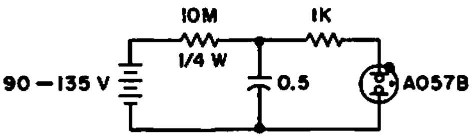
XENON TRIGGER—Two xenon flashtubes operating in 60-400 Hz range can provide pulses of light for triggering lascr's (light-activated scr's). Ujt relaxation oscillator provides alternate pulses for scr's, turning them on and making 0.22-μF capacitors discharge into primaries of high-voltage trigger transformers, to give 6-kV pulses for ionizing flashtubes to give pulses of light.—"SCR Manual," 4th Edition, General Electric, 1967, p 118–119.


6K
3K
10K
CR1
CR2
3K
6K
FT-30
50K
5K
FT-30
470
47K
47K
470
UTC
PF-7
UTC
PF-7
2μf
50μf
Q1
0.1μf
Q2
50μf
2μf
350
VDC
SCR1
SCR2
.22μf
10K
0.1μf
0.1μf
.22μf
10K
27
27
CR1, CR2 - GE Z4XL14B
Q1, Q2 - GE 2N2646
SCR1, SCR2 - GE C50



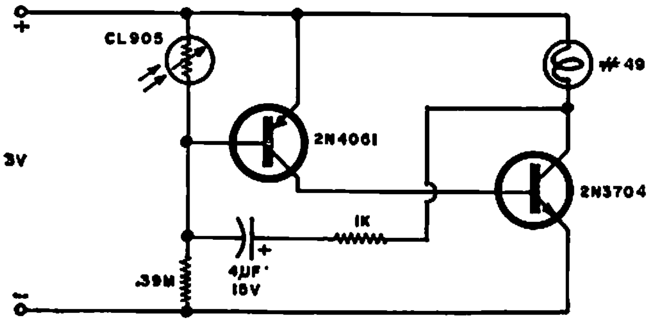
+160V
6.8 meg
6.8 meg
C1 2μF
C2
1μF
V1 NE2H
V2 NE2H

1:2:2:2:1:2:2:2 SEQUENTIAL NEON—Flashing sequence may be varied by changing capacitor values. Large capacitance values permit bright flash.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 47.



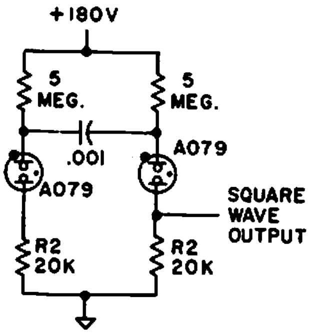
10M
1/4 W
1K
90 — 135 V
0.5
A057B

NEON BLINKER—Simple circuit flashes once every 5 s.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 153.



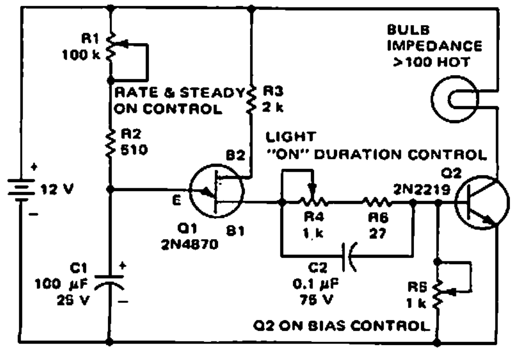
+
CL905
#49
2N4061
3V
2N3704
1K
4μF 15V
.39M
−

BLINKING NIGHT LIGHT—Gives about 50 flashes per minute when darkness falls, for drawing attention to hazards. Two type-D cells will operate flasher for several months, since battery drain is below 75 μA in daylight.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.



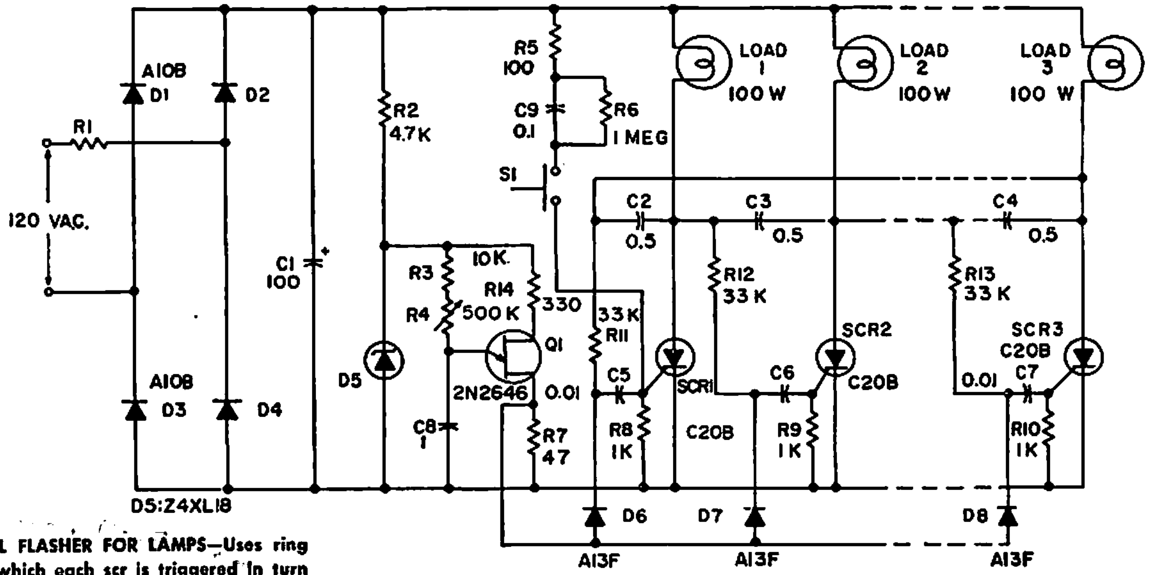
+180V
5 MEG.
5 MEG.
.001
A079
A079
SQUARE WAVE OUTPUT
R2 20K
R2 20K

300-HZ FLASHER—Provides slightly imperfect square-wave output at approximately 300 Hz. One use is as sequence flasher.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 36.



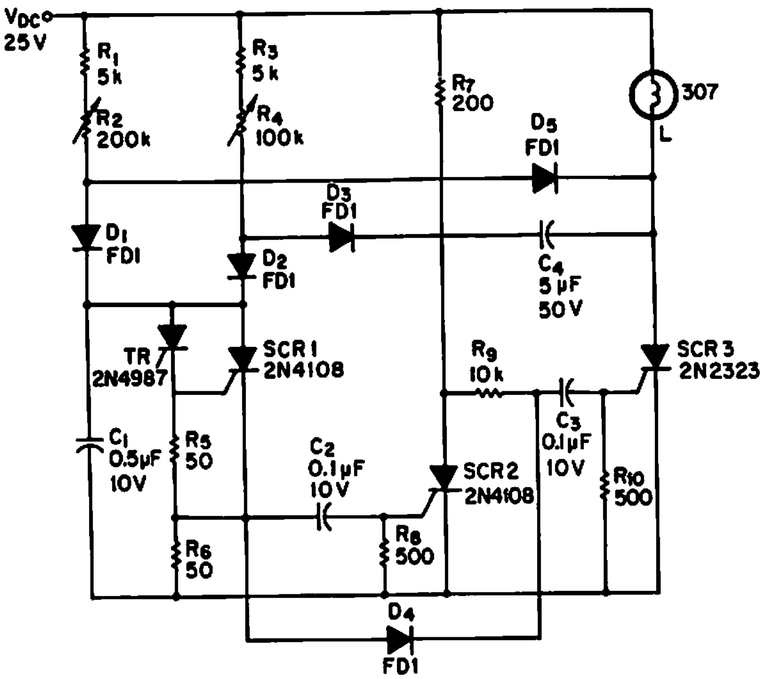
R1 100 k
RATE & STEADY ON CONTROL
R3 2 k
BULB IMPEDANCE >100 HOT
R2 510
LIGHT "ON" DURATION CONTROL
B2
Q2 2N2219
12 V
E
Q1 2N4870
B1
R4 1 k
R6 27
C1 100 μF 25 V
C2 0.1 μF 75 V
R5 1 k
Q2 ON BIAS CONTROL

1-W 12-V FLASHER—Low-cost circuit gives 6 to 120 flashes per minute, each adjustable in duration from 40 ms to 0.5 s.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–34.

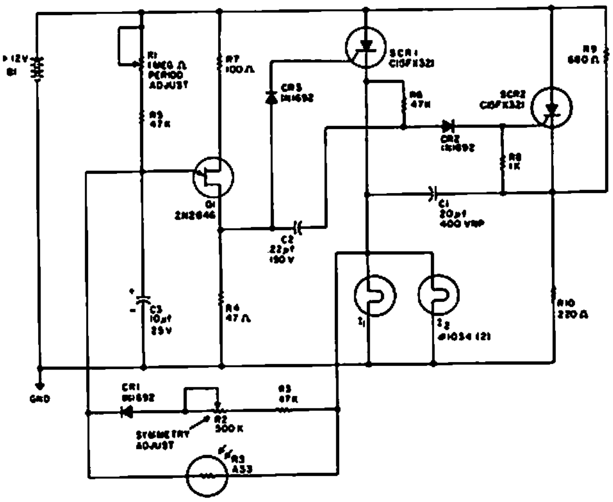


A10B D1
D2
R1
120 VAC.
A10B D3
D4
D5:Z4XL18
C1 100
D5
R2 4.7K
R3 10K
R4 R14 500 K
330
Q1 2N2646
C8 1
R5 100
C9 0.1
R6 1 MEG
S1
R7 47
0.01
33 K R11
C5
R8 1K
C2 0.5
SCR1 C20B
LOAD 1 100 W
LOAD 2 100W
LOAD 3 100 W
C3 0.5
C4 0.5
R12 33 K
R13 33 K
SCR2 C20B
C6
R9 1K
SCR3 C20B
0.01 C7
R10 1K
D6 A13F
D7 A13F
D8 A13F

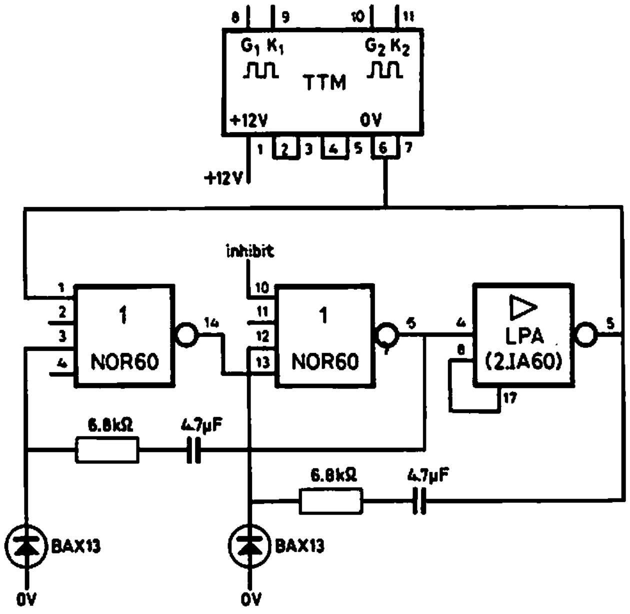
SEQUENTIAL FLASHER FOR LAMPS—Uses ring counter in which each scr is triggered in turn to operate its load. Can be used for displays, traffic warning lights, and advertising signs. Additional lamp stages can be added between the dotted lines. Article tells how to change components to handle higher-wattage lamps. Adjust R1 to give 120 V across C1.—A. A. Adem, Solid-State Ring Counters and Chasers for Light Displays, *Electronics World*, Sept. 1967, p 84–85.


VDC 25V
R1 5k
R2 200k
R3 5k
R4 100k
R7 200
307
L
D5 FD1
D3 FD1
D1 FD1
D2 FD1
C4 5μF 50V
TR 2N4987
SCR1 2N4108
R9 10k
SCR3 2N2323
C1 0.5μF 10V
R5 50
C2 0.1μF 10V
SCR2 2N4108
C3 0.1μF 10V
R10 500
R6 50
R8 500
D4 FD1

TWO-ADJUSTMENT FLASHER—On and off times are individually set by R2 and R4 in versatile lamp flasher. Any number of load-controlling scr's may be added, each with its own timed pulse spacing.—E. Kiburis, Sequential Control with Silicon Controlled Rectifiers, *EEE*, March 1970, p 100–103.


+12V B1
R1 1MEG Ω PERIOD ADJUST
R7 100Ω
SCR1 C15FX321
R9 680Ω
CR3 1N1692
R6 47K
SCR2 C15FX321
R5 47K
CR2 1N1692
R8 1K
Q1 2N2646
C1 20μF 400 VRP
C2 22μF 150V
C3 10μF 25V
R4 47Ω
I1
I2 #1034 (2)
R10 220Ω
GND
CR1 1N1692
R3 47K
R2 500K
SYMMETRY ADJUST
R3 A33

40-W NIGHT-ONLY FLASHER—Photoelectric daylight control turns flasher on at sunset and off at dawn to conserve battery light. Timing of scr flip-flop is controlled by ujt oscillator having variable control for flash rate and independent control of on and off times of flash.—High-Power, Battery-operated Flasher With Photoelectric Control, General Electric, Auburn, N.Y., No. 630.15.

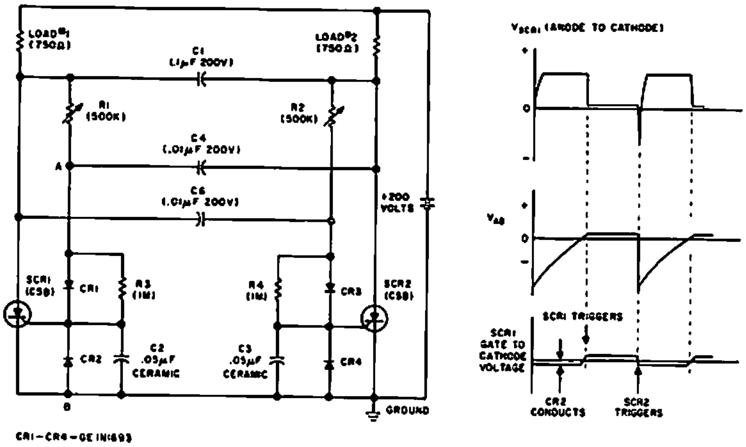

8 9 10 11
G1 K1
G2 K2
TTM
+12V
0V
1 2 3 4 5 6 7
+12V
inhibit
1 2 3 4
1
NOR60
14
10 11 12 13
1
NOR60
5
4
8
LPA (2JA60)
17
5
6.8kΩ
4.7μF
6.8kΩ
4.7μF
BAX13
BAX13
0V
0V

TRAFFIC LIGHT FLASHER—Combination of two Philips NORbit blocks and LPA amplifier serves as simple astable mvbr, used for driving TTM thyristor trigger module for switching one or two thyristors at given repetition rate as determined by values of capacitors used. With 12-V supply and values shown, flash rate is 1 Hz.—L. J. Lemmens, Multivibrator Circuit for Control of Thyristors, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 61.

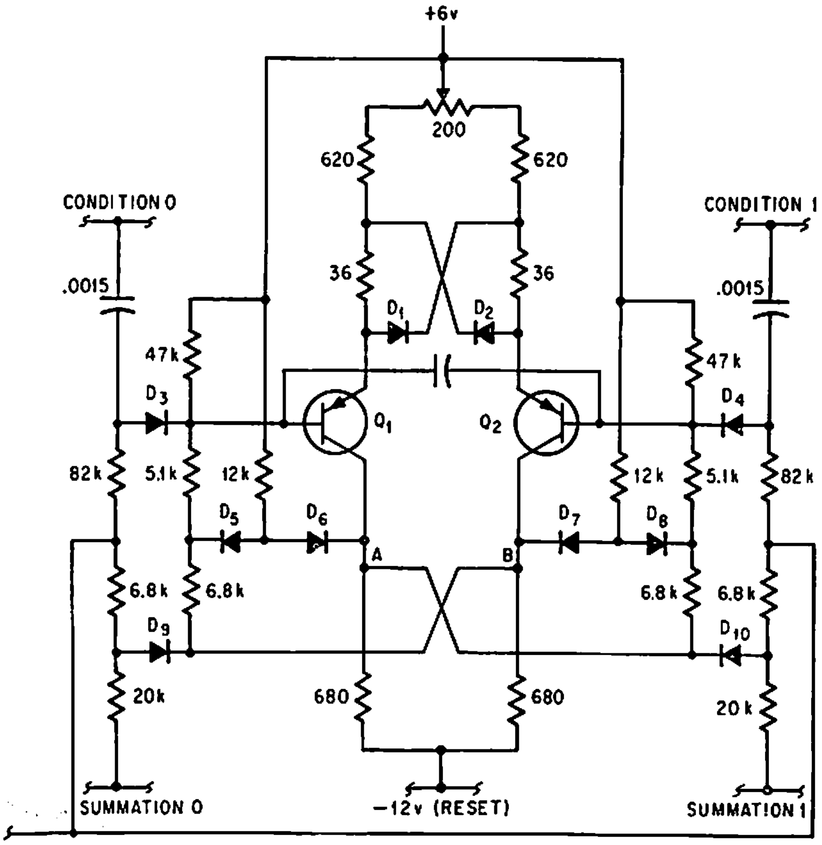
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 32

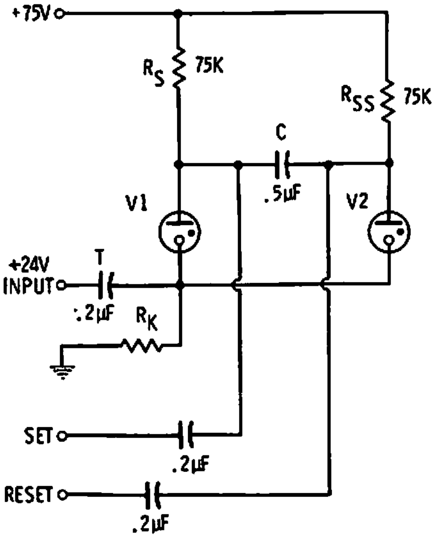
Flip-Flop Circuits


LOAD #1 (750Ω)
LOAD #2 (750Ω)
C1 (.1μF 200V)
R1 (500K)
R2 (500K)
C4 (.01μF 200V)
A
C6 (.01μF 200V)
+200 VOLTS
SCR1 (C5B)
CR1
R3 (1M)
R4 (1M)
CR3
SCR2 (C5B)
CR2
C2 .05μF CERAMIC
C3 .05μF CERAMIC
CR4
B
GROUND
CR1-CR4-GE 1N1693
V_SCR1 (ANODE TO CATHODE)
+
0
-
V_AB
SCR1 TRIGGERS
SCR1 GATE TO CATHODE VOLTAGE
CR2 CONDUCTS
SCR2 TRIGGERS

FREE-RUNNING HIGH-VOLTAGE SCR—Operates as low-frequency astable mvbr. By increasing sizes of timing capacitors C4 and C6, circuit can be made to operate at very low frequencies; it can then be used as high-voltage flasher driving lamp loads.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 27.

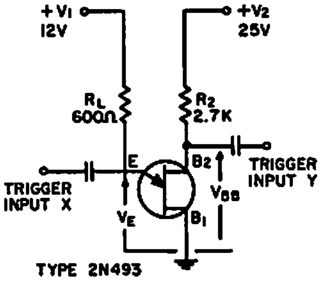

+6v
200
620
620
CONDITION 0
CONDITION 1
36
36
.0015
.0015
D1
D2
47k
47k
D3
D4
Q1
Q2
82k
5.1k
12k
12k
5.1k
82k
D5
D6
D7
D8
A
B
6.8k
6.8k
6.8k
6.8k
D9
D10
20k
680
680
20k
SUMMATION 0
−12v (RESET)
SUMMATION 1

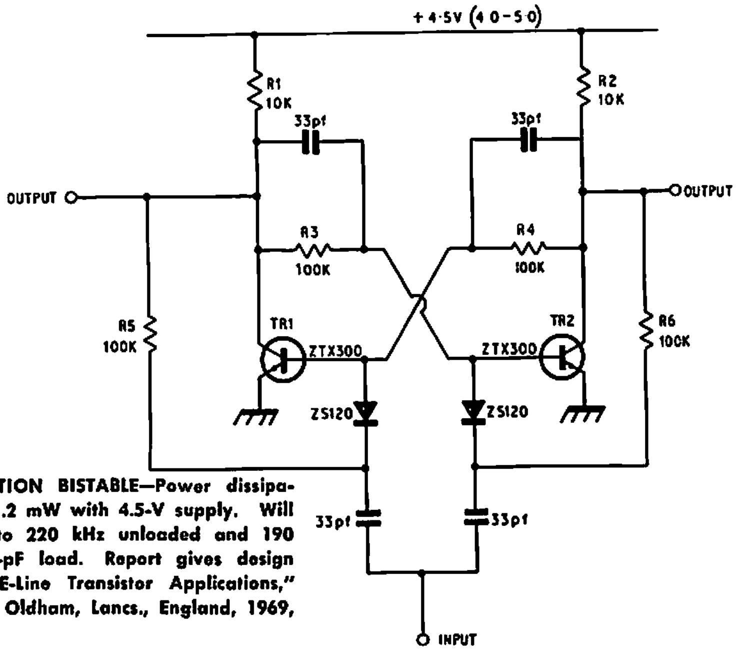
QUINARY TRIGGER—Six additional diodes (D1-D2 and D5-D8) in Eccles-Jordan flip-flop provide three additional stable states. Used as quinary memory in pattern recognizer developed by IBM for spoken words or graphic inputs. Transistor and diode types are not critical.—G. L. Clapper, Machine Looks, Listens, Learns, *Electronics*, Oct. 30, 1967, p 91–102.


+75V
RS 75K
RSS 75K
C
.5µF
V1
V2
+24V INPUT
T
.2µF
RK
SET
.2µF
RESET
.2µF

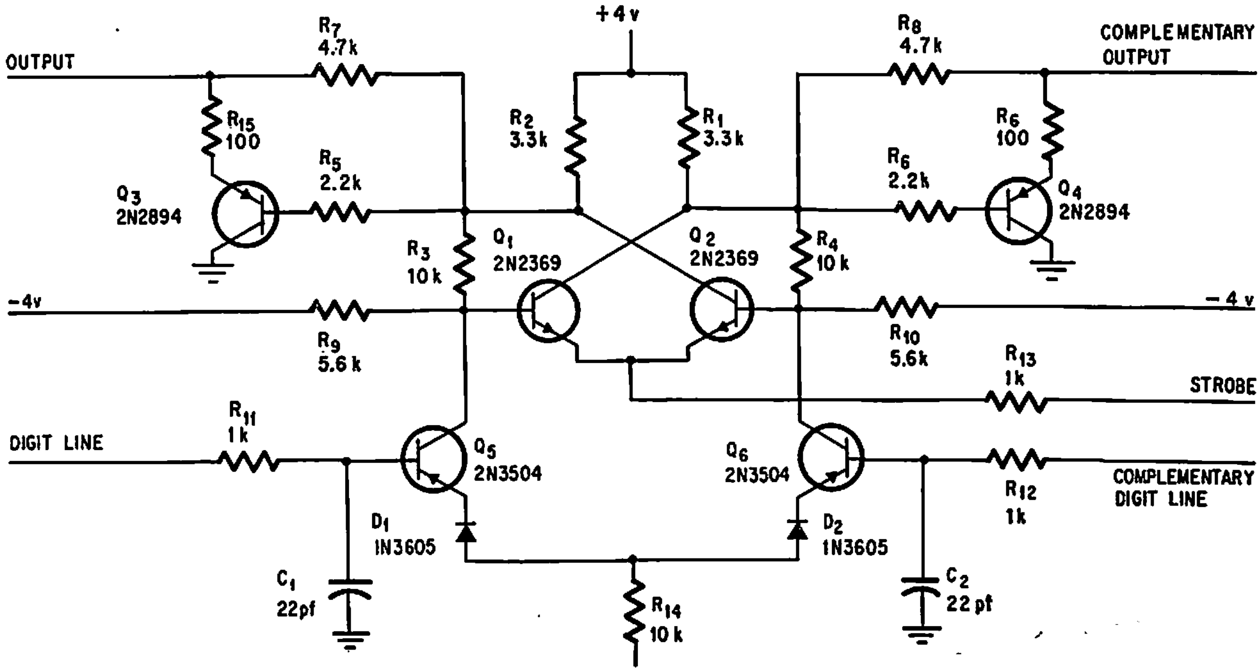
BINARY NEON—Zero potential applied at RESET terminal extinguishes V2 and permits V1 to ignite. Choose value for common cathode resistor RK such that V2 cannot fire. 24-V pulse at input, of duration depending on time constant of RK and 0.2-µF capacitor, causes flip-flop to switch, indicating count of ONE. Same lamp is lit once for every two input pulses. All lamps are 5AB-B.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 50.

BASIC BISTABLE UJT—Circuit has two stable operating points, called the ON and OFF states. When OFF, only very small current flows through load and power dissipation in load is below 1 nW. When trigger is applied to input X or Y, or both (positive for X and negative for Y), load power dissipation becomes about 135 mW. Negative trigger at X will turn circuit OFF.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 59.

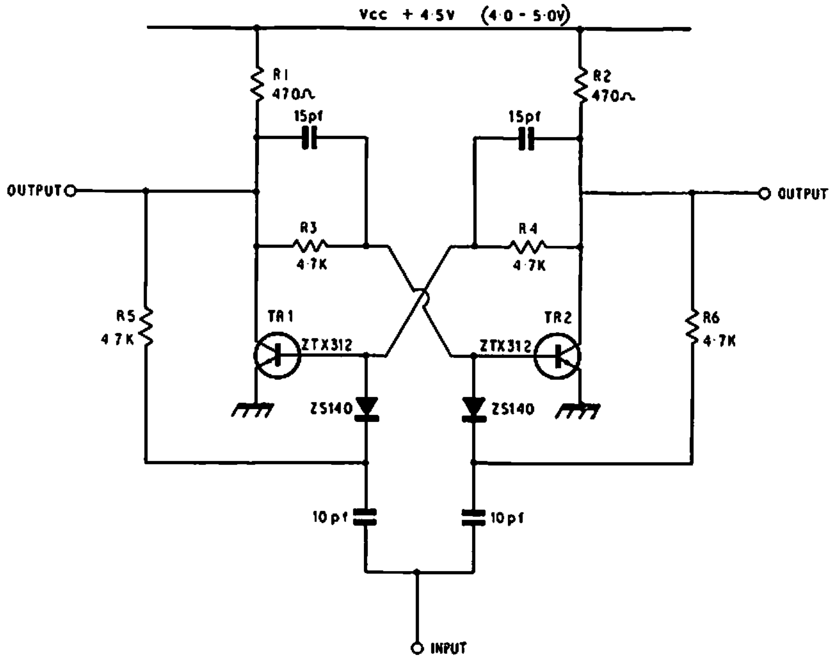

+V1 12V
+V2 25V
RL 600Ω
R2 2.7K
E
B2
B1
VE
VBB
TRIGGER INPUT X
TRIGGER INPUT Y
TYPE 2N493


+4·5V (4·0-5·0)
R1 10K
R2 10K
33pf
33pf
OUTPUT
OUTPUT
R3 100K
R4 100K
R5 100K
R6 100K
TR1
TR2
ZTX300
ZTX300
ZS120
ZS120
33pf
33pf
INPUT

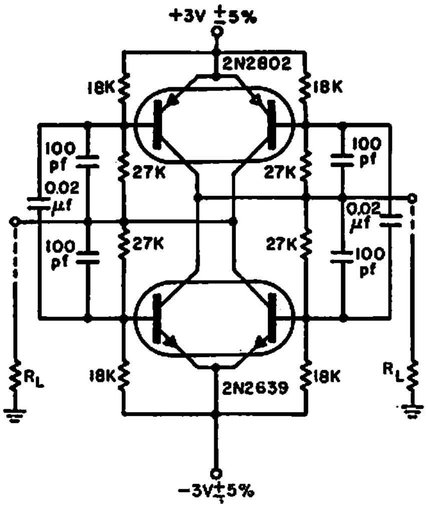
LOW-DISSIPATION BISTABLE—Power dissipation is only 2.2 mW with 4.5-V supply. Will operate up to 220 kHz unloaded and 190 kHz into 68-pF load. Report gives design procedure.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 13.


+4v
OUTPUT
R7 4.7k
R8 4.7k
COMPLEMENTARY OUTPUT
R15 100
R6 100
R2 3.3k
R1 3.3k
R5 2.2k
R6 2.2k
Q3 2N2894
Q4 2N2894
R3 10k
R4 10k
Q1 2N2369
Q2 2N2369
-4v
-4v
R9 5.6k
R10 5.6k
R13 1k
STROBE
R11 1k
DIGIT LINE
Q5 2N3504
Q6 2N3504
R12 1k
COMPLEMENTARY DIGIT LINE
D1 1N3605
D2 1N3605
C1 22pf
C2 22pf
R14 10k
+4v

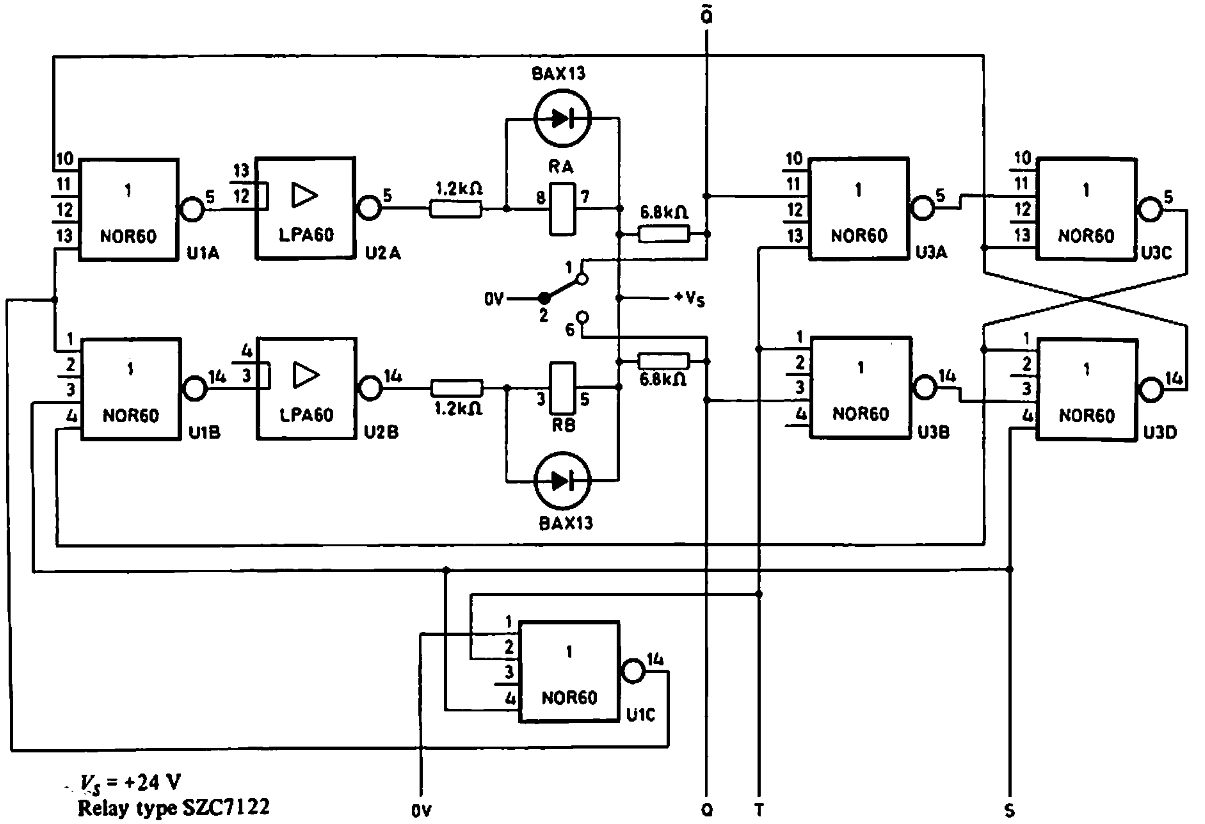
MEMORY SENSE AMPLIFIER—Picks up difference between currents in complementary digit lines, to bias flip-flop Q1-Q2 through differential amplifier Q5-Q6. Strobe read signal sets flip-flop to state toward which differential amplifier previously biased it, to generate appropriate complementary outputs. Used in computer storage developed for long space trips.—D. E. Brewer, S. Nissim, and G. V. Podraza, Suitcase-size Memory for Longer Space Trips, *Electronics*, Nov. 13, 1967, p 138–146.


Vcc + 4·5V (4·0 - 5·0V)
R1
470Ω
R2
470Ω
15pf
15pf
OUTPUT
OUTPUT
R3
4·7K
R4
4·7K
R5
4·7K
R6
4·7K
TR1
ZTX312
TR2
ZTX312
ZS140
ZS140
10pf
10pf
INPUT

FAST FLIP-FLOP—Can be used as frequency divider up to 7.5 MHz. Requires only one 4.5-V supply. Used in Johnson decade counter. Report gives design procedure and equations, along with modification for increasing speed to 13 MHz.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 11.

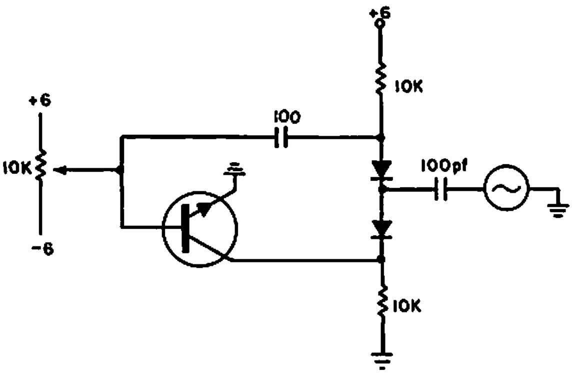

+3V ±5%
2N2802
18K
18K
100 pf
100 pf
27K
27K
0.02 µf
0.02 µf
100 pf
100 pf
27K
27K
RL
RL
18K
18K
2N2639
-3V±5%

COMPLEMENTARY SILICON TRANSISTORS—Use of complementary transistor in place of collector load resistor in basic flip-flop gives higher operating efficiency, higher operating speed, and lower output impedance. Article gives design procedure for determining optimum values of components, for operation at temperatures from −55 to +150 C at 1-mA collector currents.—P. Ward, Complementary Flip-Flops Improve Bistable Performance, *Electronic Design*, May 11, 1964, p 50–55.

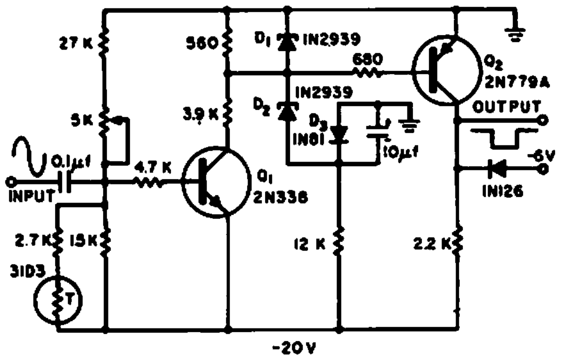

Q̄
BAX13
RA
10
11
12
13
1
NOR60
U1A
5
13
12
LPA60
U2A
5
1.2kΩ
8
7
6.8kΩ
10
11
12
13
1
NOR60
U3A
5
10
11
12
13
1
NOR60
U3C
5
0V
1
2
6
+Vs
1
2
3
4
1
NOR60
U1B
14
4
3
LPA60
U2B
14
1.2kΩ
3
5
RB
6.8kΩ
1
2
3
4
1
NOR60
U3B
14
1
2
3
4
1
NOR60
U3D
14
BAX13
1
2
3
4
1
NOR60
U1C
14
0V
Q
T
S

V_S = +24 V
Relay type SZC7122
(3522 289 97481)

MEMORY FOR POWER FAILURE—Divide-by-two flip-flop uses bipolar relay to provide memory function so information is not lost if supply voltage is removed because of power failure or any other reason. Uses Philips amplifier and gate blocks. Terminal T is input. High level at terminal S stops flip-flop. Complementary outputs are taken from terminals Q.—L. J. Lemmens, A Non-Volatile Flip-Flop, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 72.

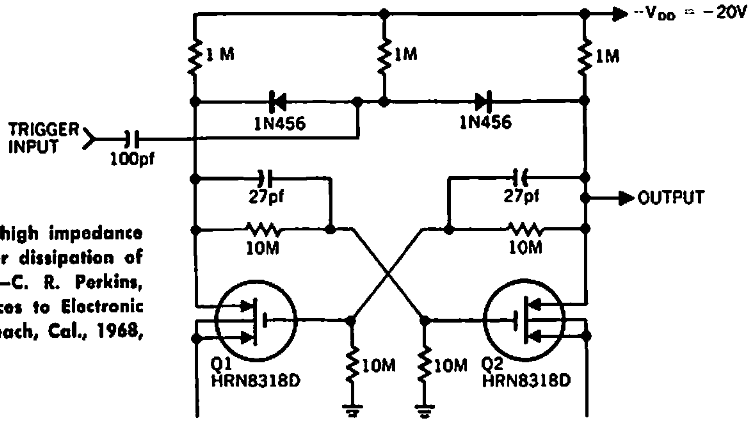

+6
10K
+6
100
10K
-6
100pf
10K

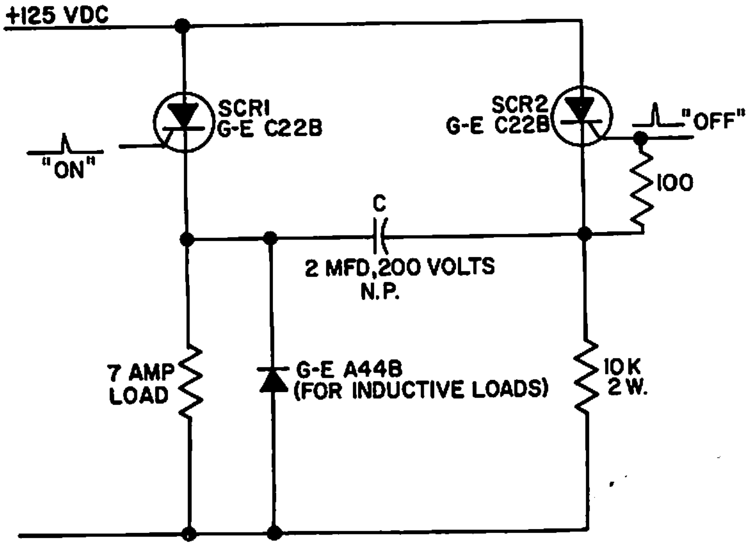
COLLECTOR-FOLLOWING EFFECT—Operation depends on driving base potential of single saturated common-emitter transistor rapidly toward cutoff. Collector voltage then follows base, if collector resistance is sufficiently high. Article gives theory of operation. No transformer is required. Will operate for collector resistances of 2K to 100K for variety of transistors ranging from 2N1613 to 2N706. Frequency of sine-wave source is not critical. Can be used as shift register, delay, and radiation detector.—R. E. Briley, One-Transistor Flip-Flop, *Electronic Design*, Aug. 17, 1964, p 132–134.


27 K
560
D1
1N2939
680
Q2
2N779A
5K
3.9 K
D2
1N2939
D3
1N81
10µf
OUTPUT
-6V
1N126
0.1µf
INPUT
4.7 K
Q1
2N338
2.7K
15K
3ID3
T
12 K
2.2 K
-20V

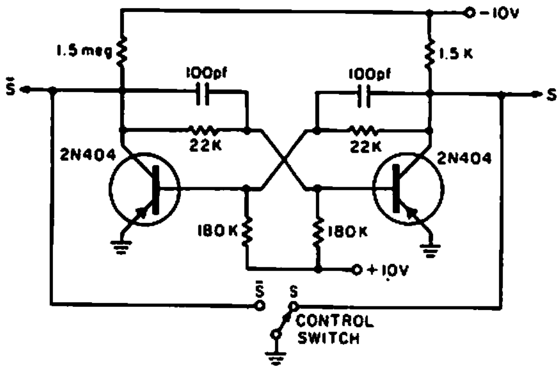
TUNNEL-DIODE FLIP-FLOP—Used in converting analog voltage waveform to digital logic levels. Provides faster rise time than conventional Schmitt trigger and maintains accurate zero-crossing information without phase distortion. Circuit requires only one supply voltage, plus lamp voltage if desired. Output is clean square wave at any frequency from 1 to 25 kHz for 1-V p-p input signal.—C. S. Miller, Fast Squaring Circuit Preserves Phase Information, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 96.

BISTABLE MOSFET—Extremely high impedance of mosfet circuit makes power dissipation of flip-flop less than 0.5 mW.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 33.

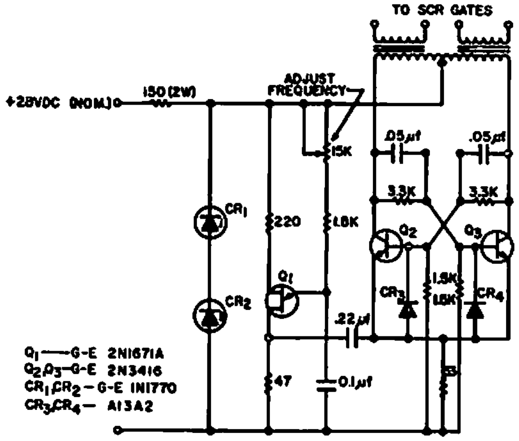

-VDD = -20V
1 M
1M
1M
1N456
1N456
TRIGGER INPUT
100pf
27pf
27pf
OUTPUT
10M
10M
10M
10M
Q1
HRN8318D
Q2
HRN8318D


+125 VDC
SCR1
G-E C22B
SCR2
G-E C22B
"ON"
"OFF"
100
C
2 MFD,200 VOLTS
N.P.
7 AMP
LOAD
G-E A44B
(FOR INDUCTIVE LOADS)
10K
2 W.

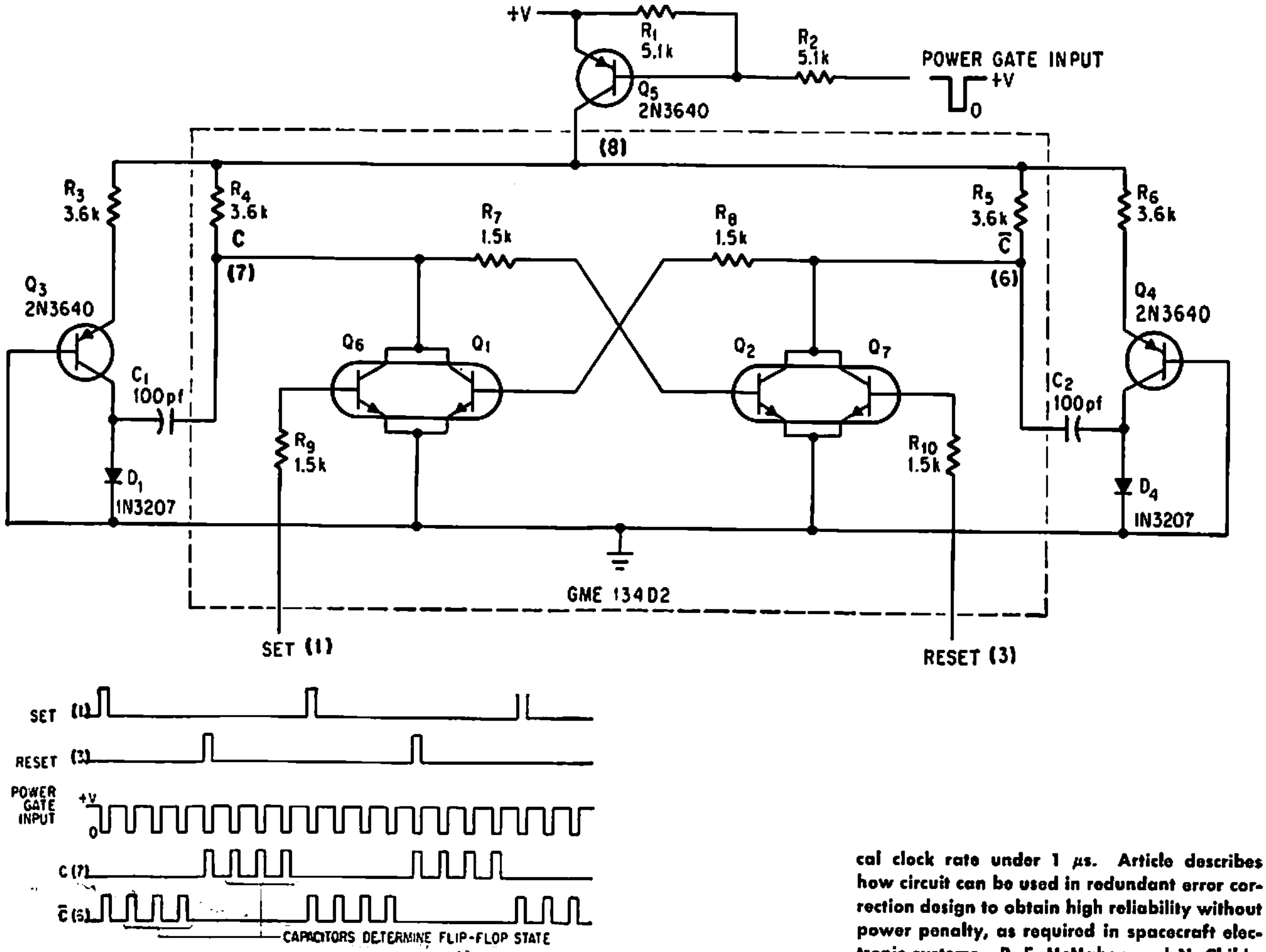
LATCHING STATIC SWITCH—Load current flows when pulse is applied to gate of SCR1, which then triggers and latches on. To turn off load, pulse is applied to SCR2 to turn it on and short out SCR1 momentarily through C to make SCR1 drop out. Can be used as flasher, heavy-duty relay, heater control, circuit breaker, power mvbr, etc.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 4.


-10V
1.5 meg
1.5 K
$\bar{S}$
S
100pf
100pf
22K
22K
2N404
2N404
180K
180K
+10V
$\bar{S}$ S
CONTROL
SWITCH

BOUNCE-FREE SWITCH—When logic signal is to be generated by manual switching of flip-flop, bounce at switch contacts can be eliminated by using spdt switch connected as shown, to short-circuit one transistor of flip-flop each time switch is operated to make flip-flop change its state.—B. Ross, Flip-Flop Switch Eliminates Contact Bounce, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 232.

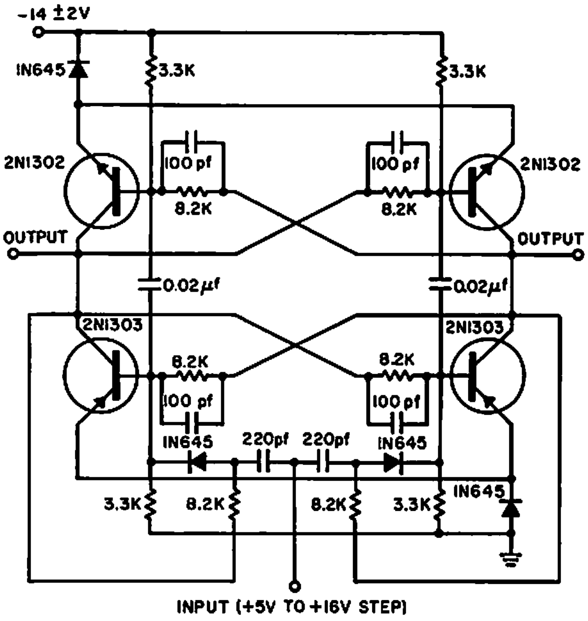

TO SCR GATES
+28VDC (NOM)
150 (2W)
ADJUST
FREQUENCY
15K
.05μf
.05μf
3.3K
3.3K
CR1
CR2
220
1.8K
Q1
Q2
Q3
1.5K
1.8K
CR3
CR4
.22μf
47
0.1μf
Q1—G-E 2N1671A
Q2,Q3—G-E 2N3416
CR1,CR2—G-E 1N1770
CR3,CR4— A13A2

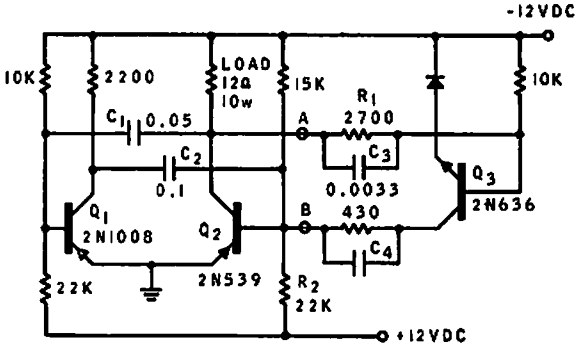
400-HZ TRIGGER—Delivers square-wave gate signals alternating from 7 V positive to 7 V negative through transformer for driving scr or triac gates. Current is up to 800 mA. Can be free-running, or driven by ujt for precise timing.—"SCR Manual," 4th Edition, General Electric, 1967, p 85–86.


+V
R1
5.1k
R2
5.1k
POWER GATE INPUT
+V
0
Q5
2N3640
(8)
R3
3.6k
R4
3.6k
C
(7)
R7
1.5k
R8
1.5k
R5
3.6k
$\bar{C}$
(6)
R6
3.6k
Q3
2N3640
Q6
Q1
Q2
Q7
Q4
2N3640
C1
100pf
C2
100pf
D1
1N3207
D4
1N3207
R9
1.5k
R10
1.5k
GME 134D2
SET (1)
RESET (3)
SET (1)
RESET (3)
POWER GATE INPUT
+V
0
C (7)
$\bar{C}$ (6)
CAPACITORS DETERMINE FLIP-FLOP STATE

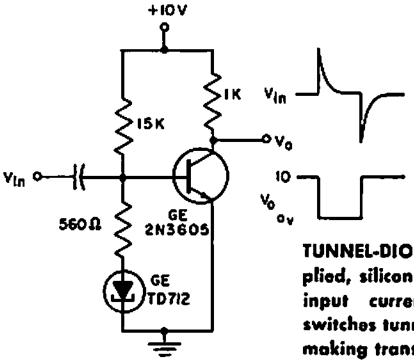
MICROPOWER FOR REDUNDANCY—Use of pulsed or gated power mode for Philco-Ford set-reset IC flip-flop cuts operating power to a few microwatts instead of the usual several milliwatts. Supply voltage is gated to digital elements only during clock interval, with typical clock rate under 1 μs. Article describes how circuit can be used in redundant error correction design to obtain high reliability without power penalty, as required in spacecraft electronic systems.—R. E. McMahon and N. Childs, Micropower Redundant Circuits Correct Errors Automatically, *Electronics*, Feb. 6, 1967, p 66–69.

COMPLEMENTARY GERMANIUM TRANSISTORS—Complementary arrangement with germanium transistors gives higher operating efficiency, higher operating speed, and lower output impedance. With circuit unbalanced to ground, only one supply voltage is needed. Circuit also illustrates use of commutative triggering from positive-going input. Article gives design procedure.—P. Ward, Complementary Flip-Flops Improve Bistable Performance, *Electronic Design*, May 11, 1964, p 50–55.

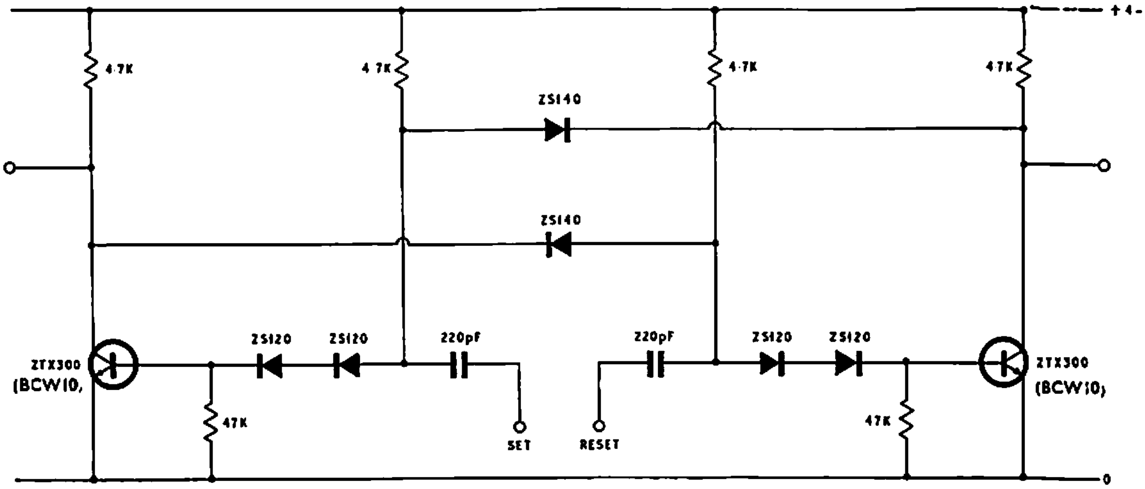

-14 ±2V
IN645
3.3K
3.3K
2N1302
100 pf
8.2K
100 pf
8.2K
2N1302
OUTPUT
OUTPUT
0.02μf
0.02μf
2N1303
2N1303
8.2K
8.2K
100 pf
100 pf
IN645
220pf
220pf
IN645
3.3K
8.2K
8.2K
3.3K
IN645
INPUT (+5V TO +16V STEP)


-12VDC
10K
2200
LOAD
12Ω
10w
15K
R1
10K
C1
0.05
A
2700
C2
C3
0.1
0.0033
Q3
2N636
Q1
2N1008
Q2
B
430
C4
22K
2N539
R2
22K
+12VDC

REGENERATIVE OUTPUT FOR FLIP-FLOP—Amplifier Q3 boosts peak power to 10 W for 12-ohm load. Circuit at left of points A-B is astable flip-flop, but technique can be applied to stable and monostable flip-flops as well.—R. A. Durand, Regenerative Stage Enhances Flip-Flop Power Output, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 180–181.


+10V
1K
15K
Vo
Vin
Vin
GE
2N3605
560Ω
GE
TD712
10
Vo
0V

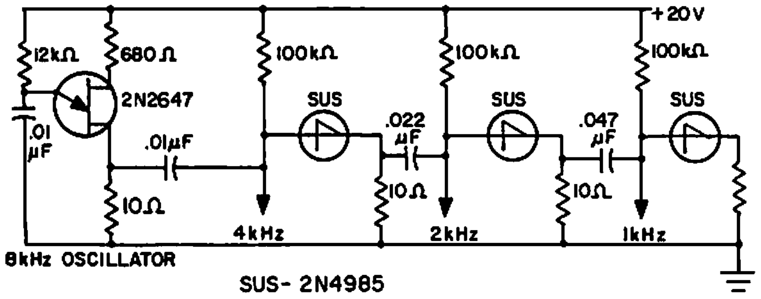
TUNNEL-DIODE HYBRID—When power is applied, silicon transistor stays off. Addition of input current through coupling capacitor switches tunnel diode to its high-voltage state, making transistor turn on. Applying negative pulse at input makes circuit switch back to low-voltage state, giving equivalent of flip-flop action.—W. R. Spofford, Jr., Applications For The New Low Cost TD 700 Series Tunnel Diodes, General Electric, Syracuse, N.Y., No. 90.66, 1967, p 8.


+4-5V
4.7K
4.7K
4.7K
4.7K
ZS140
ZS140
ZTX300
(BCW10)
ZS120
ZS120
220pF
220pF
ZS120
ZS120
ZTX300
(BCW10)
47K
47K
SET
RESET
0

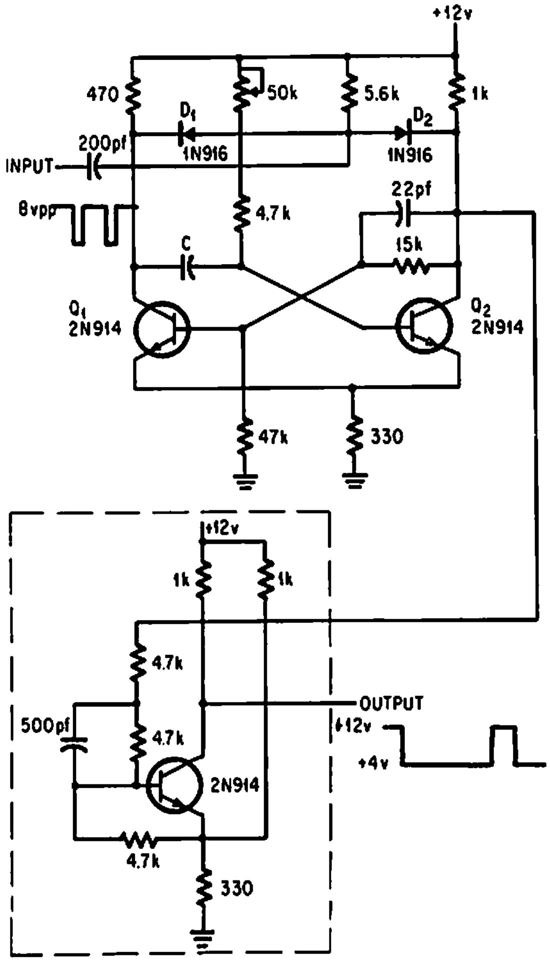
SET-RESET BISTABLE—Cross-coupling of two NOR gates gives logical flip-flop that is useful for control purposes where two separate signals are available to trigger bistable between its two states. Inputs are normally up, and triggering occurs when input is pulled to ground or below 1 V.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 10.

CHAPTER 33

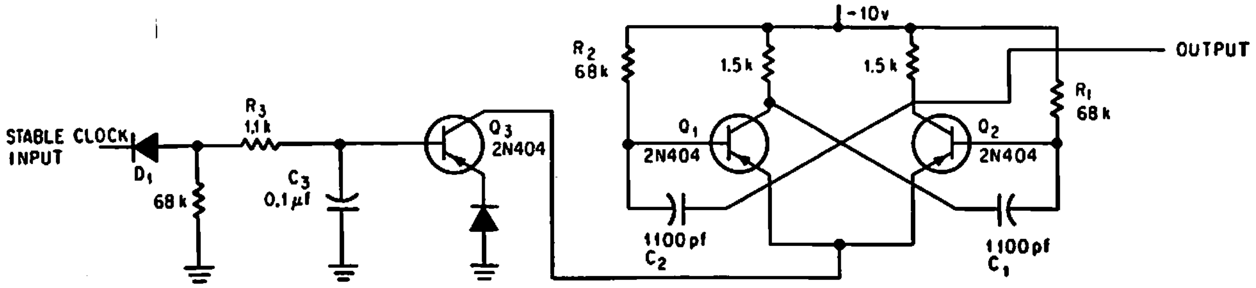
Frequency Divider Circuits


+20V
12kΩ
680Ω
2N2647
.01 µF
.01µF
10Ω
100kΩ
SUS
.022 µF
10Ω
100kΩ
SUS
.047 µF
10Ω
100kΩ
SUS
4kHz
2kHz
1kHz
8kHz OSCILLATOR
SUS- 2N4985

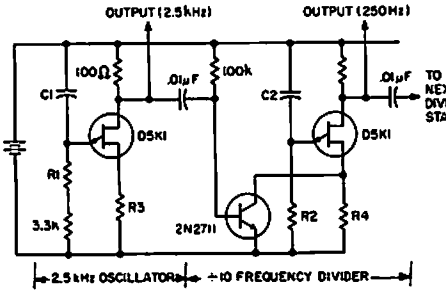
SIMPLIFIED 8 KHZ:1 KHZ DIVIDER—Sawtooth output of each silicon unilateral switch stage is half the frequency of preceding stage. May also be used with 2N4989 sus.—Silicon Unilateral Switch 2N4984/2N4985, General Electric, Syracuse, N.Y., No. 65.27, 1967.


+12v
470
50k
5.6k
1k
D1
D2
200pf
1N916
1N916
INPUT
8vpp
4.7k
22pf
C
15k
Q1 2N914
Q2 2N914
47k
330
+12v
1k
1k
4.7k
500pf
4.7k
2N914
4.7k
330
OUTPUT
+12v
+4v

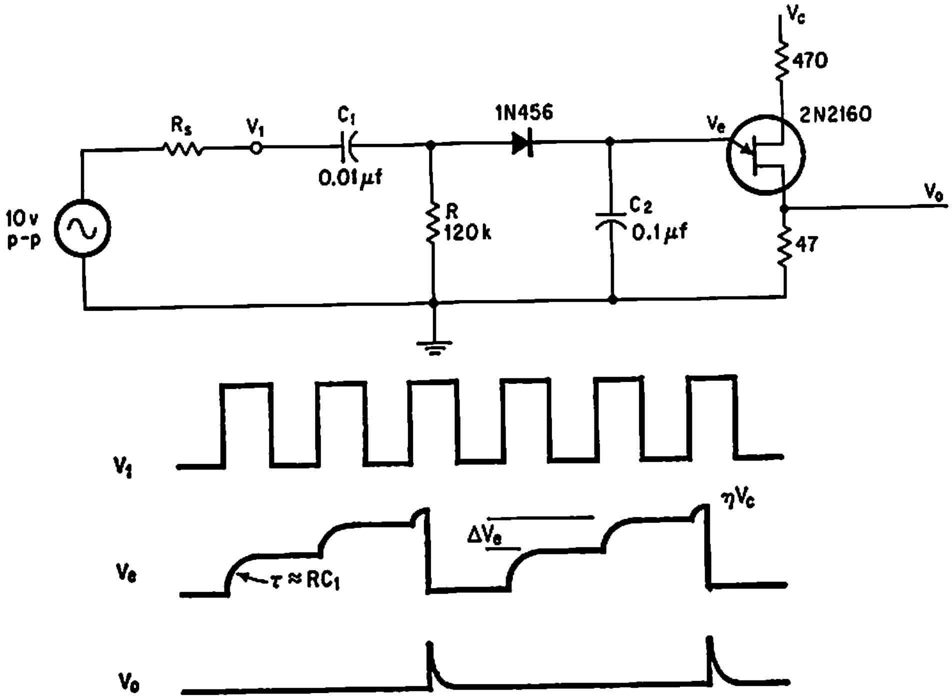
DIVIDE-BY-12 MVBR—Provides precise division up to 12 with values shown, and up to 1,000 by adding self-controlled input gate and 1-MHz crystal clock feeding three circuits in cascade. Circuit in dashed area is added to generate neatly squared 1-ms pulses for synchronizing another divider stage. Use minimum value for C and adjust pot to give desired fixed division factor. Generated pulse can be stopped or started with any positive edge of clock pulse.—V. Mosca, One-Shot Multivibrator Yields Division up to 12, *Electronics*, April 14, 1969, p 96.


-10v
R2 68k
1.5k
1.5k
OUTPUT
R1 68k
STABLE CLOCK INPUT
D1
68k
R3 1.1k
C3 0.1µf
Q3 2N404
Q1 2N404
Q2 2N404
1100pf C2
1100pf C1

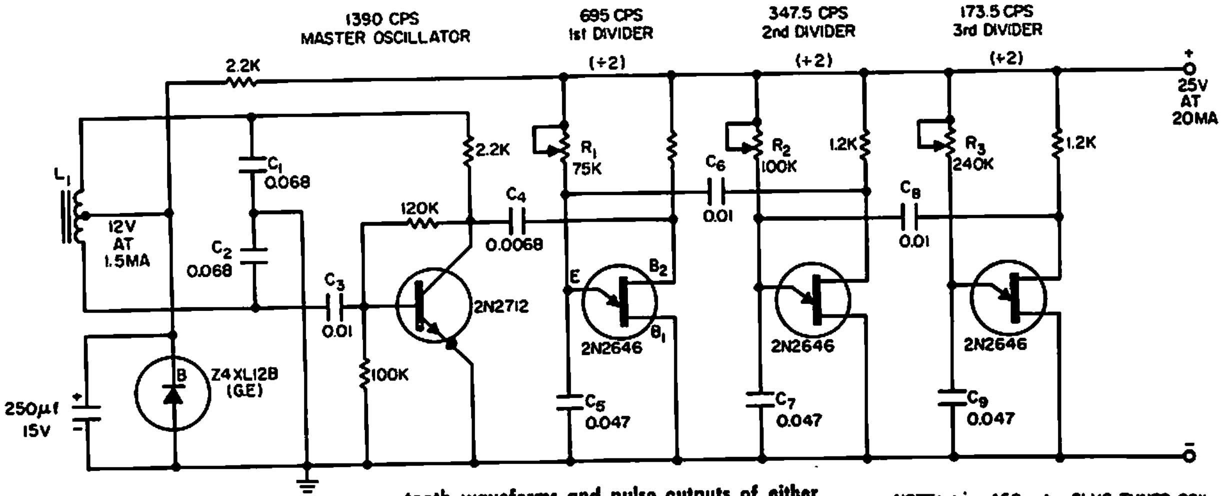
60:1 WITH ASTABLE MVBR—Circuit easily synchronizes to 92-V sinusoidal or square-wave clock input over frequency range of 10 to 600 kHz and gives either 10:1 or 60:1 frequency division. Components R3 and C3 are selected to offer ripple to base of Q3 at clock frequency; ripple is amplified by Q3 and fed to mvbr Q1-Q2 to lock it to clock. If clock fails, Q3 stops mvbr.—A. L. Plevy and E. N. Monacchio, Fail-safe Frequency Divider, *Electronics*, Sept. 19, 1966, p 127.


OUTPUT (2.5kHz)
OUTPUT (250Hz)
100Ω
.01μF
100k
C1
C2
.01μF
TO NEXT DIVIDER STAGE
D5K1
D5K1
R1
3.3k
R3
2N2711
R2
R4
2.5kHz OSCILLATOR
÷10 FREQUENCY DIVIDER

DECADE DIVIDER—Starts with 2.5-kHz ujt oscillator. Each following transistor-ujt stage divides frequency by 10. C1 and C2 are 0.0047, R1 is 100K, R2 is 1 meg, and R3 and R4 are around 1K, adjusted to match ujt's. For next stage, product of R2 and C2 should be ten times that of preceding stage, with R2 between 27K and 10 meg.—Silicon Complementary Unijunction Transistor D5K1, General Electric, Syracuse, N.Y., No. 60.15, 1967.

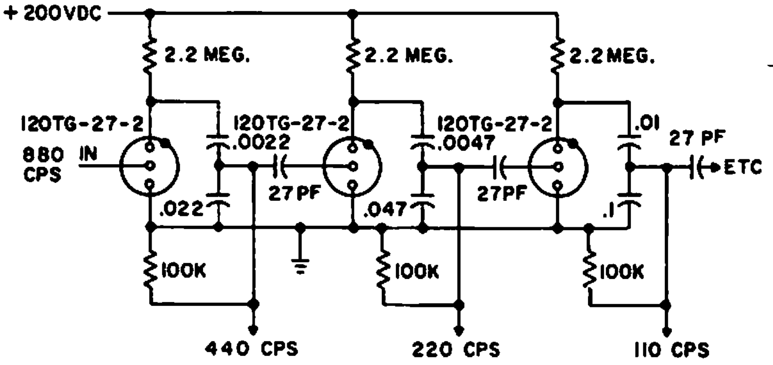

Vc
470
Rs
V1
C1
0.01μf
1N456
Ve
2N2160
10v p-p
R 120k
C2 0.1μf
Vo
47
V1
Ve
τ≈RC1
ΔVe
ηVc
Vo

JITTER KILLER—Control voltage Vc of ujt determines frequency division ratio, in range of 2 to 20. For values shown, circuit operates over frequency range of 20 to 150 Hz. Characteristics of ujt make it tolerate large amounts of jitter in input.—J. P. Budlong, UJT Gives Frequency Divider an Immunity to Input Jitter, *Electronics*, July 7, 1969, p 105.

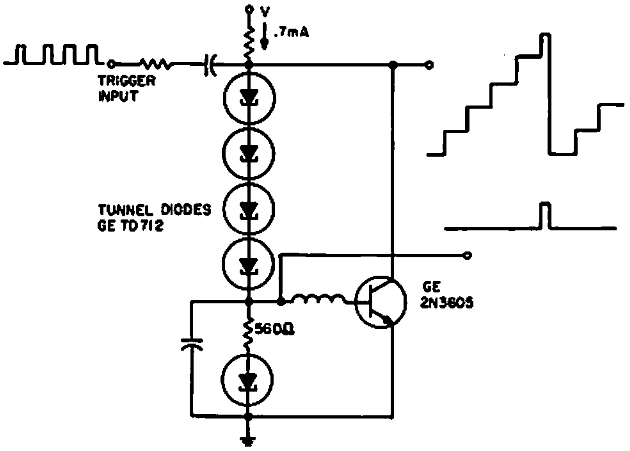

1390 CPS MASTER OSCILLATOR
695 CPS 1st DIVIDER (÷2)
347.5 CPS 2nd DIVIDER (÷2)
173.5 CPS 3rd DIVIDER (÷2)
2.2K
+
25V AT 20MA
L1
12V AT 1.5MA
C1 0.068
C2 0.068
2.2K
120K
C4
0.0068
C3
0.01
2N2712
100K
R1 75K
E
B2
B1
2N2646
C5 0.047
C6
0.01
R2 100K
1.2K
2N2646
C7 0.047
C8
0.01
R3 240K
1.2K
2N2646
C9 0.047
250μf 15V
+
Z4XL12B (GE)
B
−

CASCADED UJT'S DIVIDE 1,390 HZ BY 8—Simple ujt relaxation oscillators are cascaded and synchronized from 1,390-Hz Hartley oscillator to give reliable frequency division. Sawtooth waveforms and pulse outputs of either polarity are available from each divider stage.—J. F. Cleary and D. V. Jones, Cascaded UJT Oscillators Form Stable Frequency Divider, *Electronic Design*, Nov. 8, 1965, p 52.

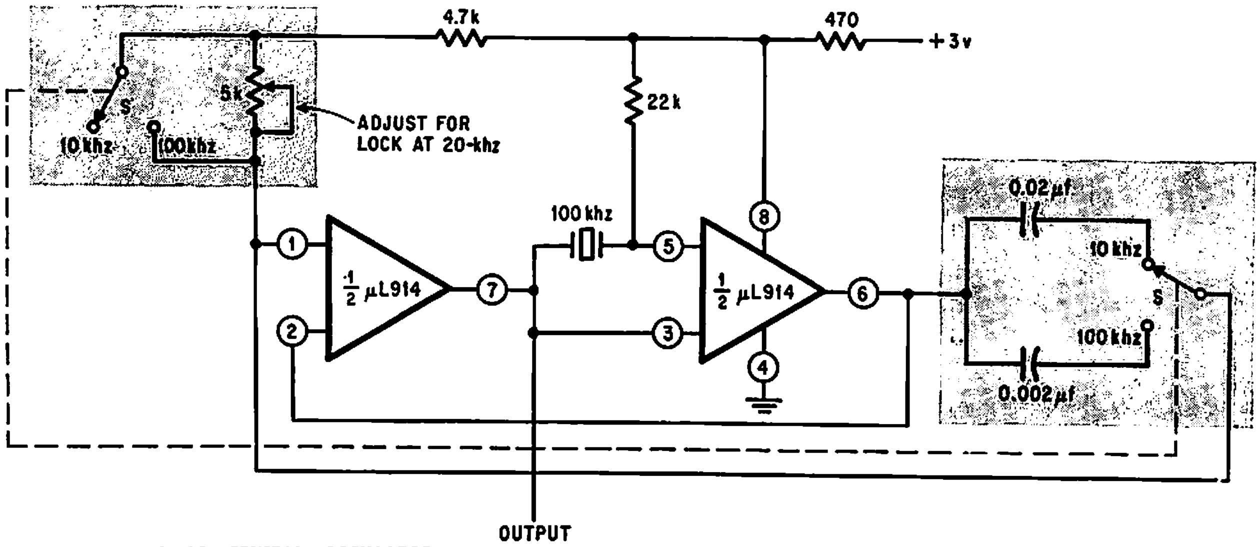
NOTE: L_1 —450 mhy SLUG TUNED COIL
Q=6 AT 1KC
DC RES. 480Ω

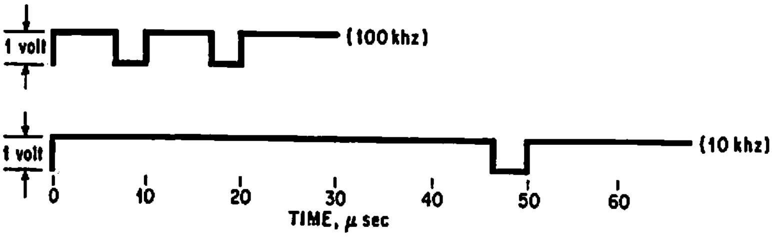

+200VDC
2.2 MEG.
2.2 MEG.
2.2MEG.
120TG-27-2
120TG-27-2
120TG-27-2
.0022
.0047
.01
27 PF
880 IN
CPS
.022
27PF
.047
27PF
.1
ETC
100K
100K
100K
440 CPS
220 CPS
110 CPS

DIVIDE-BY-2—Uses 3-element neon lamps powered by a 200-V supply which also runs 880-Hz master oscillator. Output is 440-Hz linear sawtooth.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 51.

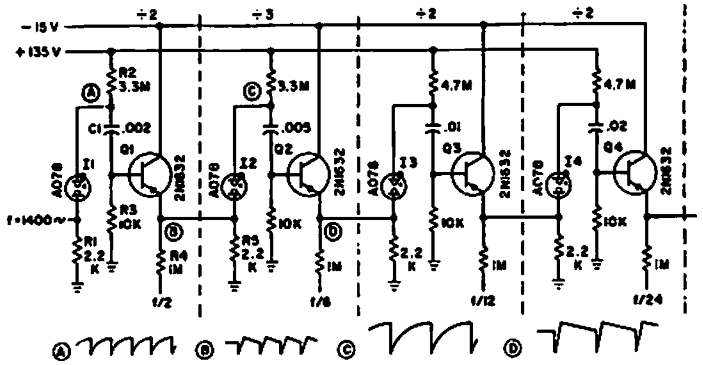

V
.7mA
TRIGGER INPUT
TUNNEL DIODES GE TD712
GE 2N3605
560Ω

TUNNEL-DIODE DIVIDER—Lowest of five diodes in series string is chosen to have highest peak point current. First trigger pulse turns on diode having lowest peak point current, creating first voltage jump at output. Successive trigger pulses will in turn trigger other diodes one at a time, until finally the bottom diode is turned on. Voltage across entire string then drops to zero, turning off all diodes, and sequence begins again. Can be used as 5:1 pulse frequency divider or as staircase waveform generator.—W. R. Spofford, Jr., Applications For The New Low Cost TD 700 Series Tunnel Diodes, General Electric, Syracuse, N.Y., No. 90.66, 1967, p 10.

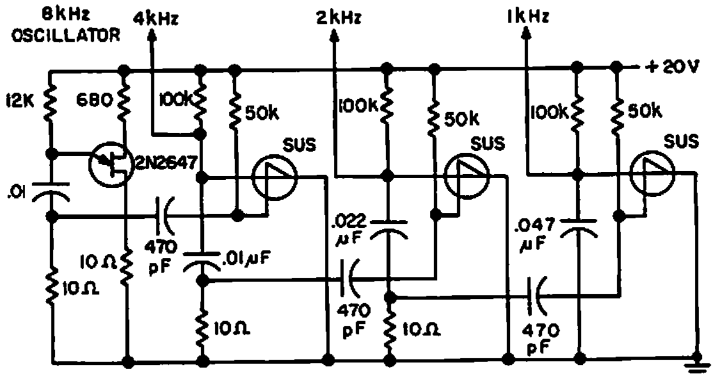

4.7k
470
+3v
5k
S
10khz
100khz
ADJUST FOR LOCK AT 20-khz
22k
100khz
1
2
7
5
3
8
6
4
1/2 μL914
1/2 μL914
0.02μf
10khz
S
100khz
0.002μf
OUTPUT



SELF-DIVIDING IC CRYSTAL OSCILLATOR—Fundamental resonant frequency is divided by 10 automatically, without separate frequency-dividing mvbr, when switch S is in 10-kHz position. Circuit actually oscillates at 20 kHz but waveform is asymmetrical and has strong 10-kHz submultiple. IC is low-cost Fairchild μL914 dual two-input gate.—J. Althouse, Dividing the Frequency of an Oscillator by 10, *Electronics*, December 11, 1967, p 98.

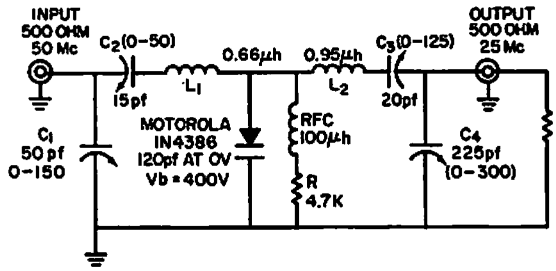

-15V
+135V
÷2
÷3
÷2
÷2
R2 3.3M
3.3M
4.7M
4.7M
C1 .002
.005
.01
.02
Q1
Q2
Q3
Q4
2N632
A078
I1
I2
I3
I4
R3 10K
10K
R1 2.2 K
R5 2.2 K
2.2 K
R4 1M
1M
f=1400~
f/2
f/6
f/12
f/24
Ⓐ
Ⓑ
Ⓒ
Ⓓ

DIVIDE BY 2 OR 3—Transistor coupling between stages prevents audio signal of one stage from leaking back into previous one. A low-impedance sine-wave generator in series with I1 provides dividing signal. Circuit may be used as organ tone generator if second stage is adjusted to divide by 2.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 50.


8kHz OSCILLATOR
4kHz
2kHz
1kHz
+20V
12K
680
100k
50k
2N2647
SUS
.01
470 pF
.01μF
10Ω
.022 μF
.047 μF
470 pF

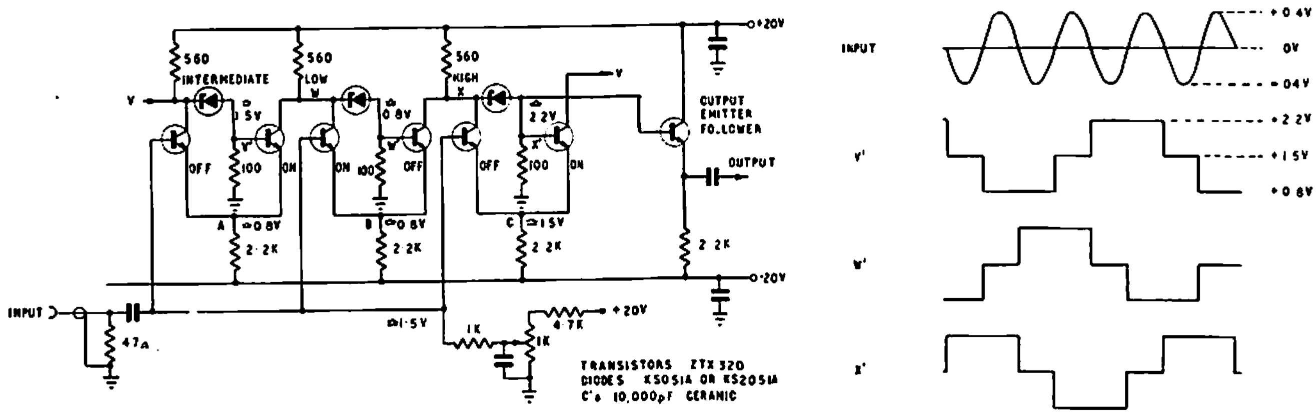
SUS - 2N4985

TRANSIENT-FREE SUS 8:1 DIVIDER—Spikes in center of sawtooth are eliminated in this silicon unilateral switch circuit by triggering at gate. May also be used with 2N4989 sus.—Silicon Unilateral Switch 2N4984/2N4985, General Electric, Syracuse, N.Y., No. 65.27, 1967.

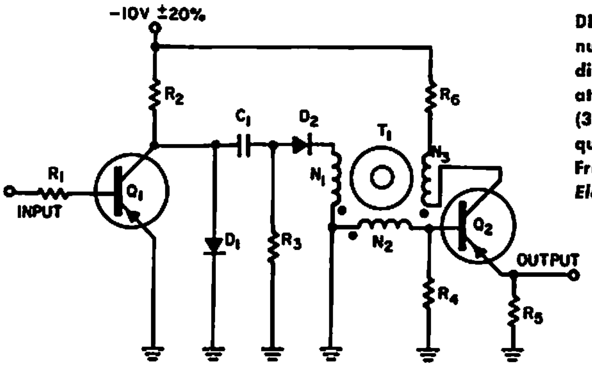

INPUT 500 OHM 50 Mc
C2(0-50)
15pf
0.66μh
L1
0.95μh
L2
C3(0-125)
20pf
OUTPUT 500 OHM 25Mc
C1 50 pf 0-150
MOTOROLA 1N4386 120pf AT 0V Vb=400V
RFC 100μh
R 4.7K
C4 225pf (0-300)
RL 50

L_1: 5 1/2 T, 1 1/8" I.D., 1/8" DIA TUBE, COPPER, 1/8" TURN SPACING
L_2: 7 1/2 T, 5/8" I.D., # 16 ENAM. WIRE, CLOSE WOUND

VARACTOR FREQUENCY-SPLITTER—Converts 50 MHz to 25 MHz with 80% efficiency. Spurious harmonic energy is 20 dB below 25-MHz output and input vswr below 1.2 for input power range of 7 to 125 W.—B. A. Ziegner, Varactor Achieves High Power Subharmonic Frequency Division, *Electronic Design*, Sept. 27, 1965, p 64–65.


+20V
560
INTERMEDIATE
LOW W
HIGH X
V
≈1.5V
≈0.8V
≈2.2V
V'
W'
X'
OFF
ON
100
A
B
C
≈0.8V
≈1.5V
2.2K
OUTPUT EMITTER FOLLOWER
OUTPUT
-20V
INPUT
47Ω
≈1.5V
1K
4.7K
+20V
TRANSISTORS ZTX 320
DIODES KS051A OR KS205IA
C's 10,000pF CERAMIC
INPUT
+0.4V
0V
-0.4V
+2.2V
+1.5V
+0.8V

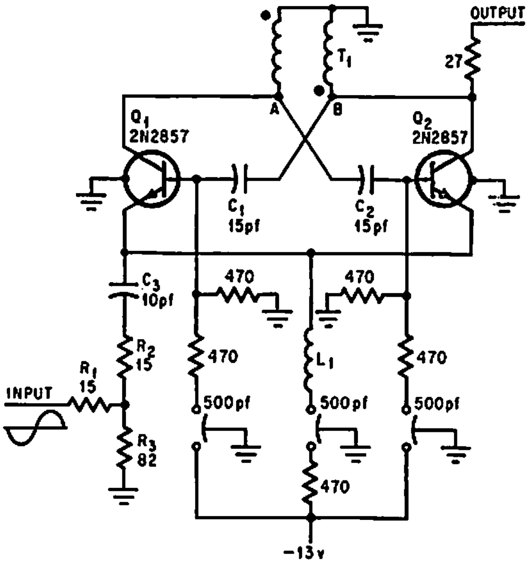
3-STAGE RING DIVIDER—Intended for feeding with sine-wave input. Can only have odd number of stages. Supply voltages are not critical, and can be as low as 10 V. When transistors are in states shown, the three pairs of collectors (V, W, and X) are at three different voltages levels—intermediate, low, and high. Intermediate level is unstable; in absence of input, this level moves around the ring and gives self-oscillation. Small input signal locks circuit to signal, so unstable state moves one stage for each input half-cycle. Can handle inputs above 300 MHz, if lead lengths are minimized.—A V.H.F. Ring Divider, Ferranti Ltd., Oldham, Lancs., England, No. 39, 1969.


-10V ±20%
R2
R6
C1
D2
T1
N1
N3
R1
INPUT
Q1
D1
R3
N2
Q2
OUTPUT
R4
R5

R1 - 150
R2 - 820
R3 - 180
R4 - 390
R5 - 3.9
R6 - 18
C1 - .068μf
Q1 - 2N2905
Q2 - 2N2905

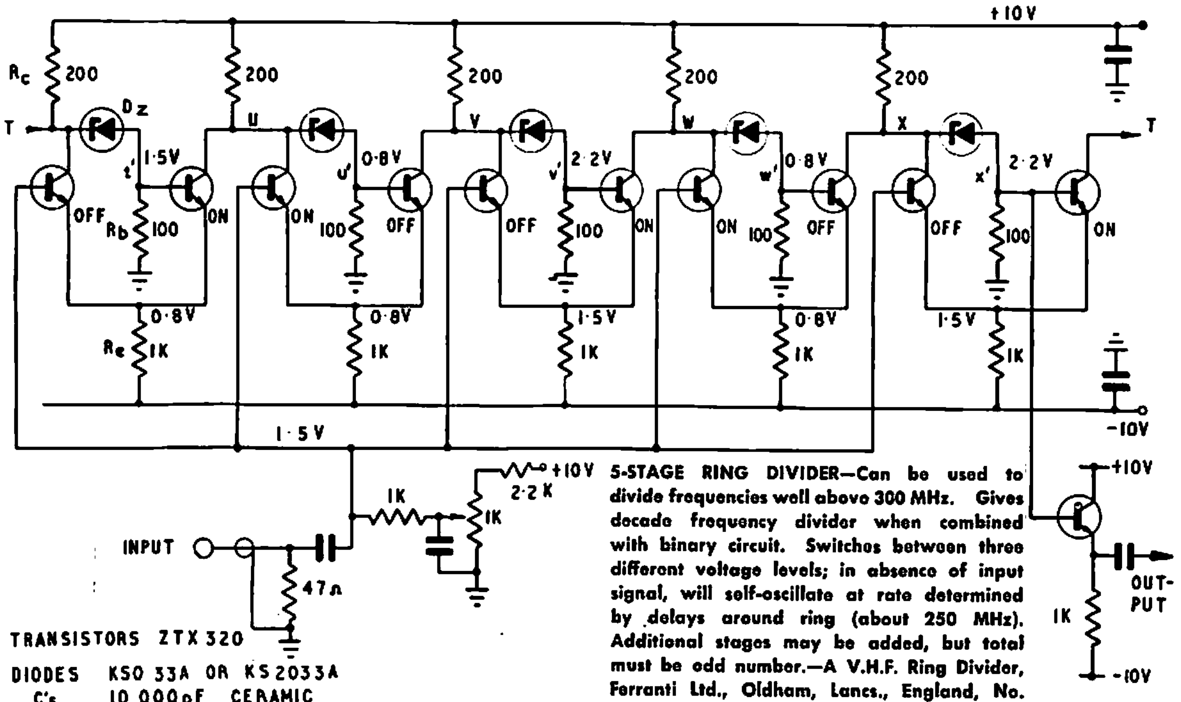
T1 - 12201000-18 (ARNOLD)
80505-1A-MA (MAGNETICS)
D1 - 1N751A
D2 - 1N3730
N1 - 31 TURNS
N2 - 60 TURNS
N3 - 30 TURNS

DIVISION FROM 1 TO 10—Adjusting C1 or number of turns on N1 of toroid core changes division. Circuit is largely immune to temperature changes. Output is sufficient across R5 (3 V) to drive another divider for further frequency division.—E. J. Willette, Magnetic Core Frequency Divider Uses Fewer Components, *Electronic Design*, Oct. 26, 1964, p 54–55.


OUTPUT
T1
27
A
B
Q1
2N2857
Q2
2N2857
C1
15pf
C2
15pf
C3
10pf
470
470
R2
15
R1
15
INPUT
470
L1
470
500pf
500pf
500pf
R3
82
470
-13v

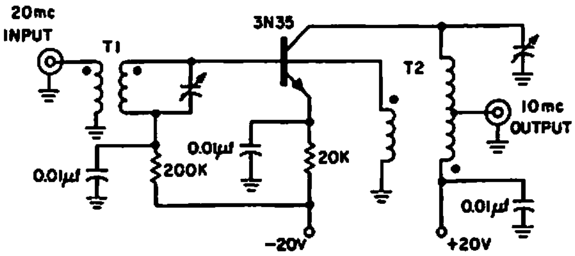
T1 = FERROX-CUBE CORE 56-590-65-3B,
1 TURN NO. 36 BIFILAR WIRE, 2 TURNS TOTAL
L1 = FERROX-CUBE CORE 56-590-65-3B, 6 TURNS NO. 36

DIVIDE BY TWO IN 150–450 MHZ RANGE—Adding transformer T1 to astable mvbr speeds turn-on and turn-off of transistors, increases maximum oscillator frequency, and makes divide-by-two operation available over entire uhf range for sine, square, or pulse input. For 4:1 division, feed output to similar circuit in which input pad R1-R2-R3 is omitted.—D. E. Sanders, Adding a Transformer Halves Uhf Frequencies, *Electronics*, March 4, 1968, p 87–88.

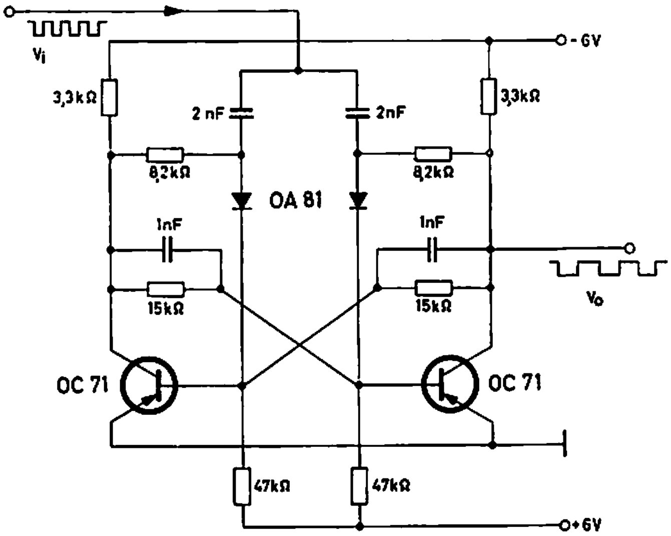

+10V
Rc
200
200
200
200
200
T
U
V
W
X
T
Dz
t'
u'
v'
w'
x'
1·5V
0·8V
2·2V
0·8V
2·2V
OFF
ON
ON
OFF
OFF
ON
ON
OFF
OFF
ON
Rb
100
100
100
100
100
0·8V
0·8V
1·5V
0·8V
1·5V
Re
1K
1K
1K
1K
1K
-10V
1·5V
+10V
2·2K
1K
1K
INPUT
47Ω
+10V
OUT-PUT
1K
-10V

TRANSISTORS ZTX 320
DIODES KSO 33A OR KS2033A
C's. 10,000pF CERAMIC

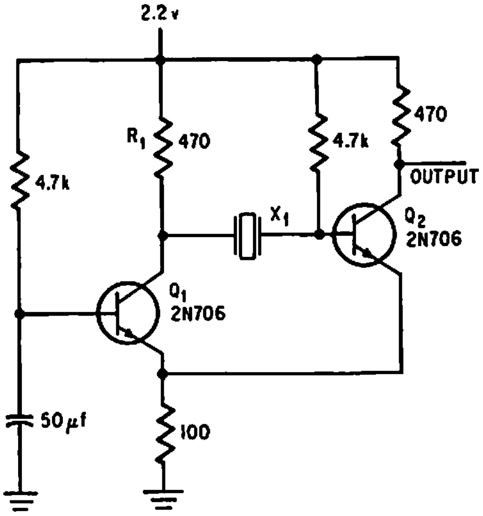
5-STAGE RING DIVIDER—Can be used to divide frequencies well above 300 MHz. Gives decade frequency division when combined with binary circuit. Switches between three different voltage levels; in absence of input signal, will self-oscillate at rate determined by delays around ring (about 250 MHz). Additional stages may be added, but total must be odd number.—A V.H.F. Ring Divider, Ferranti Ltd., Oldham, Lancs., England, No. 39, 1969.


20mc INPUT
T1
3N35
T2
10mc OUTPUT
0.01μf
200K
0.01μf
20K
0.01μf
-20V
+20V

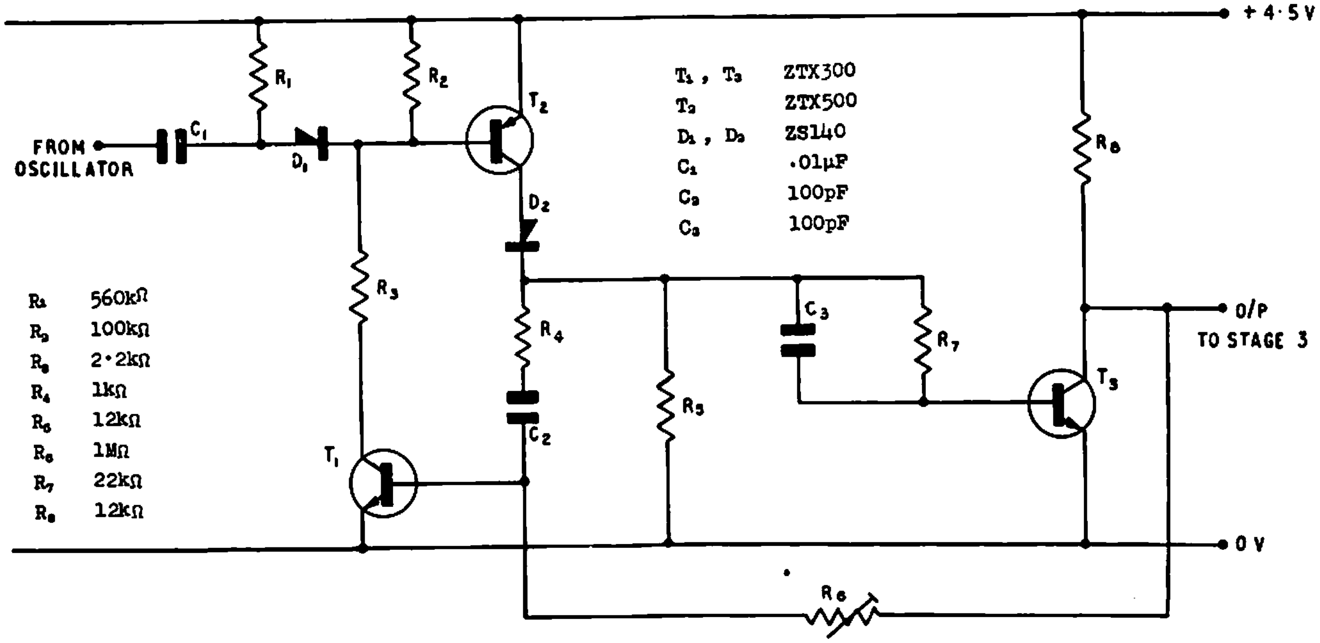
DIVIDING 20 MHZ—With input resonant circuit tuned to 20 MHz and output to 10 MHz, circuit performs well as frequency divider.—H. F. Verse, Jr., Simple Circuit Halves 20-Mc Supply Frequency, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 174.


V_i
-6V
3,3kΩ
2 nF
2nF
3,3kΩ
8,2kΩ
8,2kΩ
OA 81
1nF
1nF
15kΩ
15kΩ
V_0
OC 71
OC 71
47kΩ
47kΩ
+6V

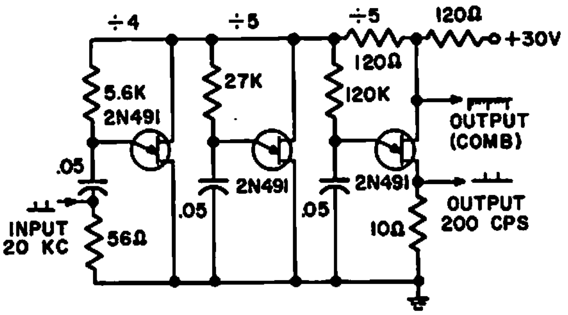
2:1 PULSE SCALER—Used when counting pulses at frequencies above reliable operating speed of counter, generally around 2,000 Hz. For higher count-down ratio, several such stages should be connected in series. Maximum input frequency for circuit is about 35 kHz.—"Counting Units for Programmed Control," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1964, p. 18.


2.2v
R_1
470
4.7k
470
OUTPUT
4.7k
X_1
Q_2
2N706
Q_1
2N706
50μf
100

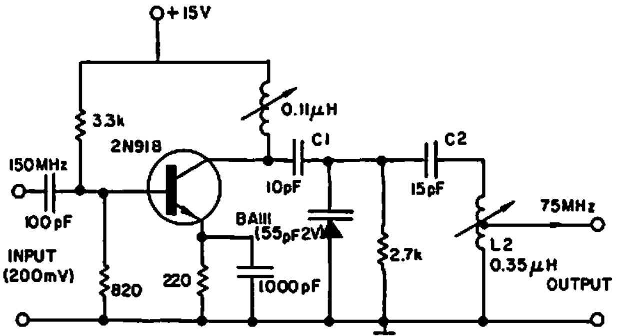
CRYSTAL DIVIDE-BY-10 MVBR—Emitter-coupled mvbr with crystal in place of timing capacitor makes excellent pulse generator for driving chain of synchronized divide-by-10 mvbr stages used in calibrating time bases of precision oscilloscopes.—G. W. Harrison, Crystal Gives Precision To a Stable Multivibrator, *Electronics*, Nov. 11, 1968, p 121.


+ 4·5 V
R_1
R_2
T_2
FROM OSCILLATOR
C_1
D_1
D_2
R_8
R_3
R_4
C_3
R_7
R_5
C_2
T_1
T_3
O/P TO STAGE 3
0 V
R_6
T_1, T_3 ZTX300
T_2 ZTX500
D_1, D_2 ZS140
C_1 ·01μF
C_2 100pF
C_3 100pF
R_1 560kΩ
R_2 100kΩ
R_3 2·2kΩ
R_4 1kΩ
R_5 12kΩ
R_6 1MΩ
R_7 22kΩ
R_8 12kΩ

SINE-WAVE DIVIDE-BY-5—Used as first counting stage of battery-powered clock controlled by 100-kHz crystal oscillator. Circuit is free-running, as form of mvbr, with no input, but synchronizes to exact multiple of sine-wave input. R6 is adjusted to give required count of 5 for this stage of clock.—A Crystal Clock Using Plastic Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 34, 1968.

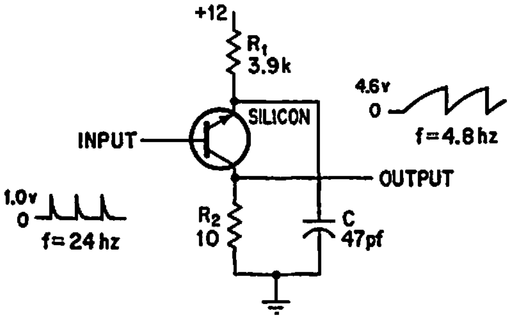

÷4
÷5
÷5
120Ω
+30V
120Ω
5.6K
2N491
27K
120K
OUTPUT (COMB)
.05
2N491
2N491
OUTPUT 200 CPS
INPUT 20 KC
56Ω
.05
.05
10Ω

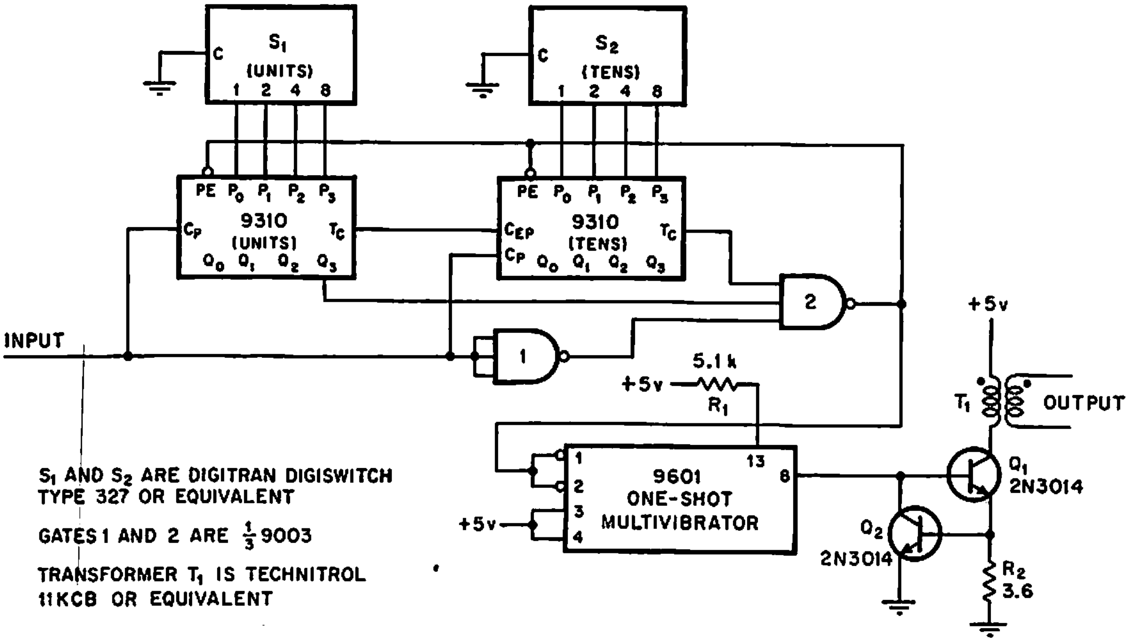
SIMPLE 100:1 DIVIDER—Requires only three ujt's to get 200 Hz output from 20,000 Hz input. With division ratios of 4 and 5, potentiometer adjustments will be required for the capacitor-charging resistors.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 73.


+15V
3.3k
0.11μH
2N918
C1
C2
150MHz
10pF
15pF
75MHz
100pF
BA111 (55pF2V)
L2 0.35μH
INPUT (200mV)
2.7k
OUTPUT
820
220
1000pF

VARACTOR DIVIDER—With C1 and first coil resonating at 150-MHz input frequency, action of varactor makes L2-C2 resonate at 75 MHz, operating over 4% bandwidth. Cost is much less than that of IC designed for these frequencies.—M. Stevens and D. Steward, Varactor Diode is the Key to a Simple Frequency Divider, *Electronic Design*, Feb. 15, 1970, p 88.

AVALANCHE-MODE DIVIDER—Operation of transistor in avalanche mode gives simple relaxation oscillator that can be operated either as frequency divider or as low-output-impedance voltage generator. Capacitor is charged until breakdown voltage of transistor is reached, then discharged through transistor to give next output pulse. Period of divider can be adjusted by changing input amplitude and value of coupling resistor from preceding stage. Division ratio depends on values of R, C, and input amplitude, and is 5:1 for values shown.—A. Meiraghi, Single Transistor Divides Frequency in Avalanche Mode, *Electronics*, Sept. 29, 1969, p 96–97.


+12
R1 3.9k
4.6v
0
SILICON
f=4.8hz
INPUT
OUTPUT
1.0v
0
f=24hz
R2 10
C 47pf

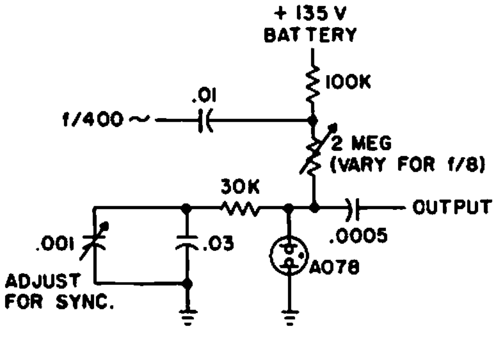

S1 (UNITS)
C
1 2 4 8
S2 (TENS)
C
1 2 4 8
PE P0 P1 P2 P3
9310 (UNITS)
CP
TC
Q0 Q1 Q2 Q3
PE P0 P1 P2 P3
9310 (TENS)
CEP
CP
TC
Q0 Q1 Q2 Q3
2
1
+5v
INPUT
5.1k
+5v
R1
T1
OUTPUT
1
2
3
4
13
8
9601 ONE-SHOT MULTIVIBRATOR
+5v
Q1 2N3014
Q2 2N3014
R2 3.6

S1 AND S2 ARE DIGITRAN DIGISWITCH TYPE 327 OR EQUIVALENT

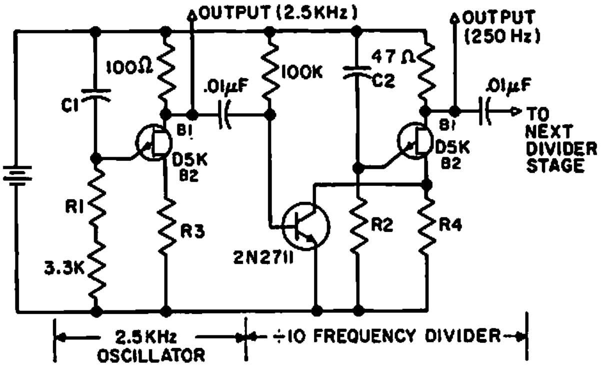
GATES 1 AND 2 ARE $\frac{1}{3}$9003

TRANSFORMER T1 IS TECHNITROL 11KCB OR EQUIVALENT

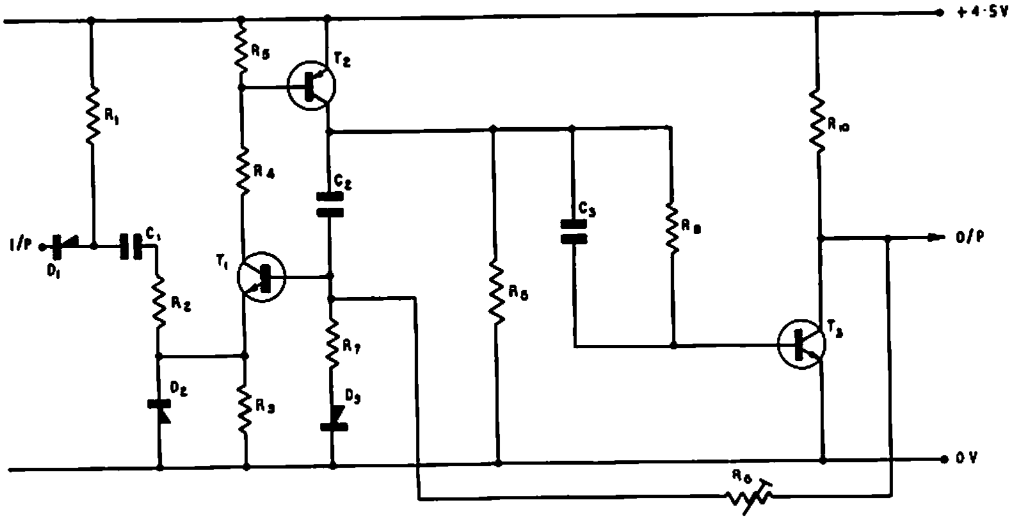
UP TO 99:1—Two thumbwheel switches, S1 and S2, can be set to provide any division ratio from 1 to 99 for programmable pulse frequency divider. Will handle frequencies exceeding 10 MHz. Uses two IC decade counters and IC one-shot to drive pulse transformer.—K. Erickson, Divider Splits Frequency into Any Ratio from 1 to 99, *Electronics*, April 13, 1970, p 107–108.


+ 135 V
BATTERY
100K
.01
f/400 ~
2 MEG
(VARY FOR f/8)
30K
OUTPUT
.001
.03
.0005
A078
ADJUST
FOR SYNC.

SCALE-OF-8—Simple battery-operated neon circuit produces one pulse every 8 Hz of 400-Hz source.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 50.


OUTPUT (2.5KHz)
OUTPUT
(250 Hz)
100Ω
.01μF
100K
47Ω
C2
C1
.01μF
TO
NEXT
DIVIDER
STAGE
B1
D5K
B2
B1
D5K
B2
R1
3.3K
R3
2N2711
R2
R4
2.5KHz
OSCILLATOR
÷10 FREQUENCY DIVIDER

10:1 DIVIDER—Complementary ujt D5K, with highly predictable voltage threshold, gives excellent performance in large-countdown frequency dividers such as are used in television color bar generators.—W. R. Spofford, Jr., Complementary Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.72, 1968, p 13.

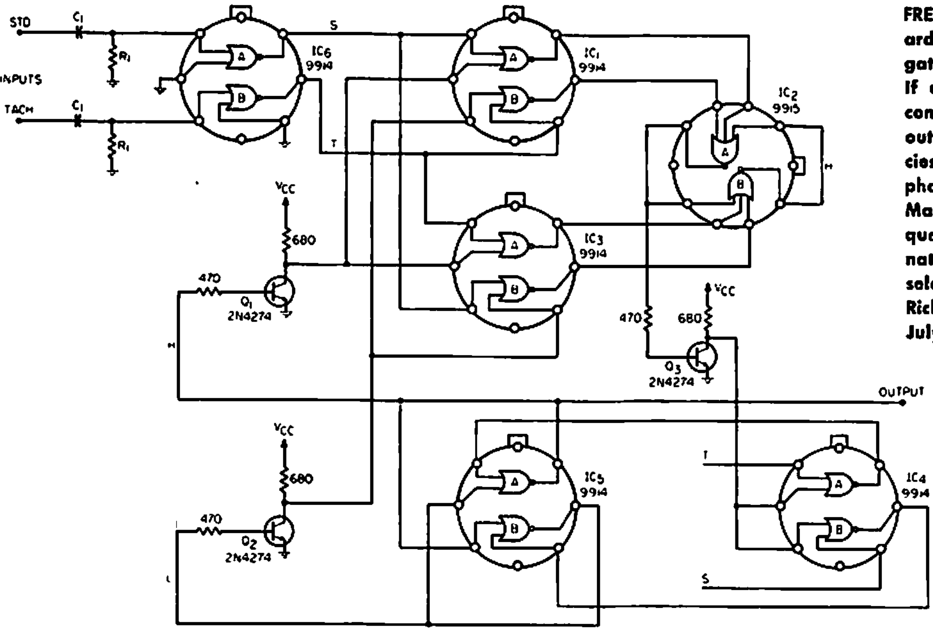

+4·5V
R1
R5
T2
R4
C2
R10
C3
R8
I/P
D1
C1
T1
R2
R9
T3
O/P
R7
D2
R3
D3
0V
R6

				Stage No.	C_3
R_1	12kΩ	R_7	1kΩ	3	220pF
R_2	330Ω	R_8	12kΩ	4	1000pF
R_3	1kΩ	R_9	22kΩ	5	5000pF
R_4	12kΩ	R_{10}	12kΩ	6	0·02μF
R_5	12kΩ			7	0·1μF
R_6 Stages 3 to 10	1MΩ plus 1MΩ preset.			8	0·5μF
R_6 Stage 11	4MΩ plus 1MΩ preset.			9	2·2μF
T_1, T_3	ZTX300			10	10μF
T_2	ZTX500	C_1	4700pF	11	10μF
D_1, D_2, D_3	ZS140	C_2	100pF		

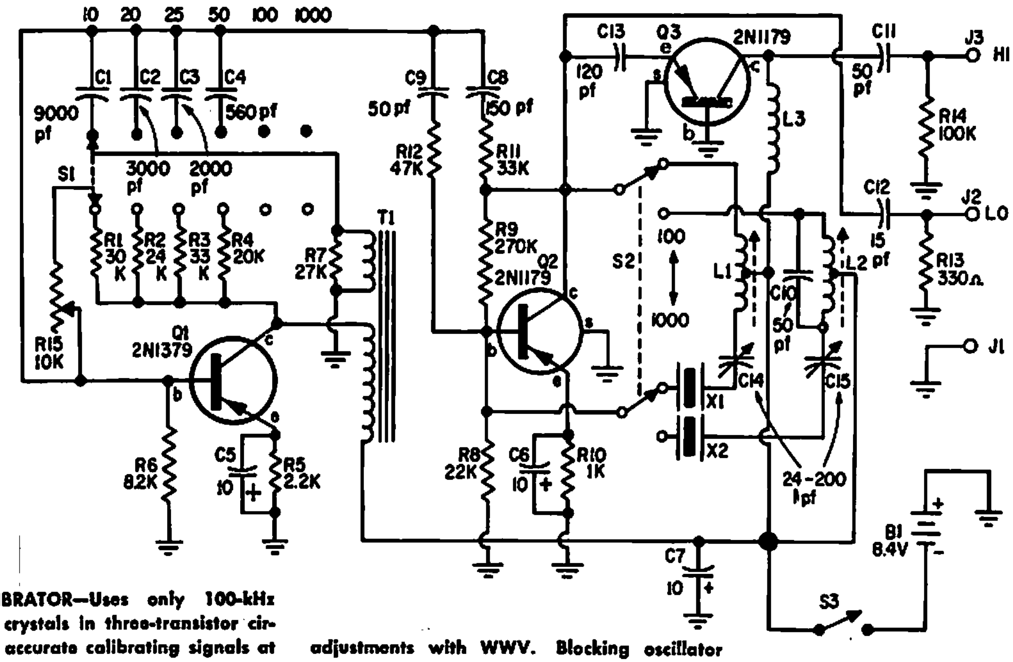
DIVISION BY 5, 4, OR 3—Used in battery-powered 100-kHz quartz crystal clock to give one pulse every half-minute for driving ratchet mechanism that moves hands of clock half a minute per pulse. Circuit synchronizes on integral number of narrow trigger pulses from preceding stage, with number determined by setting of R6. Division ratios of stages 3-11 are 5, 4, 5, 5, 4, 5, 5, 4, and 3, following stage 2 which divides sine-wave output of crystal by 5. Accuracy of clock is about 1 sec per week.—A Crystal Clock Using Plastic Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 34, 1968.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

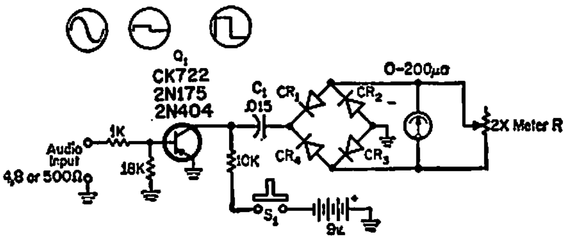
CHAPTER 34
Frequency Measuring Circuits


STD
INPUTS
TACH
C1
R1
IC6
9914
S
T
IC1
9914
IC2
9915
IC3
9914
IC5
9914
IC4
9914
A
B
H
L
VCC
680
470
Q1
2N4274
Q2
2N4274
Q3
2N4274
OUTPUT

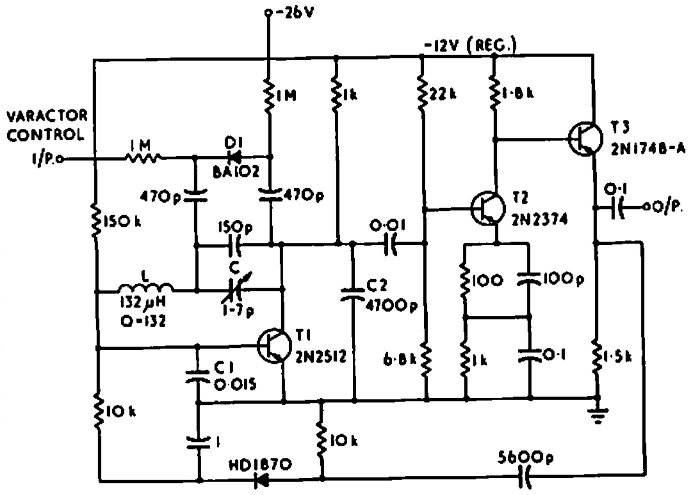
FREQUENCY COMPARATOR—Compares standard frequency at one input of dual NOR gate with unknown frequency at other input. If unknown is lower, d-c level at output of comparator is low. If unknown is higher, output d-c level is high. When input frequencies are equal, circuit functions as linear phase discriminator having no tuned circuits. May be used as vco control, go-no-go frequency comparator, or as frequency discriminator. Output may be either polarity by selecting appropriate terminal of IC5.—R. Ricks, Frequency Comparator Uses ICs, *EEE*, July 1967, p 128–129.


10 20 25 50 100 1000
C1
C2
C3
C4
9000 pf
3000 pf
2000 pf
560 pf
S1
R1 30K
R2 24K
R3 33K
R4 20K
R7 27K
T1
R15 10K
Q1 2N1379
R6 82K
C5 10
R5 2.2K
C9 50 pf
C8 150 pf
R12 47K
R11 33K
R9 270K
Q2 2N1179
R8 22K
C6 10
R10 1K
C13 120 pf
Q3 2N1179
L3
S2
100
1000
L1
C10 50 pf
L2
C14
C15
24-200 pf
X1
X2
C7 10
C11 50 pf
J3 HI
R14 100K
C12 15 pf
J2 LO
R13 330Ω
J1
B1 8.4V
S3
e
b
c

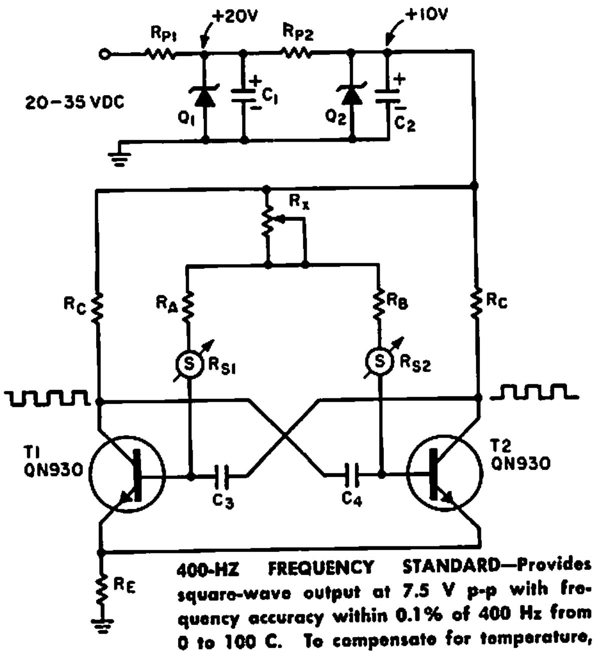
CRYSTAL CALIBRATOR—Uses only 100-kHz and 1,000-kHz crystals in three-transistor circuit to provide accurate calibrating signals at 10, 20, 25, 50, 100, and 1,000 kHz, with harmonics well beyond 34 MHz. Book gives construction details and tells how to check adjustments with WWV. Blocking oscillator transformer T1 is Stancor A-8111. L1 is 2.5-7 mH (J. W. Miller 6316), L2 is 35-300 μH (J. W. Miller 2002), and L3 is 2.5-mH r-f choke.—A. A. Mangieri, Solid-State Crystal Calibrator, "Bench-Tested Communications Projects," Hayden Book Co., N.Y., p 116–121.


Q1
CK722
2N175
2N404
C1
.015
CR1
CR2
CR3
CR4
0-200μa
2X Meter R
1K
Audio Input
4,8 or 500Ω
18K
10K
S1
9V

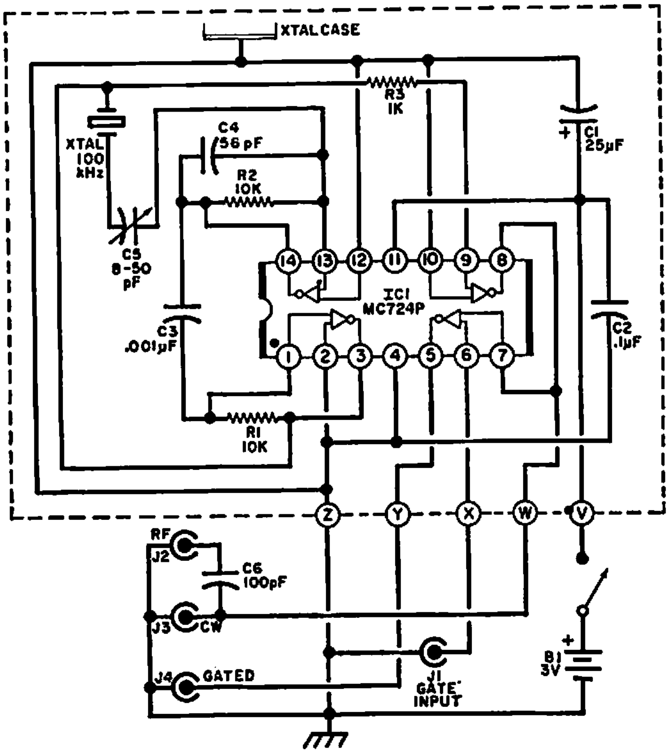
FREQUENCY METER—Full-scale range is 2 kHz, and accuracy is within 20 Hz at midscale. Accuracy is ample for ssb and radioteletype applications. Silicon rectifiers are not critical, if piv rating is above 100 V, as in Sarkes Tarzian K200 diodes.—J. Alan Biggs, The W3ZP Meter, CQ, July 1966, p 70–71.


-26V
-12V (REG.)
VARACTOR CONTROL I/P.
1M
D1
BA102
470p
470p
1M
1k
22k
1·8k
T3
2N1748-A
0·1
O/P.
150k
150p
C
1-7p
L
132μH
Q-132
0·01
C2
4700p
T2
2N2374
100
100p
T1
2N2512
C1
0·015
6·8k
1k
0·1
1·5k
10k
1
HD1870
10k
5600p

PRECISION FREQUENCY COMPARATOR—1.13-MHz Clapp vco with amplitude control is used in phase-controlled loop for high-precision maser frequency comparison. Based on multiplication of beat signal obtained after comparing two frequency standards.—J. V. Murphy, Frequency Measurement Using the Phase-Controlled Oscillator, *Proc. IEEE*, July 1967, p 1144–1153.

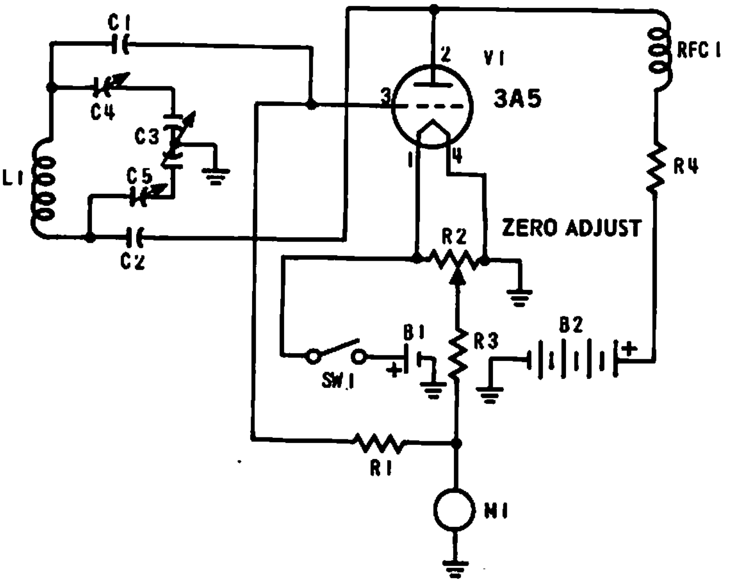

+20V
+10V
Rp1
Rp2
20-35 VDC
Q1
C1
Q2
C2
Rx
RC
RA
RB
RC
S
RS1
S
RS2
T1
QN930
T2
QN930
C3
C4
RE

400-HZ FREQUENCY STANDARD—Provides square-wave output at 7.5 V p-p with frequency accuracy within 0.1% of 400 Hz from 0 to 100 C. To compensate for temperature, resistor decade boxes are substituted for base resistors RA and RB and temperature runs are made to obtain curve of temperature vs base resistance to yield symmetrical square wave at correct frequency. Two sensistors and two series resistors are then selected to track the curves obtained. Rx, about 1/100th of RA + RS1, is adjusted for fine-tuning to exact frequency. Other values are those of conventional mvbr and power supply.—E. B. Nelson, Multivibrator Adapted As Frequency Standard, *Electronic Design*, Feb. 17, 1964, p 94–95.

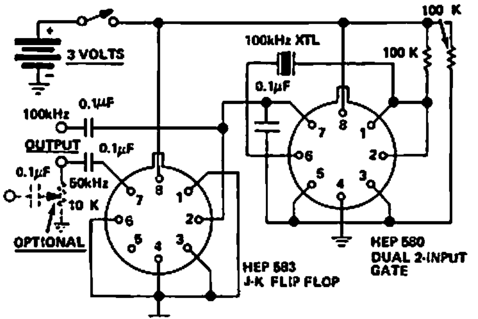

XTAL CASE
R3
1K
C1
25μF
C4
56pF
XTAL
100
kHz
R2
10K
C5
8-50
pF
IC1
MC724P
14
13
12
11
10
9
8
1
2
3
4
5
6
7
C3
.001μF
C2
.1μF
R1
10K
Z
Y
X
W
V
RF
J2
C6
100pF
J3
CW
J4
GATED
J1
GATE INPUT
B1
3V

RECEIVER CALIBRATOR—Provides birdie every 100 kHz for calibrating short-wave and amateur radio receivers. For optimum accuracy, can be adjusted to zero-beat against WWV. Uses crystal and single IC in simple circuit operating from 3-V battery. Article gives construction and adjustment details.—D. Lancaster, Build the 100-kHz Standard, *Popular Electronics*, April 1970, p 56–58 and 105.

GRID DIP METER—1-mA d-c meter dips whenever circuit is brought near resonant circuit oscillating at same frequency. Once variable capacitors in tank of 3A5 oscillator are calibrated for frequency, circuit can be used to identify exact frequency at which transmitter is putting out signal. B1 is 1.5 V and B2 67.5 V. Values: R1 5.6K; R2 750; R3 1.1K; R4 15K; C1, C2 0.0025 μF; C3 100 pF per section; C4, C5 51 pF; RFC1 2.5 mH; L1 plug-in coil for desired range (winding data given in book).—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 149.

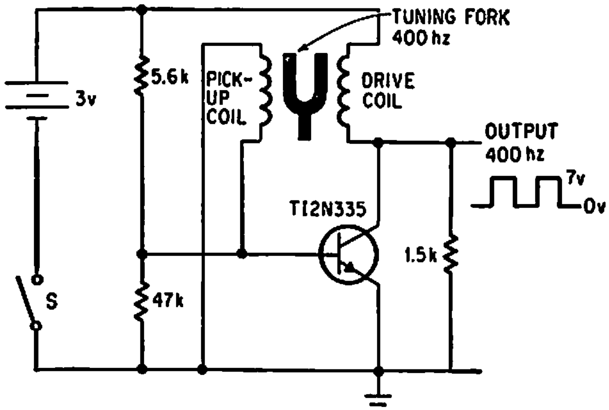


C1
C4
C3
C5
C2
L1
V1
3A5
RFC1
R4
R2
ZERO ADJUST
B1
B2
R3
SW.1
R1
M1



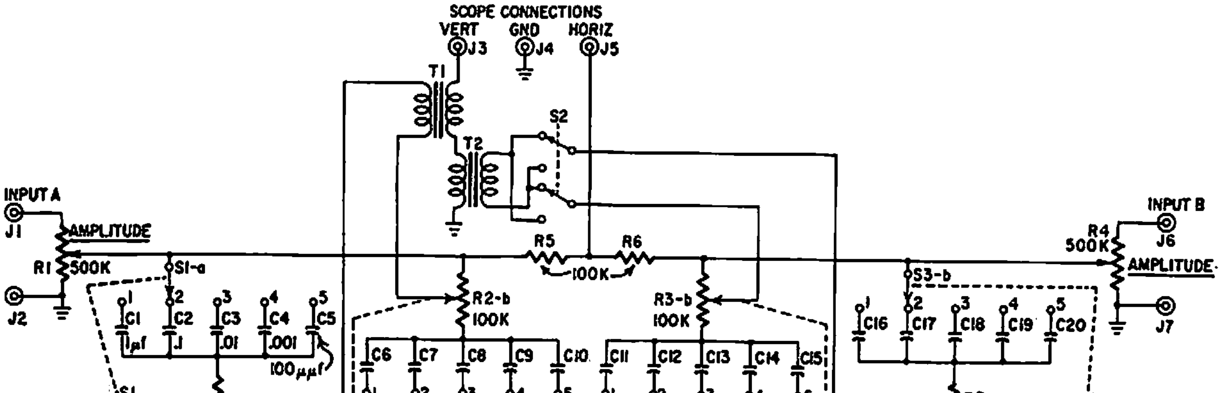
100 K
3 VOLTS
100kHz XTL
100 K
0.1μF
100kHz
0.1μF
OUTPUT
0.1μF
0.1μF
50kHz
10 K
OPTIONAL
HEP 583
J-K FLIP FLOP
HEP 580
DUAL 2-INPUT
GATE

IC FREQUENCY STANDARD—Accurate, compact, and simple-to-operate 100-kHz crystal oscillator and flip-flop frequency divider for checking or aligning frequency settings of receivers. Has harmonic-rich square-wave outputs at 100 and 50 kHz, from which lower values can be obtained by adding various combinations of divide-by-2 and divide-by-5 IC flip-flops.—"Tips on Using IC's," Motorola, Phoenix, Ariz., HMA-32, 1968.



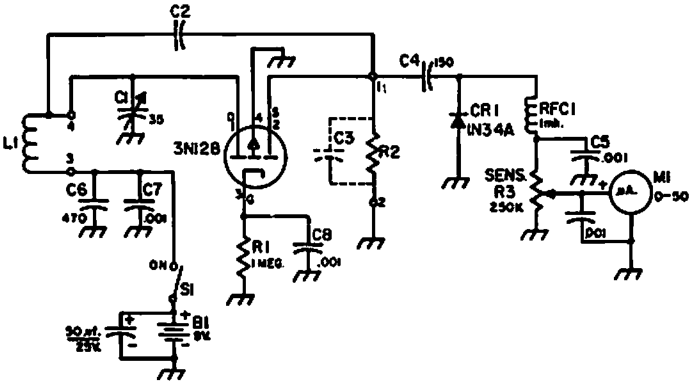
TUNING FORK
400 hz
5.6k
3v
PICK-UP COIL
DRIVE COIL
OUTPUT
400 hz
7v
0v
TI2N335
1.5k
S
47k

FORK-STABILIZED 400-HZ—Use of tuning fork in place of pulse transformer in blocking oscillator converts circuit to portable frequency standard with square-wave output. Circuit worked 39 hr on two AA cells, using Varo Model 6250L-400 fork.—S. V. Scheffel, Tuning Fork Drives Portable Frequency Standard, *Electronics*, Nov. 14, 1966, p 122–123.



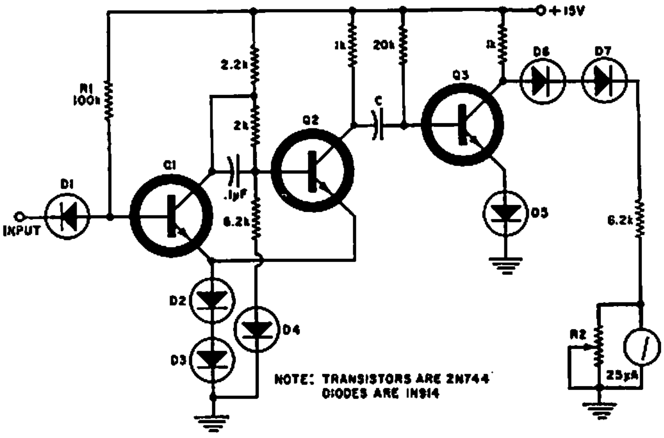
SCOPE CONNECTIONS
VERT
GND
HORIZ
J3
J4
J5
T1
T2
S2
INPUT A
J1
AMPLITUDE
R1
500K
J2
S1-a
C1
C2
C3
C4
C5
1μf
.1
.01
.001
100μμf
S1
R2-a
100K
PHASING
R5
R6
100K
R2-b
100K
C6
C7
C8
C9
C10
S1-b
R3-b
100K
C11
C12
C13
C14
C15
S3-a
SAME CAP VALUES IN
EQUIV SWITCH POSITIONS AS SHOWN IN S1-a
INPUT B
R4
500K
J6
AMPLITUDE
S3-b
C16
C17
C18
C19
C20
J7
R3-a
100K
S3
PHASING
ALL CAPS
50V

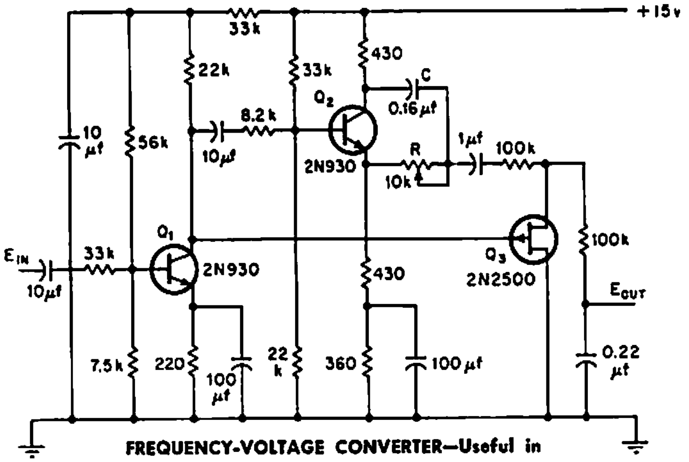
IMPROVED CYCLOID ADAPTER—Known and unknown frequencies are applied to inputs and R2 or R3 adjusted so phase difference is 90 deg. Shifting of phase does not affect magnitude of signal, so resulting cycloid patterns are much easier to read. Loops on cycloid are counted to give ratio of frequencies. May be used with practically any oscilloscope.—T. Jaski, Cycloids for Frequency Measurement, *Radio-Electronics*, July 1965, p 60–61.


C2
C4
150
L1
4
3
C1
35
3N128
C3
R2
CR1
1N34A
RFC1
1mh.
C5
.001
SENS.
R3
250K
M1
μA
0-50
C6
470
C7
.001
R1
1 MEG.
C8
.001
.001
ON
S1
B1
9V
50 μf.
25V

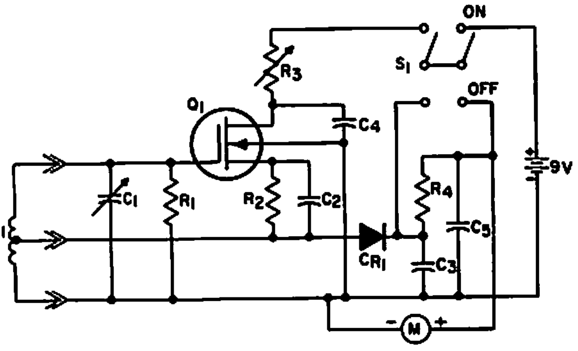
FET GRID-DIP METER—Performance is equivalent to tube-type circuit. Will work up to 150 MHz, using plug-in coils. Meter shows dip when unit is tuned to resonant frequency of coil to which it is coupled. Book gives construction details, including coil-winding data and calibration procedure.—L. G. McCoy, A Field-Effect Transistor Dipper, "The Mobile Manual for Radio Amateurs," ARRL, Newington, Conn., 1968, p 179–182.

FREQUENCY COUNTER FOR SCOPE—Designed for use with kits or less expensive scopes, to serve in place of calibrated time base found on more costly instruments, for accurate frequency measurements. Consists of Schmitt trigger Q1 and monostable multivibrator Q3, with Q2 common to both. Circuit triggers at about 2 V. Values of R2 (ohms) and C depend upon frequency range, as follows: 0–250 Hz—15,000 and 0.0072 μF; 0–2,500 Hz—8,000 and 0.001 μF; 0–2,500 Hz—1,000 and 300 pF; 0–250,000 Hz—200 and 150 pF.—R. L. Carroll, Simple Frequency Counter, *Electronics World*, July 1969, p 82.

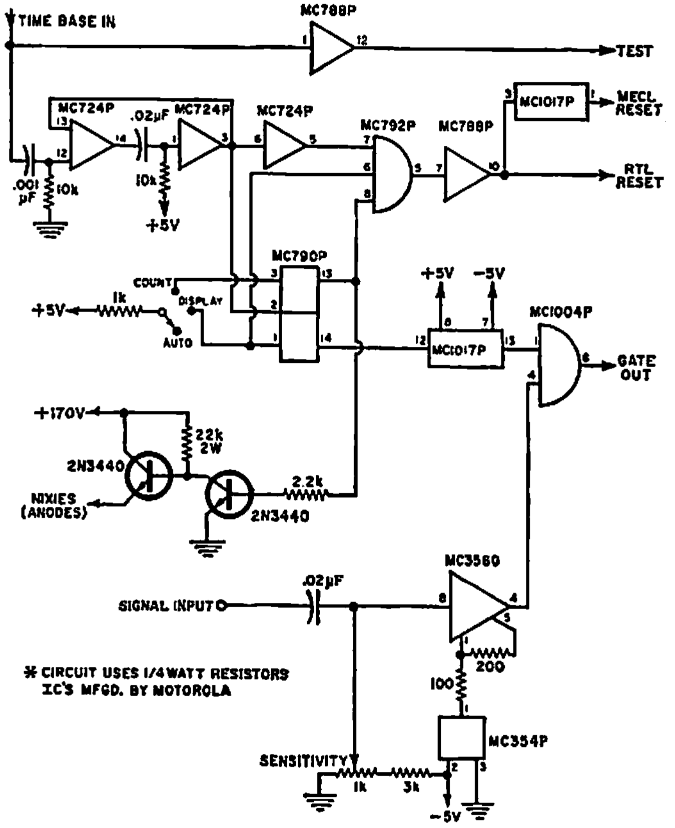

+15V
R1
100k
2.2k
1k
20k
1k
D6
D7
Q3
C
Q2
2k
Q1
.1μF
6.2k
D1
INPUT
D5
6.2k
D2
D4
D3
R2
25μA
NOTE: TRANSISTORS ARE 2N744
DIODES ARE 1N914


+15v
33k
22k
33k
430
C
0.16μf
Q2
8.2k
10 μf
10μf
56k
2N930
R
10k
1μf
100k
Q1
EIN
33k
10μf
2N930
Q3
2N2500
100k
430
EOUT
7.5k
220
100 μf
22 k
360
100μf
0.22 μf

FREQUENCY-VOLTAGE CONVERTER—Useful in frequency meters and for measuring carrier frequency drift of r-f signals after demodulation. Will operate in audio range. Uses fet Q3 with phase-shifted inputs to gate and source, wherein amount of phase shift depends on frequency and on setting of pot R. With 90-deg phase shift, d-c output voltage of phase-sensitive detector is zero. At lower frequency, output is positive, while higher frequencies produce negative output.—J. Kalinski, FET Phase Detector Can Be Frequency-Voltage Converter, *Electronics*, July 20, 1970, p 87–88.

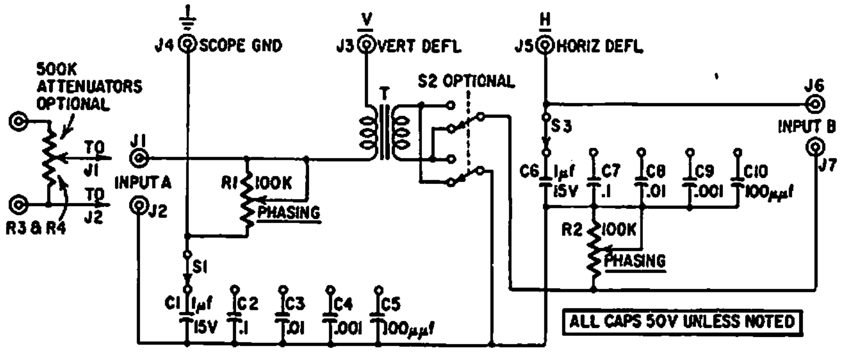

ON
S1
R3
Q1
OFF
C4
9V
L1
C1
R1
R2
C2
R4
C5
CR1
C3
M
-
+

DIP/WAVE METER—Uses mosfet oscillator with set of seven plug-in coils to cover range of 1.16 to 110 MHz. With power switch off, circuit becomes absorption-type wavemeter that measures resonant frequency of energized r-f circuits. Needle of meter jumps upward slightly when frequency of oscillator in meter matches that of L-C circuit being measured. With power switch on, meter measures resonant frequency of unenergized r-f circuits. Book gives winding data for plug-in coils. Values: R1 47K; R2 1K; R3 10K; R4 6.8K; C1 50 pF; C2, C4, C5 0.01 μF; C3 0.001 μF; CR1 1N914; Q1 3N128; M 100 μA.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 141.


TIME BASE IN
MC788P
TEST
MC724P
.02μF
MC724P
MC724P
MC792P
MC788P
MC1017P
MECL RESET
RTL RESET
.001 μF
10k
10k
+5V
MC790P
COUNT
DISPLAY
AUTO
+5V
1k
+5V
−5V
MC1017P
MC1004P
GATE OUT
+170V
22k 2W
2N3440
NIXIES (ANODES)
2.2k
2N3440
MC3560
.02μF
SIGNAL INPUT
200
100
* CIRCUIT USES 1/4WATT RESISTORS
IC'S MFGD. BY MOTOROLA
MC354P
SENSITIVITY
1k
3k
−5V

$400 UNIT MEASURES CB FREQUENCIES—Uses IC's and Nixies in special circuits to cut cost while meeting FCC requirement of 0.005% measuring accuracy. Combines Motorola and Fairchild logic units. Control circuits, signal-conditioning section, and main gate are shown. Schmitt trigger changes input signal to pulse train having one pulse for each cycle of signal input. Article gives IC interconnections and circuits of the three power supplies used.—F. E. Cody, A 50-mHz Digital Counter, *Electronics World*, March 1969, p 40–42 and 61.

CYCLOID ADAPTER FOR CRO—Based on use of two sine waves 90 deg out of phase, to produce cycloid patterns on screen from which ratio of unknown to known frequency can be seen at glance. Article gives 14 such patterns. Technique is comparable to that using Lissajous figures. One drawback of adapters shown is that changing of phase relationship with R1 or R2 will also change amplitude, distorting pattern and making frequency ratio more difficult to recognize.—T. Jaski, Cycloids for Frequency Measurement, *Radio-Electronics*, July 1965, p 60–61.

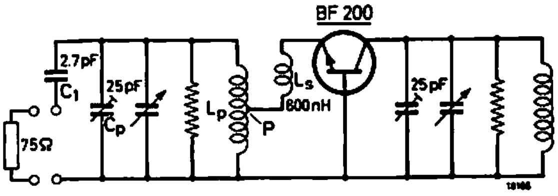

J4 SCOPE GND
V
J3 VERT DEFL
H
J5 HORIZ DEFL
500K ATTENUATORS OPTIONAL
TO J1
TO J2
R3 & R4
J1
INPUT A
J2
R1 100K PHASING
T
S2 OPTIONAL
J6
S3
INPUT B
J7
C6 1μf 15V
C7 .1
C8 .01
C9 .001
C10 100μμf
R2 100K PHASING
S1
C1 1μf 15V
C2 .1
C3 .01
C4 .001
C5 100μμf
ALL CAPS 50V UNLESS NOTED

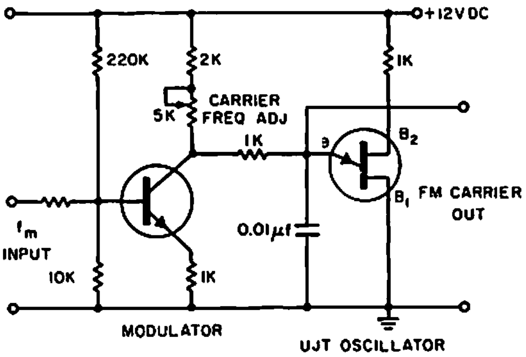
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 35

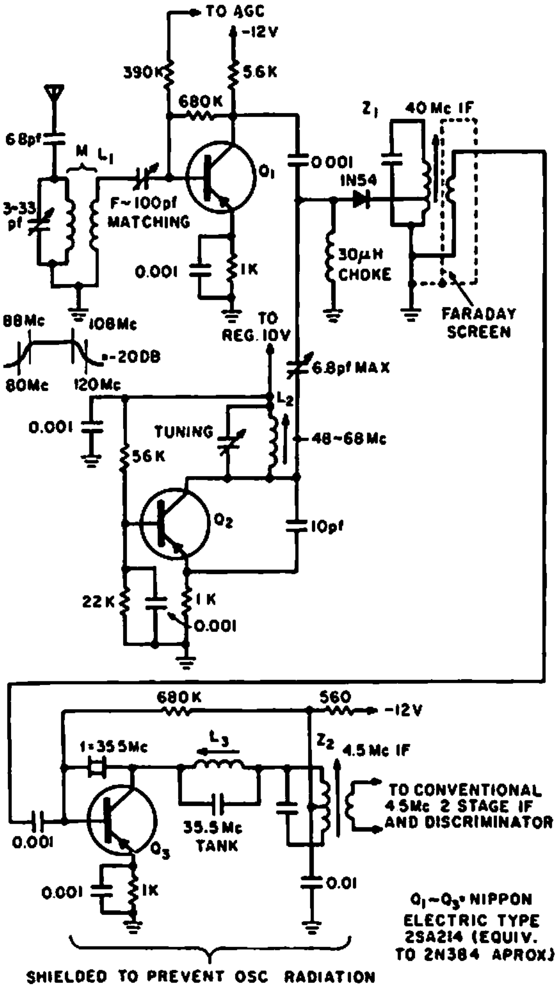
Frequency Modulation Circuits

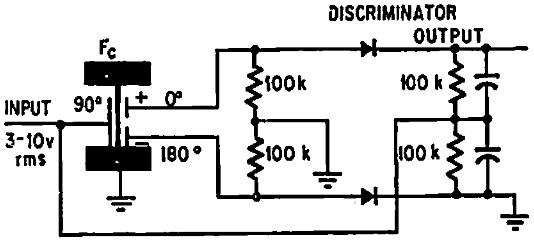
R-F INPUT STAGE—For use in high-quality f-m broadcast receivers. Minimum noise figure is 2.2 dB at 100 MHz. Article discusses theory of circuit design.—G. Wolf, Recent Developments in Circuits and Transistors for Television Receivers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 26, No. 4, 1965–1966, p 145–165.


BF 200
2.7pF
C1
25pF
Cp
Lp
P
Ls
800nH
25pF
75Ω
10166


+12VDC
220K
2K
1K
5K
CARRIER FREQ ADJ
1K
B
B2
B1
FM CARRIER OUT
fm INPUT
10K
1K
0.01μf
MODULATOR
UJT OSCILLATOR

500-HZ DEVIATION OF 2 KHZ—Simple ujt relaxation oscillator is frequency-modulated by npn transistor, neither of which are critical as to type. Transistor input of 0.45 V at base sets center frequency at 2 kHz.—D. Learned, UJT Oscillator Makes Simple FM Modulator, *Electronic Design*, May 10, 1965, p 47–48.

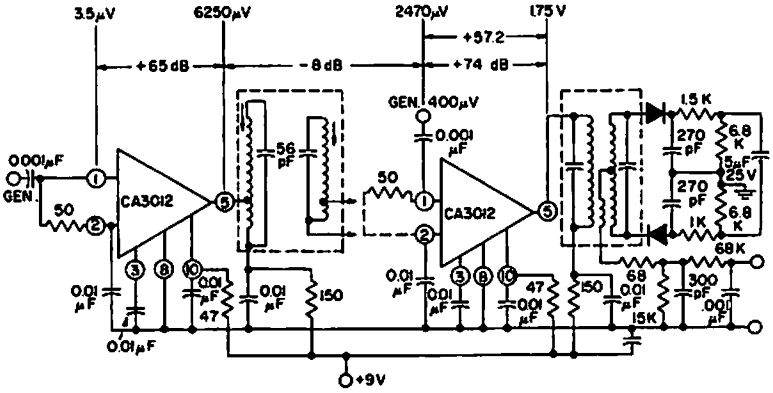

TO AGC
-12V
390K
5.6K
680K
6.8pf
M
L1
3-33 pf
F~100pf MATCHING
Q1
0.001
1N54
Z1
40 Mc IF
30μH CHOKE
0.001
1K
FARADAY SCREEN
88Mc
108Mc
-20DB
80Mc
120Mc
TO REG. 10V
6.8pf MAX
L2
0.001
TUNING
48~68Mc
56K
Q2
10pf
22K
1K
0.001
680K
560
-12V
1=35.5Mc
L3
Z2
4.5Mc IF
TO CONVENTIONAL 4.5Mc 2 STAGE IF AND DISCRIMINATOR
0.001
Q3
35.5Mc TANK
0.001
1K
0.01
Q1–Q3 = NIPPON ELECTRIC TYPE 2SA214 (EQUIV. TO 2N384 APROX)
SHIELDED TO PREVENT OSC RADIATION

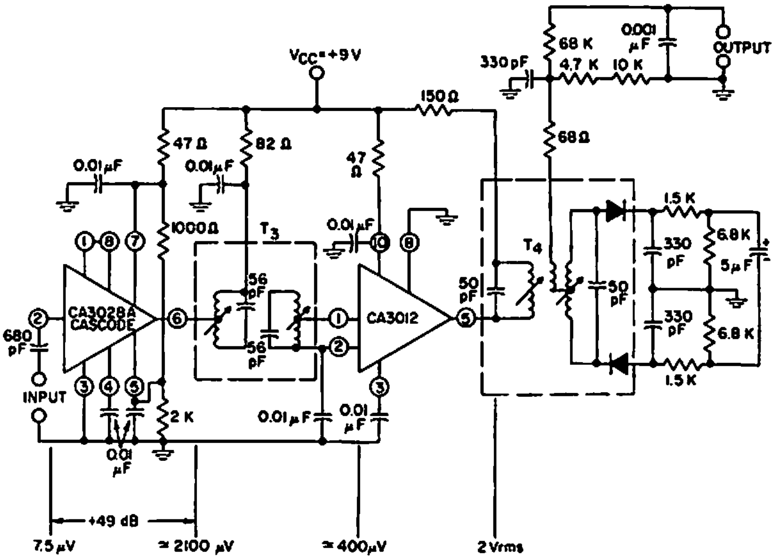

DISCRIMINATOR OUTPUT
Fc
INPUT
3-10v rms
90°
+
0°
180°
100k
100 k
100 k
100 k

H RESONATOR GIVES LARGE F-M SWINGS—Twintron H-shaped piezoelectric resonator with Q of 4,000 acts with out-of-phase transducers to make f-m discriminator produce large change in output for small shift in frequency. Effect is that of ultra-narrow-band discriminator. Article gives other applications for Twintrons in tone communication systems. —H. Baker and J. R. Cressey, H-Shaped Resonators Signal Upturn in Tone Telemetering, *Electronics*, Oct. 2, 1967, p 99–106.

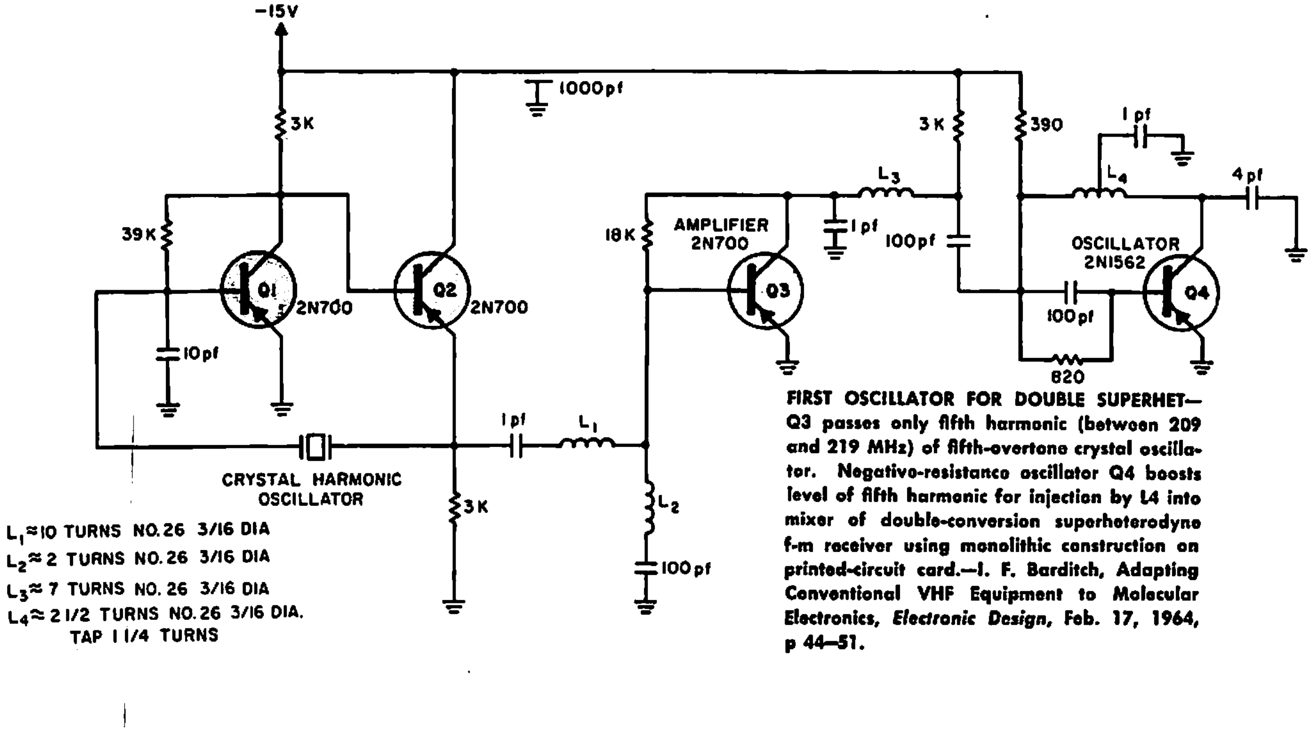
DOUBLE-CONVERSION RECEIVER—Crystal in overtone circuit converts 40-MHz first i-f down to 4.5 MHz. With crystal control, afc is not needed. Intended for use in areas having many f-m stations, where receiver must handle both powerful and weak signals without audio distortion caused by narrow i-f passband. Crystal can be low-cost CB unit.—L. E. Geisler, Double Conversion Improves Transistorized FM Receivers, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 33–34.

10.7-MHZ TWO-IC I-F STRIP—Requires triple-tuned filter ahead of first IC to provide required selectivity. Available gain of strip is 65 dB, but limiting by second IC reduces this about 17 dB.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 283.


3.5µV
6250µV
2470µV
175V
+57.2
+65dB
-8dB
+74 dB
GEN. 400µV
0.001 µF
0.001µF
GEN.
50
CA3012
CA3012
56 pF
50
0.01 µF
0.01µF
0.01 µF
47
0.01 µF
150
0.01 µF
0.01 µF
47
0.001 µF
150
68
0.01 µF
15K
1.5K
270 pF
6.8 K
5µF 25V
270 pF
1K
6.8 K
68K
300 pF
.001 µF
+9V

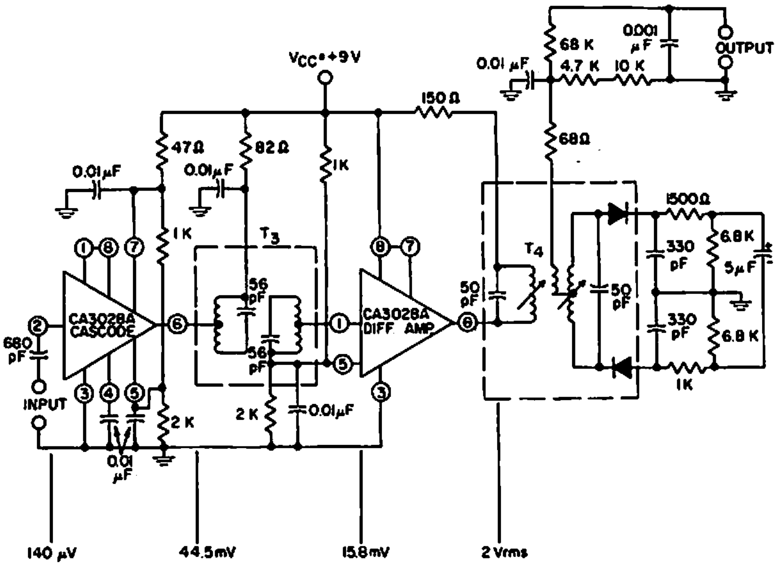

VCC=+9V
0.01µF
47 Ω
82 Ω
0.01µF
47 Ω
1000Ω
T3
0.01µF
56 pF
56 pF
CA3028A CASCODE
CA3012
680 pF
INPUT
2 K
0.01 µF
0.01µF
0.01 µF
150Ω
330pF
68 K
4.7 K
10 K
0.001 µF
OUTPUT
68Ω
T4
50 pF
50 pF
1.5 K
330 pF
6.8K
5µF
330 pF
6.8 K
1.5K
+49 dB
7.5µV
≈2100 µV
≈400µV
2Vrms

10.7-MHZ CASCODE I-F IC—CA3028A IC r-f amplifier is used in high-gain, high-performance cascode configuration in conjunction with CA3012 IC f-m i-f amplifier having sensitivity of 7.5 µV. T3 is TRW 22486 and T4 is TRW 22516. Provides 155 mV audio output for 140 µV input.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 217.

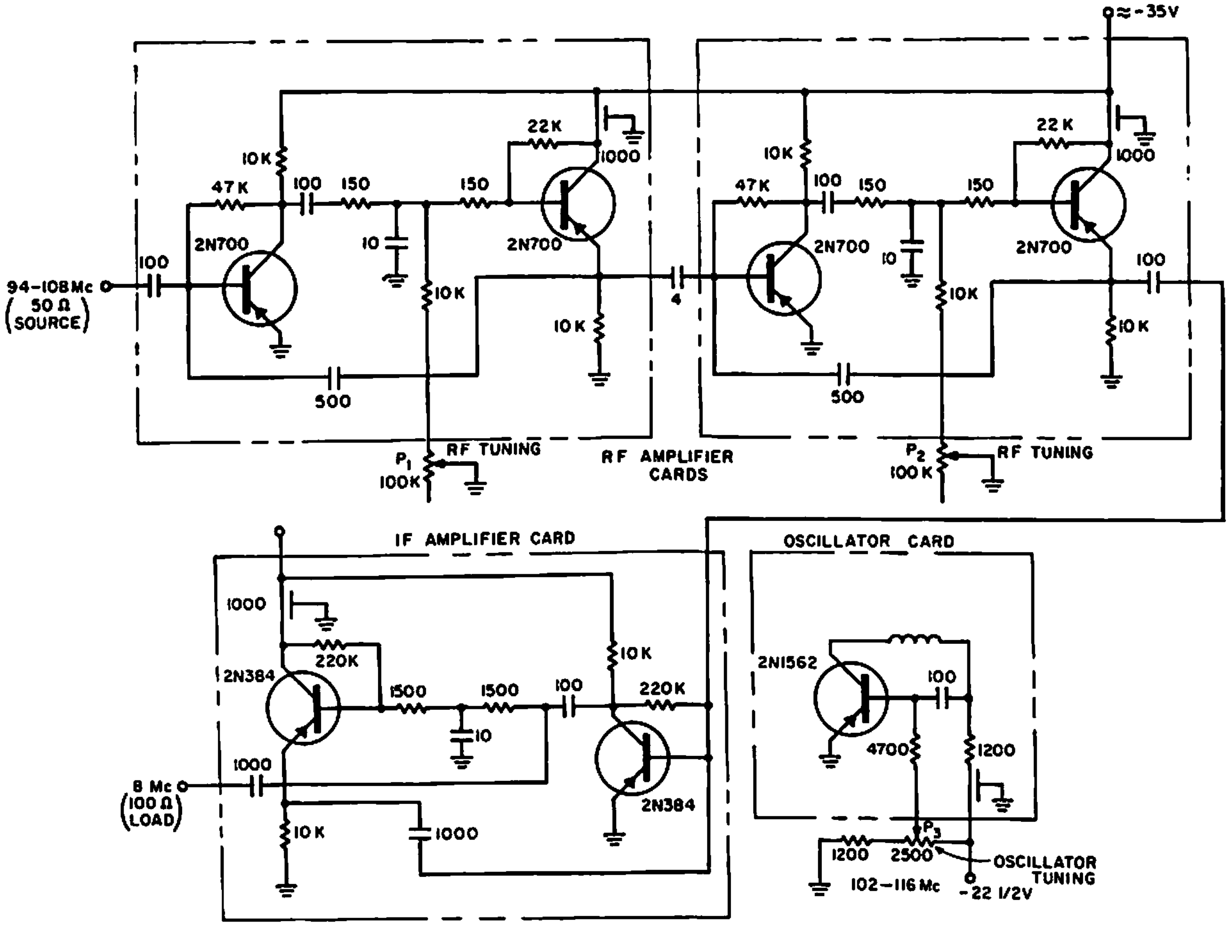

-15V
1000pf
3K
39K
Q1
2N700
Q2
2N700
10pf
CRYSTAL HARMONIC OSCILLATOR
1pf
L1
3K
18K
AMPLIFIER 2N700
Q3
1pf
L3
3K
100pf
L2
100pf
390
1pf
L4
4pf
OSCILLATOR 2N1562
Q4
100pf
820
L1≈10 TURNS NO.26 3/16 DIA
L2≈2 TURNS NO.26 3/16 DIA
L3≈7 TURNS NO.26 3/16 DIA
L4≈2 1/2 TURNS NO.26 3/16 DIA. TAP 1 1/4 TURNS

FIRST OSCILLATOR FOR DOUBLE SUPERHET—Q3 passes only fifth harmonic (between 209 and 219 MHz) of fifth-overtone crystal oscillator. Negative-resistance oscillator Q4 boosts level of fifth harmonic for injection by L4 into mixer of double-conversion superheterodyne f-m receiver using monolithic construction on printed-circuit card.—I. F. Barditch, Adapting Conventional VHF Equipment to Molecular Electronics, *Electronic Design*, Feb. 17, 1964, p 44–51.

10.7-MHZ IC I-F STRIP—Uses two IC r-f amplifiers, one connected as cascode amplifier having 50 dB voltage gain, and the other as differential amplifier having 42 dB voltage gain.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 219.

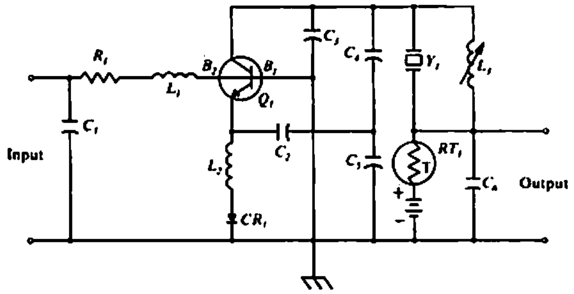

VCC=+9V
150Ω
0.01 µF
68 K
0.001 µF
OUTPUT
4.7 K
10 K
68Ω
47Ω
82Ω
0.01µF
0.01µF
1K
1K
T3
T4
CA3028A CASCODE
CA3028A DIFF AMP
56 pF
56 pF
680 pF
INPUT
2 K
2 K
0.01µF
0.01 µF
50 pF
50 pF
1500Ω
330 pF
330 pF
6.8K
6.8 K
5µF
1K
140 µV
44.5mV
15.8mV
2 Vrms

T_3: Interstage transformer TRW #22486 or equiv.
T_4: Ratio detector TRW #22516 or equiv.


≈-35V
22K
1000
10K
47K
100
150
150
2N700
10
100
94-108Mc (50 Ω SOURCE)
10K
10K
4
500
P1 100K
RF TUNING
RF AMPLIFIER CARDS
P2 100 K
RF TUNING
IF AMPLIFIER CARD
OSCILLATOR CARD
1000
220K
2N384
1500
1500
100
220K
10K
10
1000
8 Mc (100 Ω LOAD)
10K
1000
2N1562
100
4700
1200
P3
1200
2500
OSCILLATOR TUNING
102–116 Mc
-22 1/2V

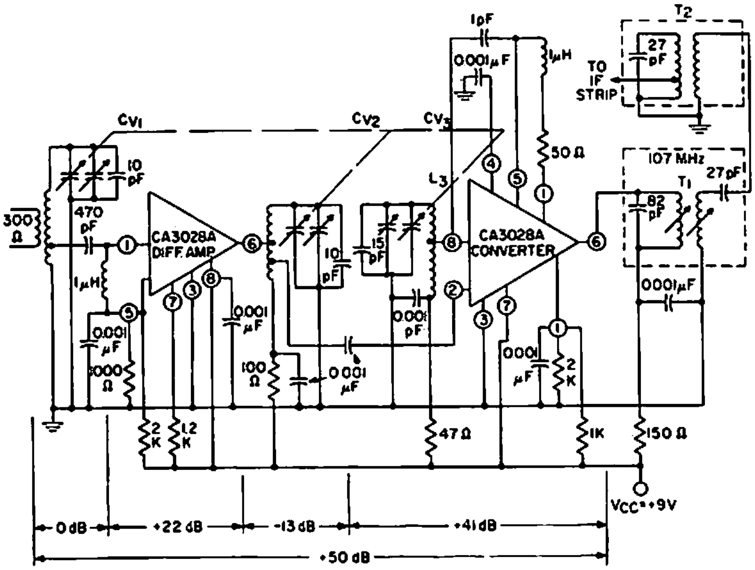
OVERALL GAIN 20 TO 30db
OVERALL BANDWIDTH ≈ 20KC

INDUCTORLESS 94–108 MHZ TUNER—Three 100-MHz R-C selective amplifiers using monolithic construction on printed-circuit cards are combined with distributed-inductance oscillator, with potentiometers used for tuning. Chief drawbacks are distortion and detuning for signal levels above 1 mV, and instability with small changes in source impedance. Oscillator injection to i-f card acting as mixer is achieved by proximity.—I. F. Barditch, Adapting Conventional VHF Equipment to Molecular Electronics, *Electronic Design*, Feb. 17, 1964, p 44–51.

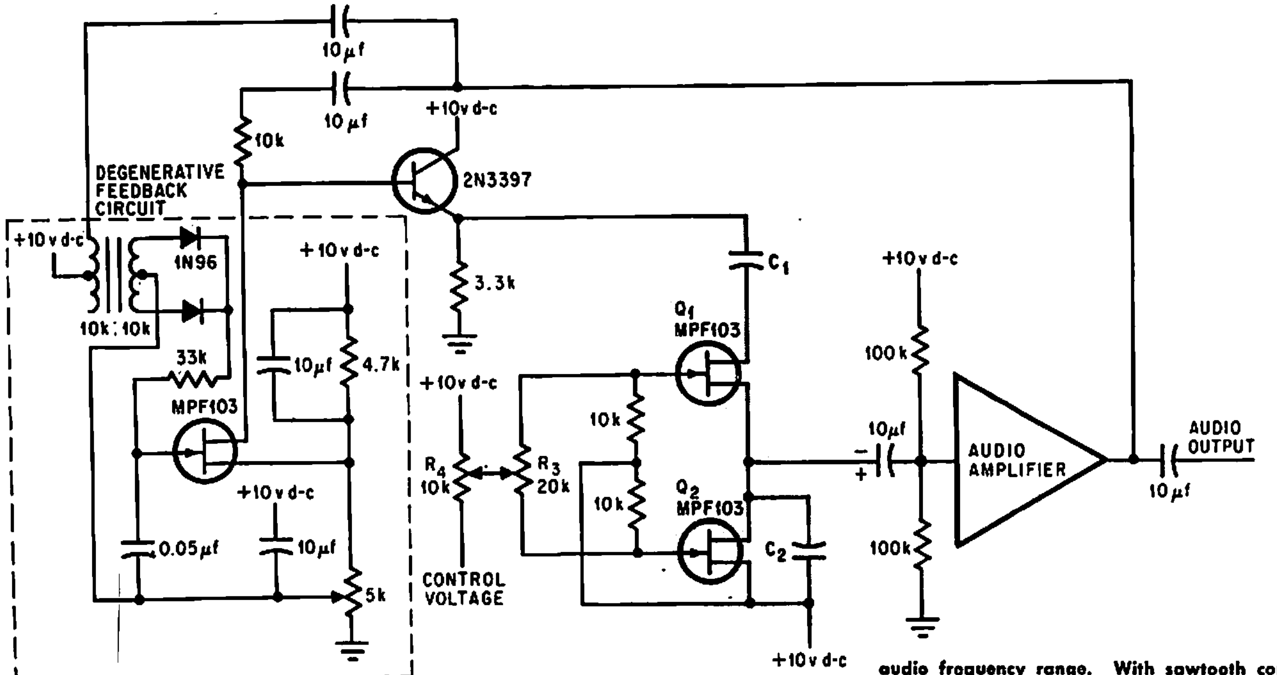

R1
L1
B2
B1
Q1
C1
C2
C3
C4
C5
C6
Y1
L3
RT1
T
L2
CR1
Input
Output

R_1	15K
C_1	0.01 μF
C_2	0.5 μF
C_3	82 pF
C_4	200 pF
C_5	220 pF
C_6	0.5 μF
L_1	2.5 mH
L_2	2.5 mH
L_3	480–800 μH

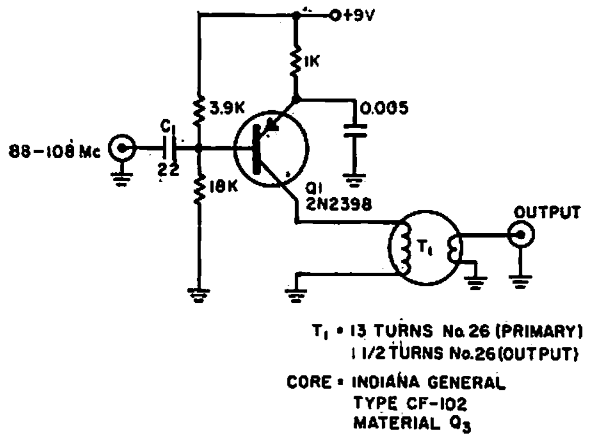
CURRENT-CONTROLLED F-M OSCILLATOR—Q1 is T1926 tetrode driving 455-kHz crystal Y1. Frequency is controlled by feeding input current to second base B2 of tetrode operated in reverse mode. Can be used in small f-m transmitters and vco applications. Supply voltage is 4 V. Choose CR1 to allow 0.5 mA. Thermistor is 10K Fenwal 4151.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 18.


CV1
CV2
CV3
10 pF
470 pF
300 Ω
1 μH
0.001 μF
1000 Ω
CA3028A DIFF. AMP
①
⑤
⑥
⑦
③
⑧
0.001 μF
2 K
1.2 K
100 Ω
0.001 μF
10 pF
15 pF
0.001 pF
L3
1 pF
0.001 μF
1 μH
50 Ω
④
⑤
①
⑧
②
CA3028A CONVERTER
⑥
③
⑦
①
0.001 μF
2 K
47 Ω
1K
150 Ω
T2
27 pF
TO IF STRIP
107 MHz
T1
27 pF
82 pF
0.001 μF
VCC=+9V
0 dB
+22 dB
-13 dB
+41 dB
+50 dB

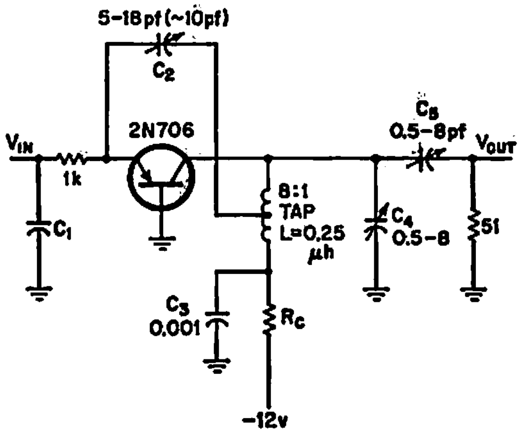
IC FRONT END—Pair of IC r-f amplifiers serves as complete tuner for 88–108 MHz f-m receiver. Book gives winding data for coils.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 221.


10 μf
10 μf
+10 v d-c
10k
2N3397
DEGENERATIVE FEEDBACK CIRCUIT
+10 v d-c
1N96
10k : 10k
+10 v d-c
33k
10 μf
4.7k
MPF103
+10 v d-c
0.05 μf
10 μf
5k
3.3k
C1
Q1 MPF103
+10 v d-c
R4 10k
R3 20k
10k
10k
Q2 MPF103
C2
CONTROL VOLTAGE
+10 v d-c
+10 v d-c
100k
10 μf
100k
AUDIO AMPLIFIER
AUDIO OUTPUT
10 μf

TALKING TO DOLPHINS—Circuit shown is modification of Wien-bridge oscillator in audio signal generator. Used to make audio output frequency vary with d-c control voltage derived from human amplitude-modulated speech. Resulting frequency-modulated human speech is then similar to whistle signal of dolphin and can be used to control his movements. Degenerative feedback circuit keeps output amplitude constant over wide audio frequency range. With sawtooth controlled voltage, can be used to sweep output across entire audio spectrum for checking frequency response of systems.—S. L. Moshier, FET Oscillator Helps Dolphins Understand People, *Electronics*, Feb. 5, 1968, p 85–86.

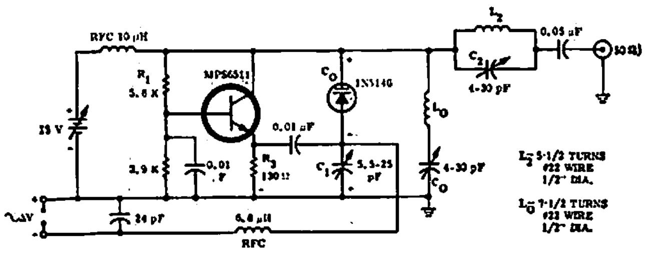

+9V
1K
3.9K
0.005
88–108 Mc
C1
22
18K
Q1
2N2398
T1
OUTPUT
T1 = 13 TURNS No.26 (PRIMARY)
1 1/2 TURNS No.26 (OUTPUT)
CORE = INDIANA GENERAL
TYPE CF-102
MATERIAL Q3

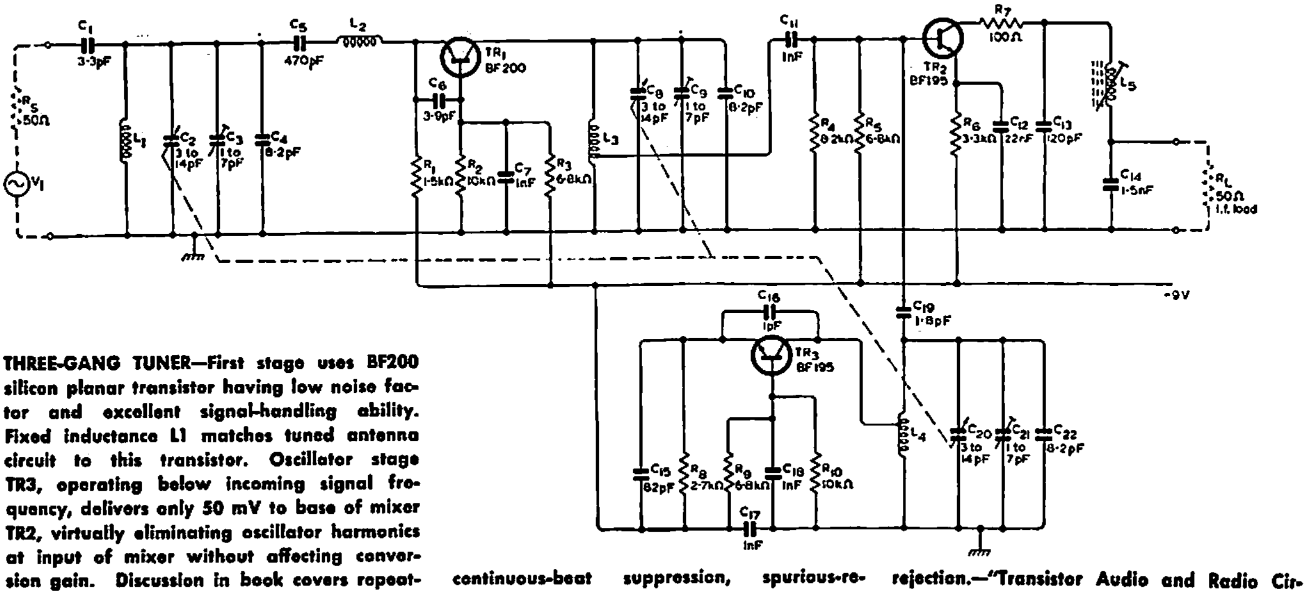
SIMPLE F-M PREAMP—Provides substantial gain across 88–108 MHz band, by taking advantage of low noise and high gain of transistor and wide-band properties of ferrite core in transformer. Gain is about 16 dB at center frequency and down only 3 dB at band limits.—G. Costa, FM Preamp Uses VHF Ferrite Transformer, *Electronic Design*, Feb. 3, 1964, p 51.


5–18pf (~10pf)
C2
2N706
VIN
1k
C1
8:1
TAP
L=0.25 μh
C3
0.001
Rc
−12v
C8
0.5–8pf
VOUT
C4
0.5–8
51

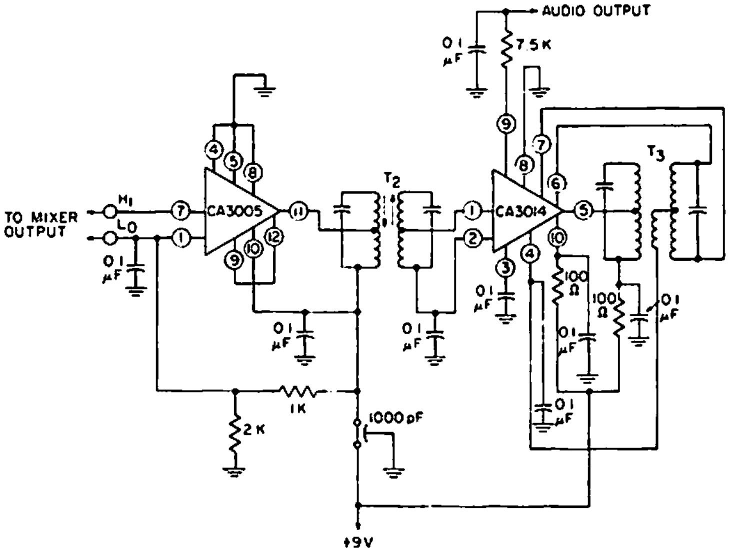
DUAL MODULATION—Modulating both emitter current and collector voltage of transistor in 100-MHz Hartley oscillator provides good linearity and stability when only small deviation is required. Deviation sensitivity is high, being up to 2.5 MHz per V. Modulation can be audio or video.—R. J. Turner, Stable F-M Oscillator Offers Sensitivity and Linearity, *Electronics*, Aug. 18, 1969, p 95.

F-M WITH VARACTOR DIODE—Frequency modulator gives deviation of 75 kHz above and below 52 MHz. Voltage input is limited to 200 mV. Article also describes other methods of using varactors in place of bulky tuning capacitors.—I. Carroll, Variable-Capacitance Diodes, *Electronics World*, July 1969, p 38–40.

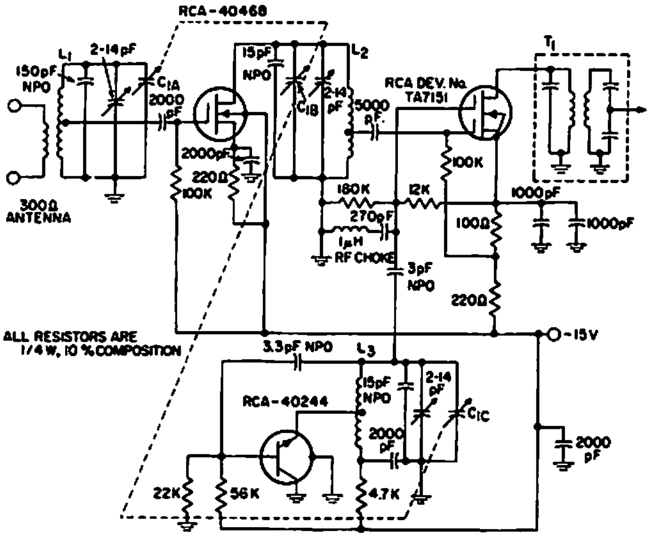

RFC 10 μH
R1
5.6 K
MPS6511
3.9 K
0.01
15 V
R3
130 Ω
0.01 μF
C0
1N5140
C1
5.5-25 pF
L0
4-30 pF
C0
L2
C2
4-30 pF
0.05 μF
50 Ω
24 pF
6.8 μH
RFC
ΔV
L2 = 5-1/2 TURNS #22 WIRE 1/2" DIA.
L0 = 7-1/2 TURNS #22 WIRE 1/2" DIA.


C1
3·3pF
RS
50Ω
V1
L1
C2
3 to 14pF
C3
1 to 7pF
C4
8·2pF
C5
470pF
L2
TR1
BF200
C6
3·0pF
R1
1·5kΩ
R2
10kΩ
C7
1nF
R3
6·8kΩ
L3
C8
3 to 14pF
C9
1 to 7pF
C10
8·2pF
C11
1nF
R4
8·2kΩ
R5
6·8kΩ
TR2
BF195
R7
100Ω
R6
3·3kΩ
C12
22nF
C13
120pF
L5
C14
1·5nF
RL
50Ω
I.F. load
−9V
C16
1pF
TR3
BF195
C19
1·8pF
L4
C20
3 to 14pF
C21
1 to 7pF
C22
8·2pF
C15
82pF
R8
2·7kΩ
R9
6·8kΩ
C18
1nF
R10
10kΩ
C17
1nF

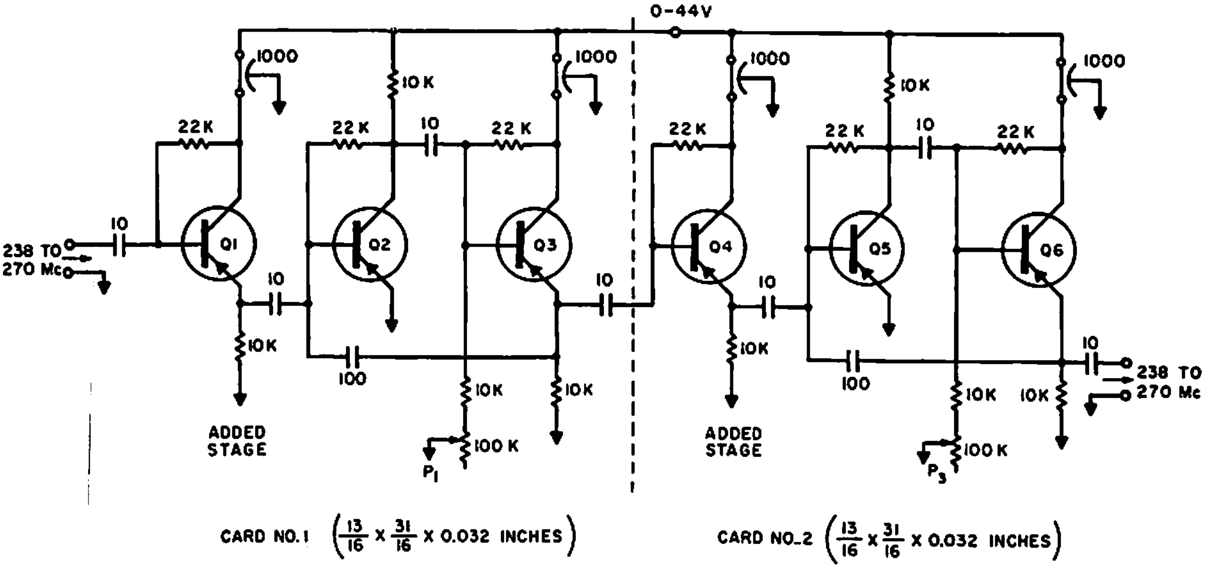
THREE-GANG TUNER—First stage uses BF200 silicon planar transistor having low noise factor and excellent signal-handling ability. Fixed inductance L1 matches tuned antenna circuit to this transistor. Oscillator stage TR3, operating below incoming signal frequency, delivers only 50 mV to base of mixer TR2, virtually eliminating oscillator harmonics at input of mixer without affecting conversion gain. Discussion in book covers repeat-spot suppression, double-beat suppression, continuous-beat suppression, spurious-response suppression, image rejection, and i-f rejection.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 146.


AUDIO OUTPUT
0.1 μF
7.5 K
TO MIXER OUTPUT
Hi
Lo
0.1 μF
CA3005
T2
CA3014
T3
0.1 μF
0.1 μF
100 Ω
100 Ω
0.1 μF
0.1 μF
0.1 μF
0.1 μF
1K
2K
1000 pF
+9V

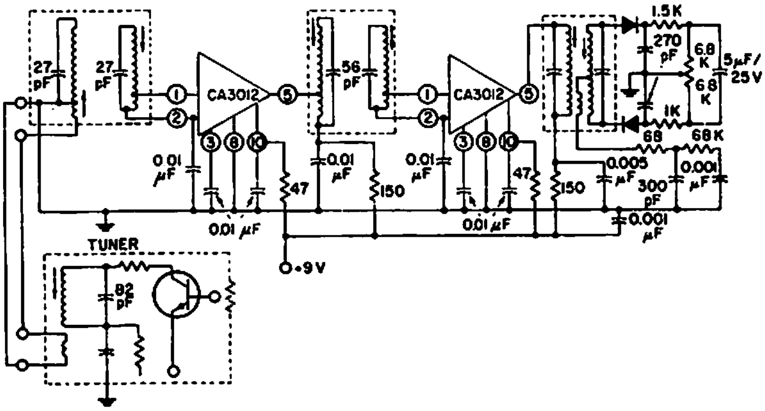
95 DB GAIN AT 10.7 MHZ—Two IC i-f amplifier stages feed discriminator. Input limiting knee for strip is 30 μV. T2 is TRW 21969 and T3 is 21590.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 291.


RCA-40468
L1
2-14pF
150pF NPO
C1A
2000 pF
15pF NPO
L2
C1B
2-14 pF
5000 pF
RCA DEV. No. TA7151
T1
300Ω ANTENNA
2000pF
220Ω
100K
100K
180K
12K
1000pF
270pF
1μH RF CHOKE
3pF NPO
100Ω
1000pF
220Ω
ALL RESISTORS ARE 1/4 W, 10 % COMPOSITION
3.3pF NPO
L3
-15V
15pF NPO
2-14 pF
C1C
RCA-40244
2000 pF
2000 pF
22K
56K
4.7K

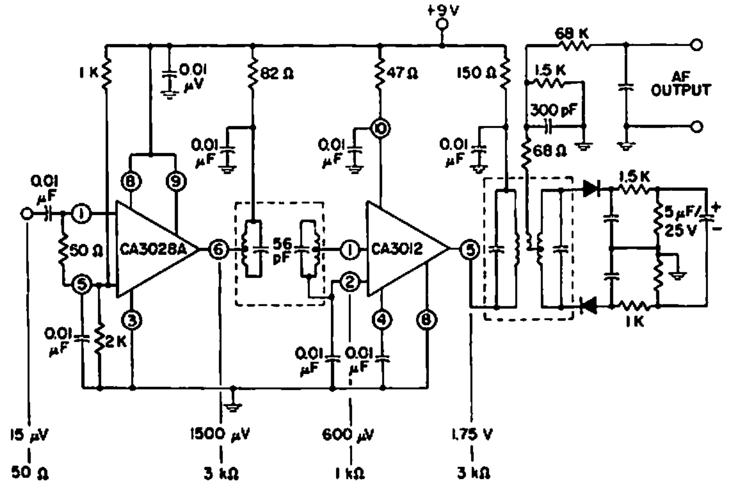
TUNER USING DUAL-GATE MOSFET MIXER—TA7151 mixer is preceded by single-gate mosfet r-f amplifier that provides 13 dB power gain at 5 mA. Total gain of tuner is 31 dB. Requires only three coils, with minimum shielding. Report gives coil data and complete design procedure.—H. M. Kleinman, Application of Dual-Gate MOS Field-Effect Transistors in Practical Radio Receivers, RCA, Somerville, N.J., ST-3486, 1967.


0-44V
1000
10 K
1000
1000
10K
1000
22K
22 K
10
22 K
22K
22 K
10
22K
238 TO 270 Mc
10
Q1
Q2
Q3
Q4
Q5
Q6
10
10
10
10K
100
10K
10K
10K
100
10K
10K
10
238 TO 270 Mc
ADDED STAGE
100 K
P1
ADDED STAGE
100 K
P3
CARD NO.1 ($\frac{13}{16} \times \frac{31}{16} \times 0.032$ INCHES)
CARD NO.2 ($\frac{13}{16} \times \frac{31}{16} \times 0.032$ INCHES)

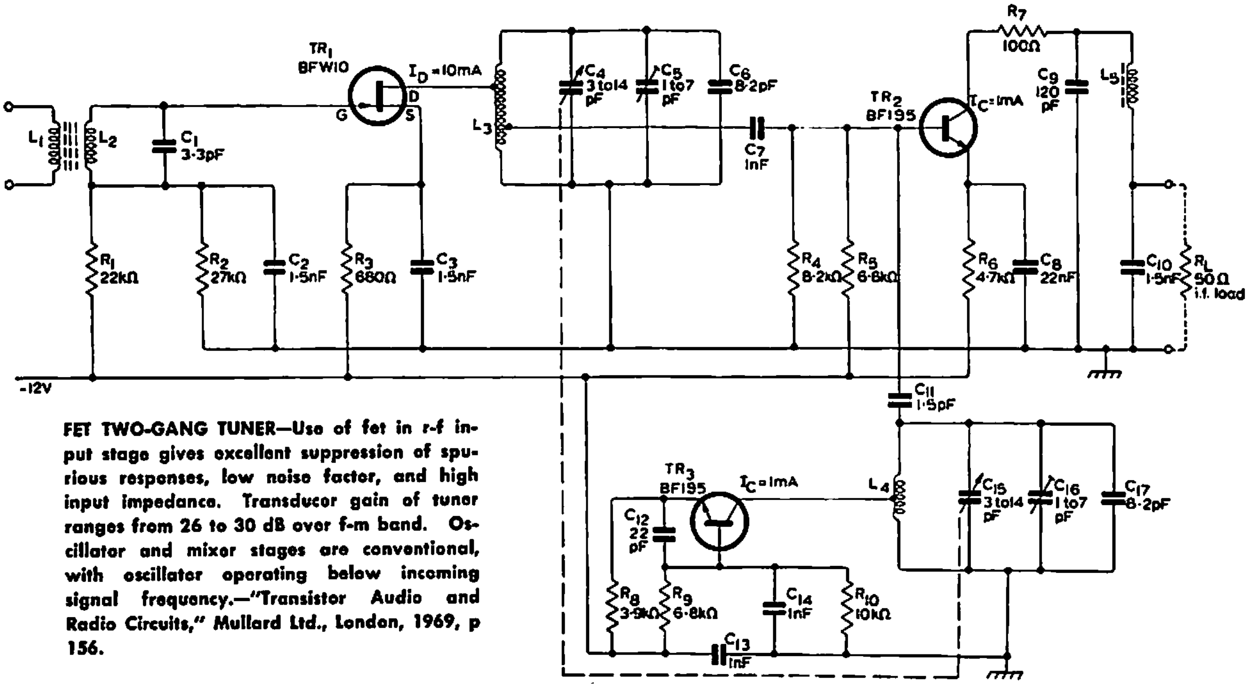
238–270 MHZ R-F AMPLIFIER—Used in experimental 243 MHz to 28 MHz R-C tuner-converter using potentiometers for tuning. All transistors are 2N700. Stability is fair, but gain falls rapidly at higher frequencies if fixed bias supply is used.—I. F. Barditch, Adapting Conventional VHF Equipment to Molecular Electronics, *Electronic Design*, Feb. 17, 1964, p 44–51.


27 pF
27 pF
CA3012
①
②
⑤
③
⑧
⑩
0.01 µF
56 pF
47
150
0.01 µF
TUNER
82 pF
o+9V
1.5K
270 pF
6.8 K
5µF/25V
1K
68
68K
0.005 µF
300 pF
0.001 µF

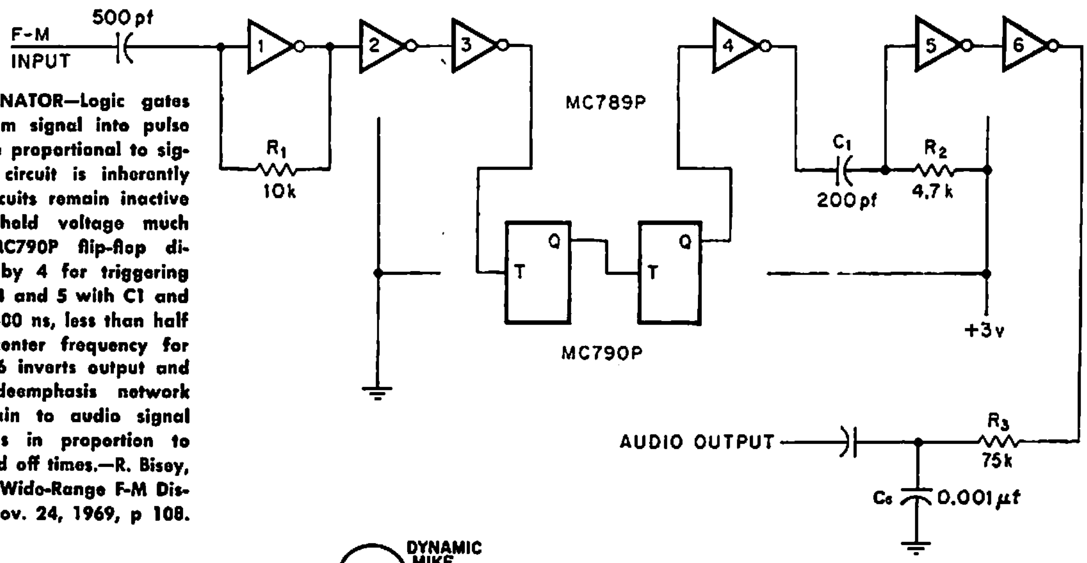
COMPLETE 10.7-MHZ I-F STRIP—Provides 155-mV audio signal at output of ratio detector. Capture ratio varies from 5 dB at 2 µV to 1.2 dB above 500 µV. Book gives performance curves.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 287.


+9V
1K
0.01 µV
82 Ω
47 Ω
150 Ω
68 K
1.5 K
300 pF
68 Ω
AF OUTPUT
0.01 µF
CA3028A
CA3012
56 pF
50 Ω
2K
1.5K
5µF/25V
1K
15 µV
50 Ω
1500 µV
3 kΩ
600 µV
1 kΩ
1.75 V
3 kΩ

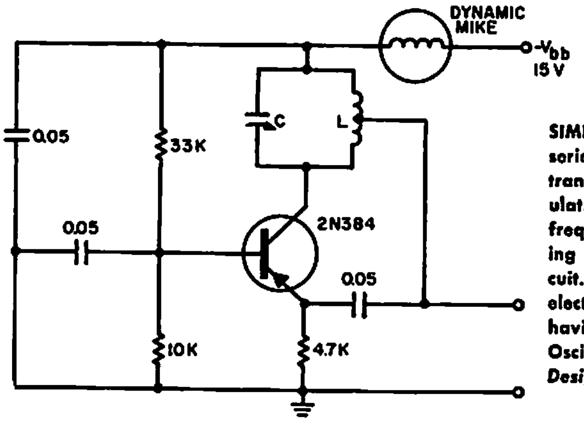
TWO-STAGE IC I-F STRIP—Combines high gain with single-stage-per-package approach. Both IC amplifiers are used in differential-mode connection. Gives i-f sensitivity of 15 µV.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 289.


TR1 BFW10
ID=10mA
G
D
S
L1
L2
C1 3·3pF
R1 22kΩ
R2 27kΩ
C2 1·5nF
R3 680Ω
C3 1·5nF
L3
C4 3to14 pF
C5 1to7 pF
C6 8·2pF
C7 1nF
R4 8·2kΩ
R5 6·8kΩ
TR2 BF195
IC=1mA
R7 100Ω
C9 120 pF
L5
R6 4·7kΩ
C8 22nF
C10 1·5nF
RL 50Ω i.f. load
-12V
C11 1·5pF
TR3 BF195
IC=1mA
L4
C15 3to14 pF
C16 1to7 pF
C17 8·2pF
C12 22 pF
R8 3·9kΩ
R9 6·8kΩ
C14 1nF
R10 10kΩ
C13 1nF

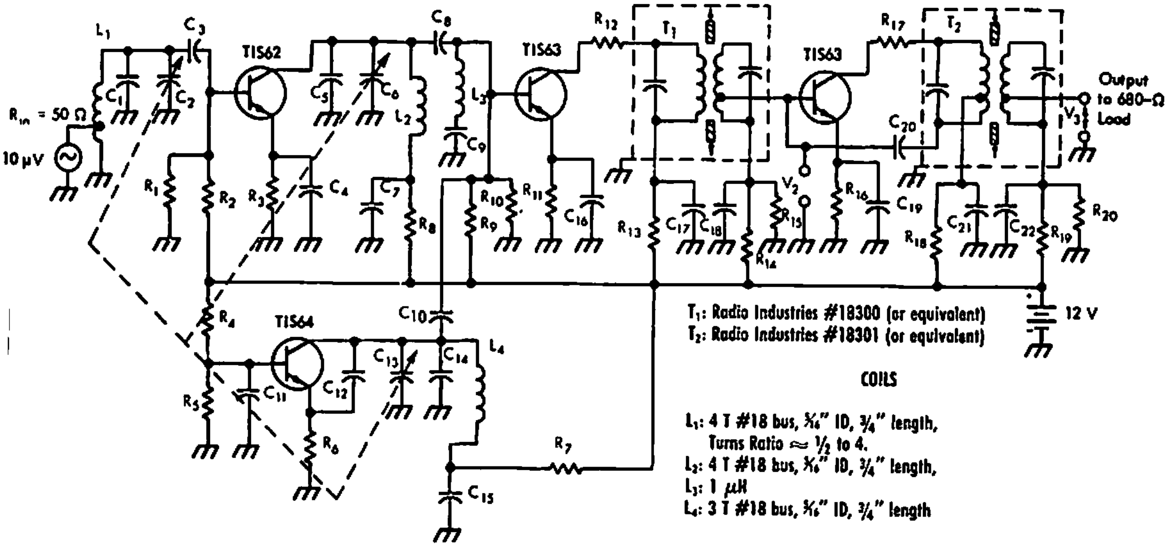
FET TWO-GANG TUNER—Use of fet in r-f input stage gives excellent suppression of spurious responses, low noise factor, and high input impedance. Transducer gain of tuner ranges from 26 to 30 dB over f-m band. Oscillator and mixer stages are conventional, with oscillator operating below incoming signal frequency.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 156.


F-M INPUT
500 pf
1
2
3
R_1
10k
MC789P
4
5
6
C_1
200 pf
R_2
4.7 k
T
Q
T
Q
MC790P
+3v
AUDIO OUTPUT
R_3
75k
C_6
0.001 μf

PULSE TRAIN DISCRIMINATOR—Logic gates 1-3 convert incoming f-m signal into pulse train with repetition rate proportional to signal frequency. Digital circuit is inherently quieting, because all circuits remain inactive until they reach threshold voltage much greater than noise. MC790P flip-flop divides signal frequency by 4 for triggering mono using logic gates 4 and 5 with C1 and R2. Period of mvbr is 400 ns, less than half the period of 1-MHz center frequency for f-m signal. Final gate 6 inverts output and feeds high-frequency deemphasis network that converts pulse train to audio signal whose amplitude varies in proportion to change in ratio of on and off times.—R. Bisey, No Tuned Circuits In IC Wide-Range F-M Discriminator, *Electronics*, Nov. 24, 1969, p 108.


DYNAMIC MIKE
-V_{bb} 15 V
0.05
33K
C
L
0.05
2N384
0.05
10K
4.7K

SIMPLE MODULATOR—Dynamic microphone, in series with negative supply lead of stable transistor oscillator, provides frequency modulation with deviation of 4 to 6 kHz. Carrier frequency is in range of 3 to 4 MHz, depending on values used for L and C in tank circuit. Operation depends on transistor interelectrode capacitance becoming part of tank having high L/C ratio.—R. E. Baird, Modulated Oscillator Makes Simple FM Source, *Electronic Design*, March 30, 1964, p 72.


L_1
C_3
TIS62
C_8
R_{12}
T_1
TIS63
TIS63
R_{17}
T_2
Output to 680-Ω Load
V_3
R_{in} = 50 Ω
C_1
C_2
V_1 = 10 μV
C_5
C_6
L_2
L_3
C_9
C_{20}
R_1
R_2
R_3
C_4
C_7
R_8
R_{10}
R_9
R_{11}
C_{16}
R_{13}
C_{17}
C_{18}
V_2
R_{15}
R_{14}
R_{16}
C_{19}
R_{18}
C_{21}
C_{22}
R_{19}
R_{20}
12 V
R_4
TIS64
C_{10}
C_{13}
C_{14}
L_4
R_5
C_{11}
C_{12}
R_6
R_7
C_{15}

T_1: Radio Industries #18300 (or equivalent)
T_2: Radio Industries #18301 (or equivalent)

COILS

L_1: 4 T #18 bus, 5/16" ID, 3/4" length,
Turns Ratio ≈ 1/2 to 4.
L_2: 4 T #18 bus, 5/16" ID, 3/4" length,
L_3: 1 μH
L_4: 3 T #18 bus, 5/16" ID, 3/4" length

R_1: 8.2 kΩ
R_2: 33 kΩ
R_3: 1 kΩ
R_4: 12 kΩ
R_5: 2.7 kΩ
R_6: 1 kΩ
R_7: 330 Ω
R_8: 330 Ω
R_9: 15 kΩ
R_{10}: 2.7 kΩ

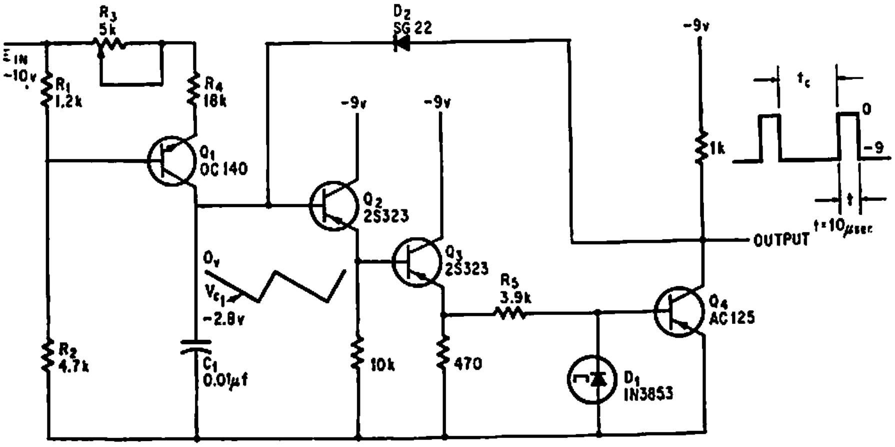
R_{11}: 1 kΩ
R_{12}: 120 Ω
R_{13}: 330 Ω
R_{14}: 10 kΩ
R_{15}: 3.9 kΩ
R_{16}: 1.2 kΩ
R_{17}: 120 Ω
R_{18}: 330 Ω
R_{19}: 10 kΩ
R_{20}: 3.9 kΩ

All resistors 1/2 W, ten percent tolerance.

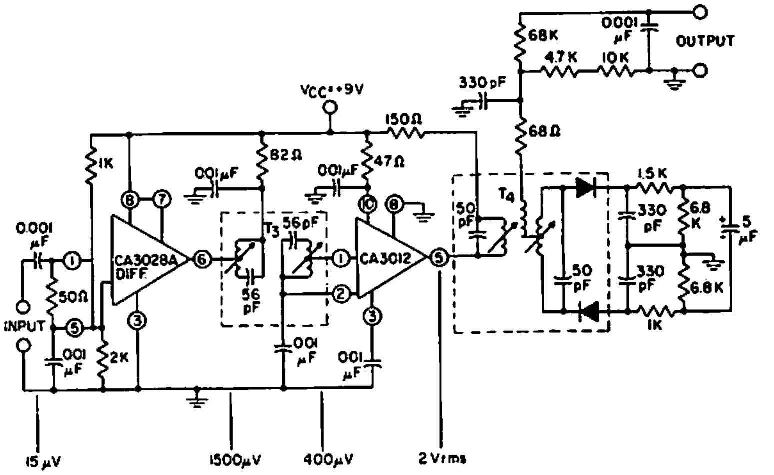
C_1: 10 pF
C_2: 30-45 pF
C_3: 3.3 pF
C_4: 0.001 μF
C_5: 10 pF
C_6: 30-45 pF
C_7: 0.001 μF
C_8: 3.3 pF
C_9: 240 pF
C_{10}: 0.82 pF
C_{11}: 0.001 μF

C_{12}: 3.3 pF
C_{13}: 30-45 pF
C_{14}: 10 pF
C_{15}: 0.001 μF
C_{16}: 0.01 μF
C_{17}: 0.01 μF
C_{18}: 0.01 μF
C_{19}: 0.01 μF
C_{20}: 2.2 pF
C_{21}: 0.01 μF
C_{22}: 0.01 μF

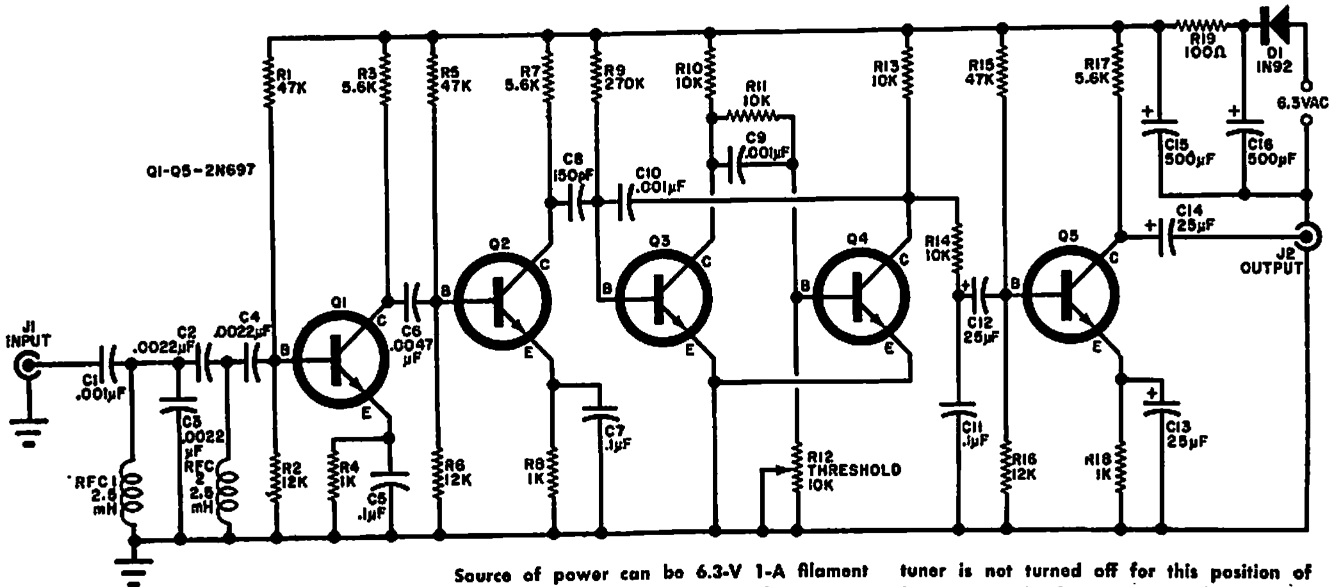
F-M TUNER WITH I-F STAGE—Uses four npn planar silicon transistors. Power gain is 54 dB. Image rejection at 98 MHz is 50 dB. I-f input voltage V2 is 1.5 mV and output V3 is 19 mV.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, CC101, 1968, p 1030.


R3
5k
D2
SG22
-9v
E IN
-10v
R1
1.2k
R4
18k
Q1
OC140
-9v
-9v
Q2
2S323
Q3
2S323
0v
Vc1
-2.8v
R5
3.9k
Q4
AC125
1k
tc
0
-9
t=10μsec
OUTPUT
R2
4.7k
C1
0.01μf
10k
470
D1
IN3853

PULSE FREQUENCY MODULATOR—R3 varies repetition frequency of fast pulses linearly from 1,300 to 2,600 pps. Pulse width is 10 μs. D1 operates as fast switch that turns Q4 on and off to produce output pulses. Article gives design equation, performance curves, and detailed operation.—T. W. Sian, Tunnel Diode Speeds Pulse Frequency Modulation, *Electronics*, Jan. 22, 1968, p 73.


68K
.0001 μF
OUTPUT
4.7K
10K
330pF
VCC=+9V
150Ω
68Ω
1K
82Ω
.001μF
.001μF
47Ω
8
7
10
8
T3
56pF
T4
150 pF
1.5K
330 pF
6.8K
5 μF
0.001 μF
1
CA3028A DIFF
6
56 pF
1
CA3012
5
50Ω
INPUT
5
2
3
3
.001 μF
2K
.001 μF
.001 μF
50 pF
330 pF
6.8K
1K
15μV
1500μV
400μV
2Vrms

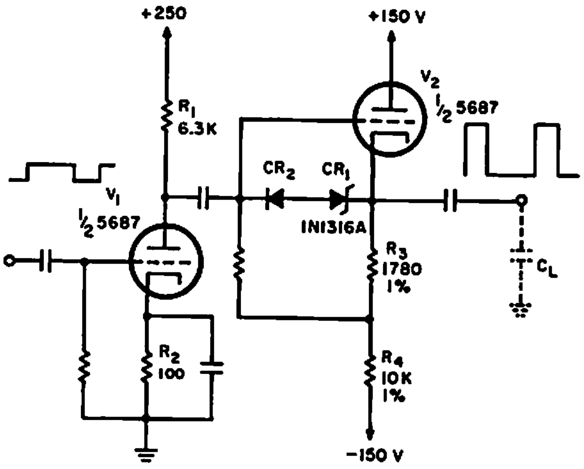
10.7-MHZ MEDIUM-GAIN I-F IC—First IC is connected as differential amplifier, and next serves as wide band f-m i-f amplifier. Book gives transformer data.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 220.


R1
47K
R3
5.6K
R5
47K
R7
5.6K
R9
270K
R10
10K
R11
10K
C9
.001μF
R13
10K
R15
47K
R17
5.6K
R19
100Ω
D1
IN92
6.3VAC
C15
500μF
C16
500μF
Q1-Q5-2N697
C8
150pF
C10
.001μF
C14
25μF
J2
OUTPUT
Q2
Q3
Q4
R14
10K
Q5
J1
INPUT
C1
.001μF
C2
.0022μF
C4
.0022μF
Q1
C6
.0047 μF
B
C
E
C3
.0022 μF
RFC1
2.5 mH
RFC2
2.5 mH
R2
12K
R4
1K
C5
.1μF
R6
12K
R8
1K
C7
.1μF
R12
THRESHOLD
10K
C12
25μF
C11
.1μF
R16
12K
R18
1K
C13
25μF

SCA BACKGROUND-MUSIC ADAPTER—Permits listening to continuous music uninterrupted by commercials or news, on f-m subcarrier that is offset from regular carrier frequency of f-m station by 67.5 kHz. Called SCA for Subsidiary Communications Authorization. Source of power can be 6.3-V 1-A filament transformer connected to terminals at upper right. Adapter is connected between detector and R-C deemphasis network of f-m receiver. Output of adapter may be fed either to separate amplifier and speaker or to auxiliary input jack at rear of set, provided f-m tuner is not turned off for this position of function switch of set. Input jack should be connected to set through isolation resistor of about 3,000 ohms, with exact value depending on receiver used.—W. F. Splichal, Jr., Simple SCA Adapter, *Popular Electronics*, June 1970, p 49–52.

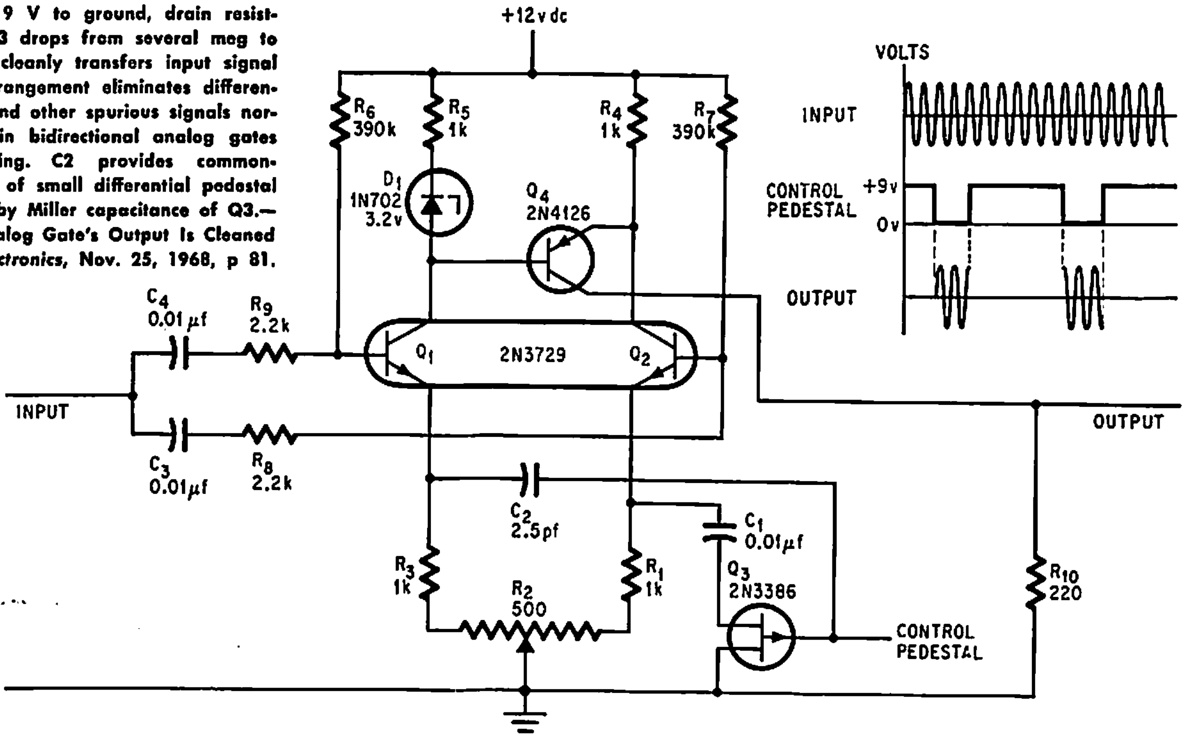
CHAPTER 36

Gate Circuits

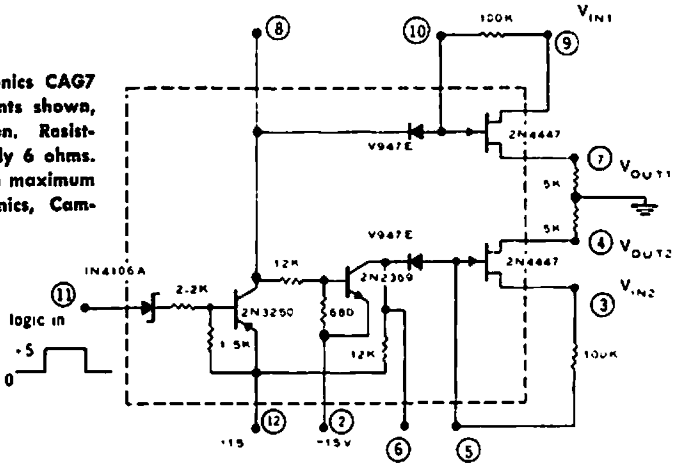

+250
+150 V
R_1 6.3K
V_2 ½ 5687
CR_2
CR_1
V_1 ½ 5687
1N1316A
R_3 1780 1%
C_L
R_2 100
R_4 10K 1%
-150 V

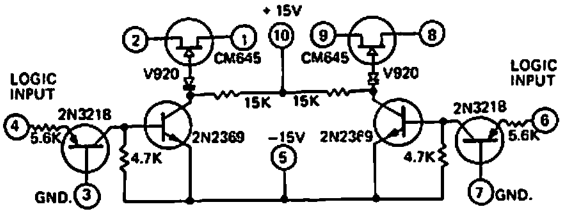
FASTER FALL TIME—Use of zener diode as switch gives low output impedance for both positive and negative excursions of gating pulse. This offsets shunt capacitance in load, to give fast transit times with conventional circuit and components. Article gives equation for fall times; for values shown, it is 0.9 μs, and 0.5 μs for rise time. Capacitor values are not critical.—B. I. Wolff, Gate Generator Arrangement Speeds Up Fall Time, *Electronic Design*, Oct. 26, 1964, p 53–54.

FET BLOCKS SPIKES—When control signal switches from 9 V to ground, drain resistance of fet Q3 drops from several meg to 90 ohms and cleanly transfers input signal to output. Arrangement eliminates differentiated spikes and other spurious signals normally arising in bidirectional analog gates during switching. C2 provides common-mode rejection of small differential pedestal spikes passed by Miller capacitance of Q3.—T. J. Davis, Analog Gate's Output Is Cleaned Up By FET, *Electronics*, Nov. 25, 1968, p 81.

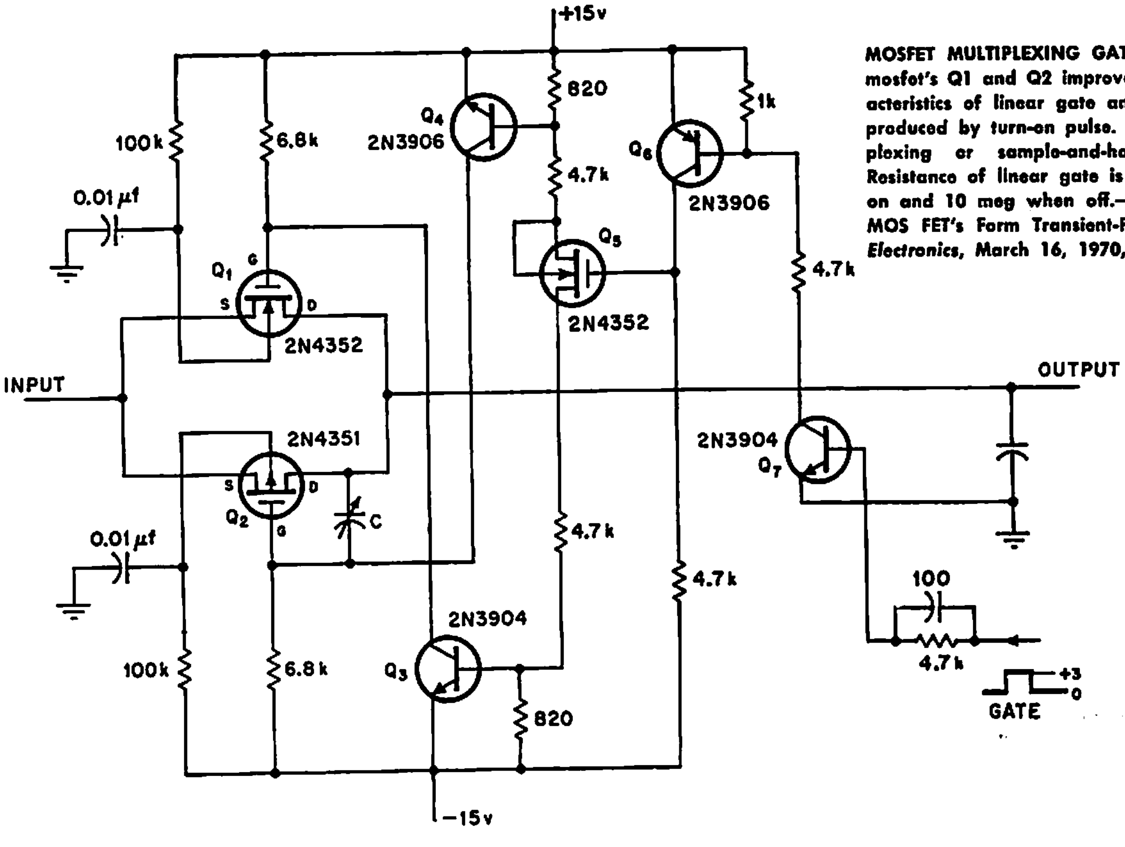

+12 v dc
R_6 390k
R_5 1k
R_4 1k
R_7 390k
D_1 1N702 3.2v
Q_4 2N4126
C_4 0.01 μf
R_9 2.2k
Q_1
2N3729
Q_2
INPUT
C_3 0.01 μf
R_8 2.2k
C_2 2.5 pf
C_1 0.01 μf
R_3 1k
R_2 500
R_1 1k
Q_3 2N3386
CONTROL PEDESTAL
R_{10} 220
OUTPUT
VOLTS
INPUT
CONTROL PEDESTAL
+9v
0v
OUTPUT

FET ANALOG GATE—With Crystalonics CAG7 package having external components shown, provides either spdt or dpst action. Resistance when ON is maximum of only 6 ohms. Turn-on and turn-off times are both maximum of 1.5 μs.—Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.

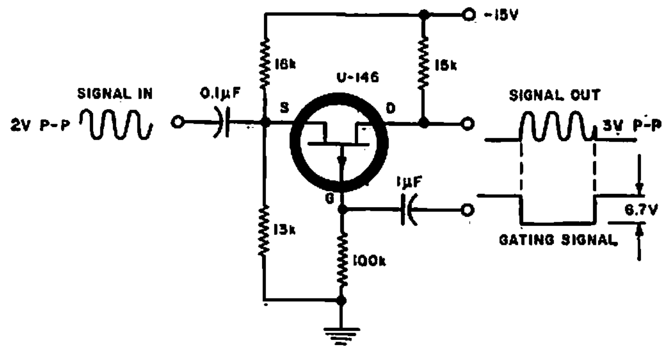

⑧
⑩
100K
V_{IN1}
⑨
V947E
2N4447
⑦ V_{OUT1}
5K
5K
④ V_{OUT2}
V947E
2N4447
1N4106A
⑪
logic in
+5
0
2.2K
2N3250
1.5K
12K
680
2N2369
12K
V_{IN2}
③
100K
⑫
+15
②
−15V
⑥
⑤


+15V
②
①
⑩
⑨
⑧
CM645
CM645
V920
V920
LOGIC INPUT
LOGIC INPUT
15K
15K
2N3218
2N3218
④
5.6K
2N2369
−15V
2N2369
⑤
4.7K
4.7K
5.6K
⑥
GND. ③
⑦ GND.

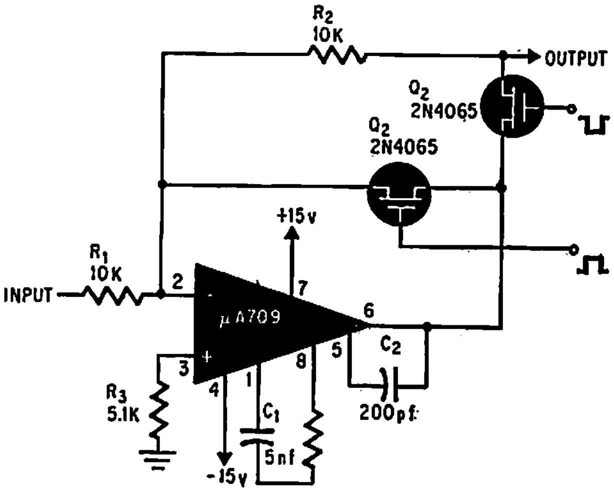
DUAL FET ANALOG GATE—Crystalonics CAG13 package provides spst action with 500-ns switching speed, break-before-make, and inherent zero offset voltage. Handles positive and negative 9-V signal levels directly from most logic circuits. Maximum ON resistance is 50 ohms at room temperature.—Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.


+15v
820
1k
100k
6.8k
Q_4
2N3906
Q_6
4.7k
2N3906
0.01 μf
Q_5
Q_1
G
S
D
2N4352
4.7k
2N4352
INPUT
OUTPUT
2N4351
2N3904
Q_7
S
D
C
Q_2
G
0.01 μf
4.7k
4.7k
100
100k
6.8k
2N3904
Q_3
4.7k
820
+3
0
GATE
−15v

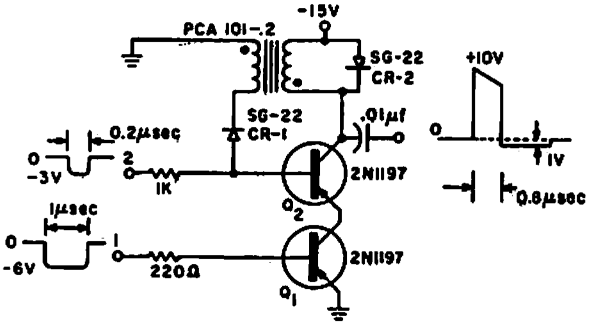
MOSFET MULTIPLEXING GATE—Paralleling of mosfet's Q1 and Q2 improves coupling characteristics of linear gate and cancels spikes produced by turn-on pulse. Useful in multiplexing or sample-and-hold applications. Resistance of linear gate is 200 ohms when on and 10 meg when off.—J. M. Firth, Two MOS FET's Form Transient-Free Linear Gate, *Electronics*, March 16, 1970, p 89.


-15V
16k
15k
U-146
SIGNAL IN
0.1µF
2V P-P
S
D
SIGNAL OUT
3V P-P
G
1µF
6.7V
GATING SIGNAL
13k
100k

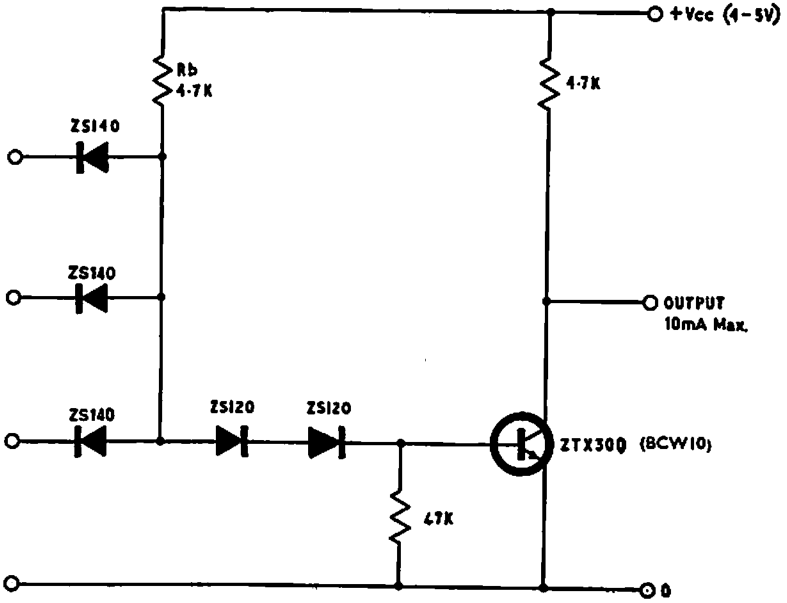
LINEAR FET GATE—Can also serve as electronic switch for amplitude modulator.—J. H. Wujek, Jr. and M. E. McGee, Field-Effect Transistor Circuits, *Electronics World*, May 1967, p 32–33 and 75.


R2
10K
OUTPUT
Q2
2N4065
Q2
2N4065
+15v
R1
10K
INPUT
2
7
µA709
6
5
C2
3
8
4
1
R3
5.1K
C1
5nf
200pf
-15v

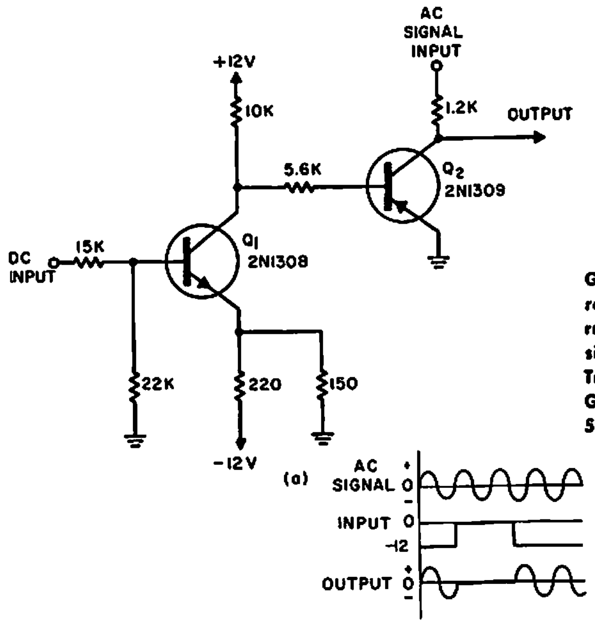
PRECISION ANALOG GATE—Uses Fairchild µA709 opamp with fet switches in feedback loop. Gate is opened and closed by alternately driving the two switches Q2 on and off. Circuit operates as unity-gain inverting amplifier having essentially zero on-gate resistance. Isolation between input signal and load is nearly perfect.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


-15V
PCA 101-.2
SG-22
CR-2
+10V
SG-22
CR-1
.01µf
0.2µsec
0
-3V
2
1K
2N1197
Q2
0
1V
0.8µsec
1µsec
0
-6V
1
220Ω
2N1197
Q1

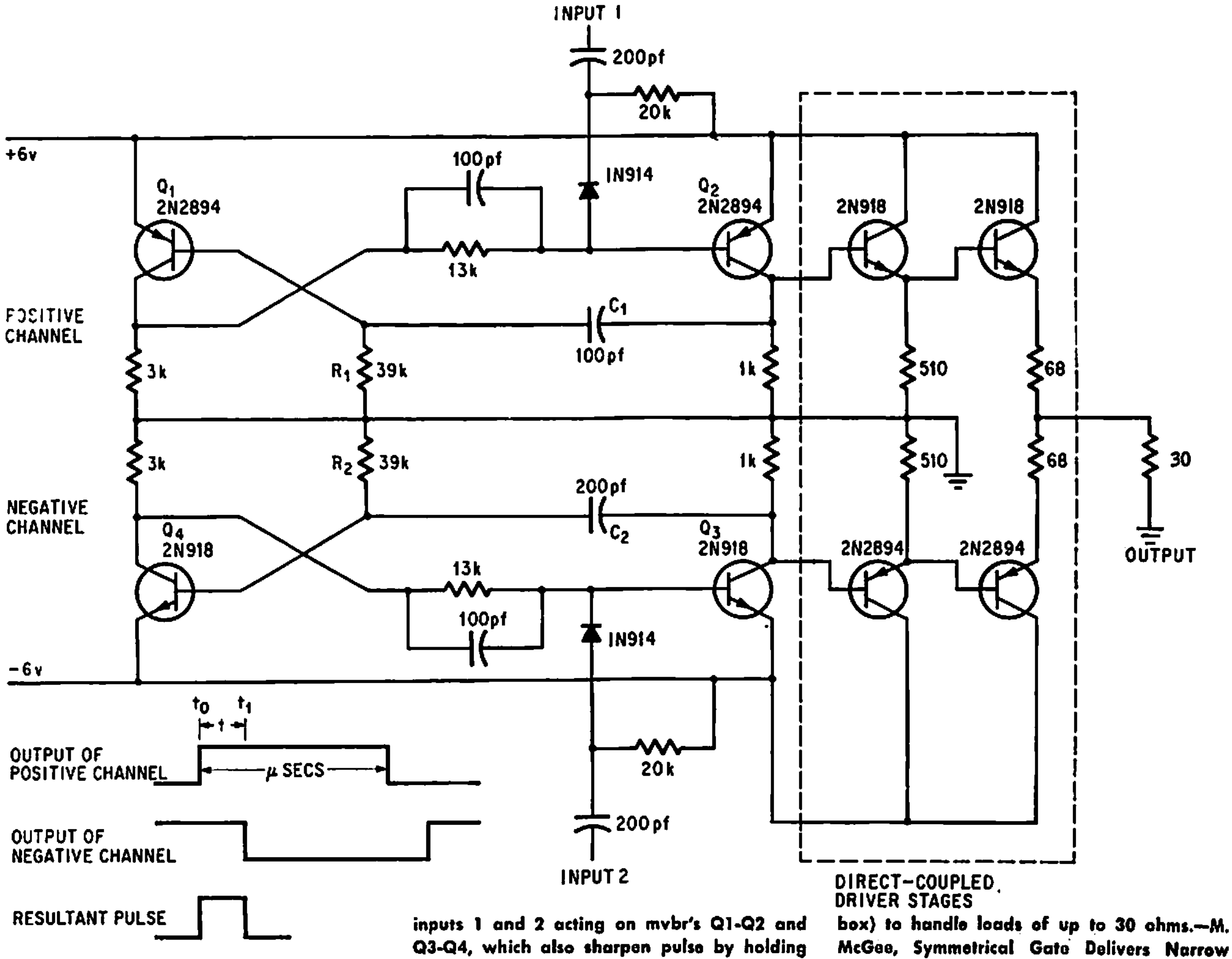
BLOCKING OSCILLATOR AND GATE—Produces standard output pulse only when input signals are applied simultaneously to both transistors. Gate at input 1 must be wider than 0.8-µs output pulse, in order to keep Q1 conducting until output pulse is terminated. Diode prevents trigger feedback from input 2 into transformer.—A. W. Zinn, Blocking Oscillator-And Gate Produces Standard Output Pulse, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 77.


+Vcc (4-5V)
Rb
4.7K
4.7K
ZS140
ZS140
OUTPUT
10mA Max.
ZS140
ZS120
ZS120
ZTX300 (BCW10)
47K
0

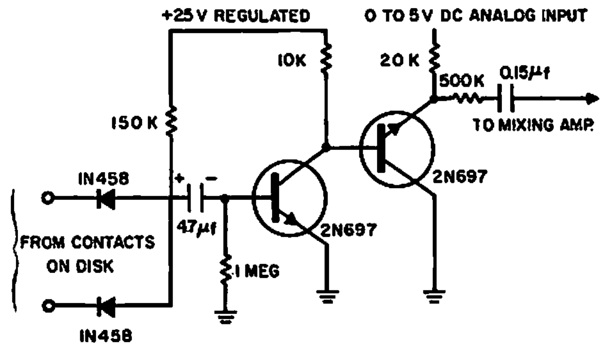
DTL NOR—Provides fan-out of 11 for low-voltage low-power noncritical diode-transistor logic applications.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 8.


AC SIGNAL INPUT
+12V
10K
1.2K
OUTPUT
5.6K
Q2 2N1309
DC INPUT
15K
Q1 2N1308
22K
220
150
-12V
(a)
AC SIGNAL
INPUT
-12
OUTPUT

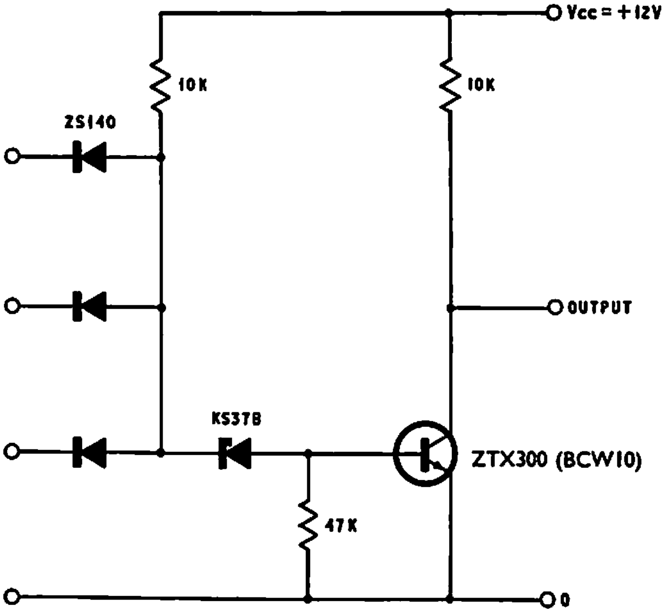
GATING A-C WITH D-C—Simple transistor arrangement achieves positive gating of 2-V rms a-c signal by 12-V d-c input. Blocked signal output is 46 dB down.—T. A. Radomski, Transistorized Switch Provides A-C Signal Gate, *Electronic Design*, Jan. 18, 1965, p 49–50.


INPUT 1
200pf
20k
+6v
100pf
IN914
Q1 2N2894
Q2 2N2894
2N918
2N918
13k
POSITIVE CHANNEL
C1 100pf
3k
R1 39k
1k
510
68
3k
R2 39k
1k
510
68
30
OUTPUT
200pf
C2
NEGATIVE CHANNEL
Q4 2N918
Q3 2N918
2N2894
2N2894
13k
100pf
IN914
-6v
t0 t1
t
OUTPUT OF POSITIVE CHANNEL
μ SECS
20k
OUTPUT OF NEGATIVE CHANNEL
200pf
INPUT 2
DIRECT-COUPLED DRIVER STAGES
RESULTANT PULSE

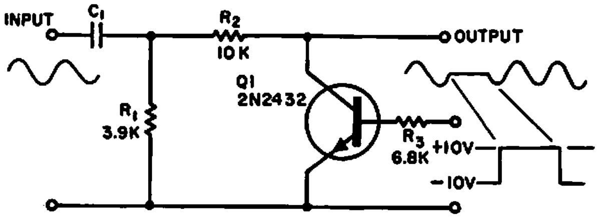
PULSE-SHARPENING GATE—Width of output pulse is determined by time interval between inputs 1 and 2 acting on mvbr's Q1-Q2 and Q3-Q4, which also sharpen pulse by holding rise and fall times to less than 5 ns. Two d-c amplifiers are used as drivers (dashed box) to handle loads of up to 30 ohms.—M. McGee, Symmetrical Gate Delivers Narrow Pulses to Fan-Out, *Electronics*, Dec. 11, 1967, p 99.


+25 V REGULATED
0 TO 5 V DC ANALOG INPUT
10K
20 K
500K
0.15μf
TO MIXING AMP.
150 K
1N458
+
-
47μf
2N697
2N697
FROM CONTACTS ON DISK
1 MEG
1N458

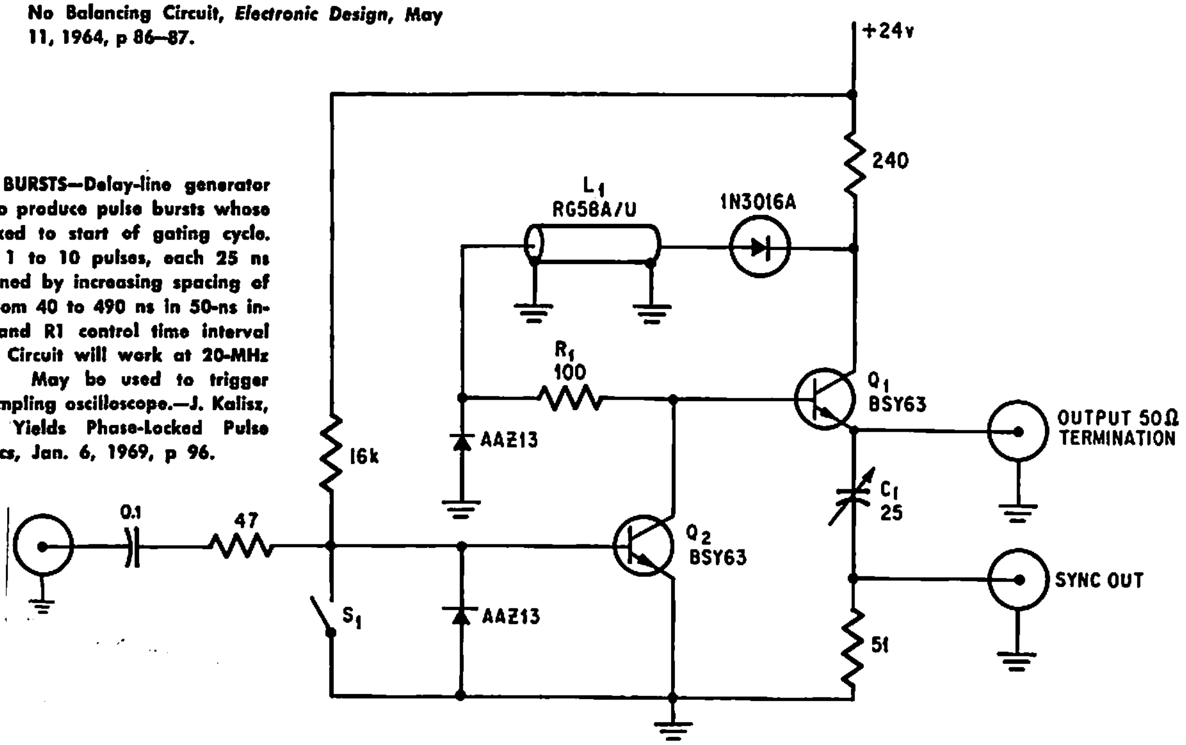
POSITIVE-ONLY GATE—Responds only to peaks above zero voltage level, to prevent frequency-doubling of signals picked off multiphase generating disk. Used with electronic commutator disk having 32 contacts around edge to provide gating for 32 channels.—J. P. Spacer, Jr., Pick Off Multiphase Signals From a Disk, *Electronic Design*, July 19, 1965, p 20–23.


Vcc = +12V
10K
10K
ZS140
OUTPUT
KS37B
ZTX300 (BCW10)
47K
0

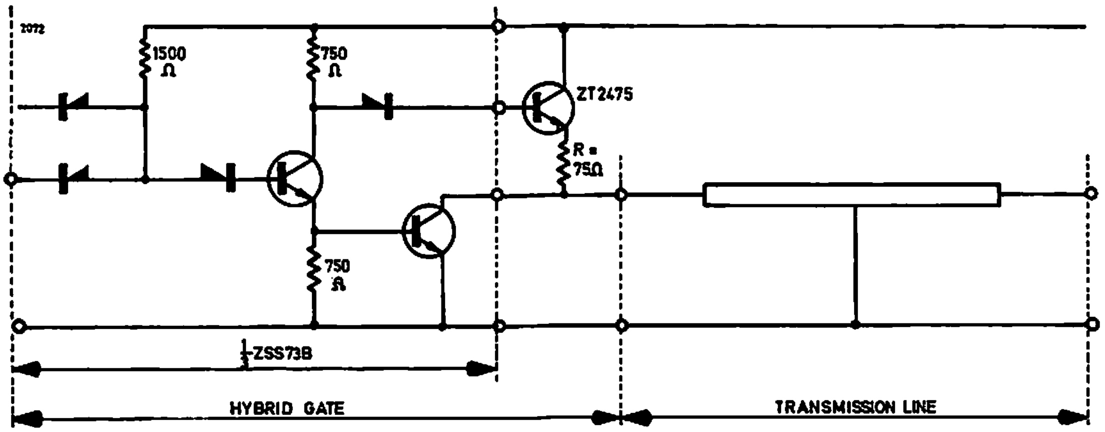
HIGH NOISE IMMUNITY—Provides d-c noise immunity of 4 V minimum, for applications having switching transients in a-c line and stray magnetic or electric fields. Intended for low-speed systems. Maximum fan-out is 10.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 10.


INPUT
C1
R2
10K
OUTPUT
R1
3.9K
Q1
2N2432
R3
6.8K
+10V
-10V

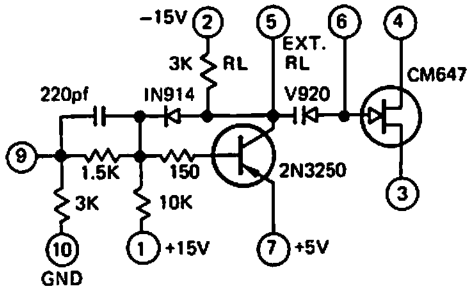
VIDEO CONTROL GATE—When base of transistor is made negative by square-wave control signal, gate passes both positive-going and negative-going video signals. When base is made positive, gate is closed. Attenuation of 20-kHz signal then exceeds 45 dB.—R. Vokoun, Bipolar Video Gate Needs No Balancing Circuit, *Electronic Design*, May 11, 1964, p 86–87.


+24v
240
L1
RG58A/U
1N3016A
R1
100
Q1
BSY63
AAZ13
OUTPUT 50Ω TERMINATION
16k
C1
25
0.1
47
Q2
BSY63
SYNC OUT
S1
AAZ13
51

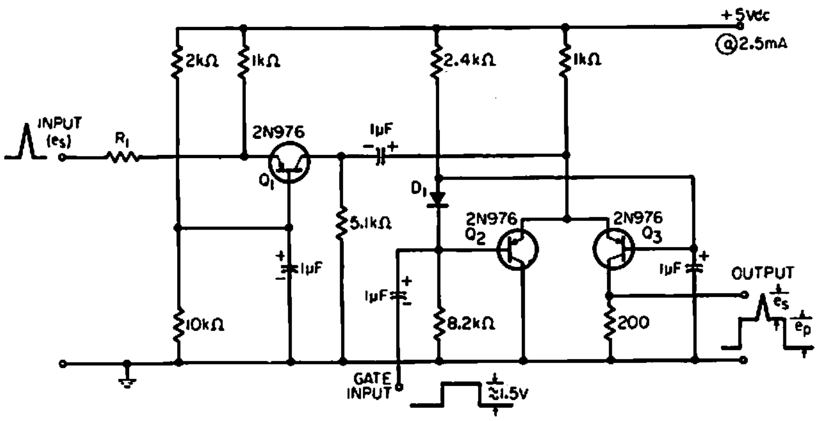
PHASE-LOCKED BURSTS—Delay-line generator circuit is used to produce pulse bursts whose phases are locked to start of gating cycle. Bursts of from 1 to 10 pulses, each 25 ns wide, are obtained by increasing spacing of gating pulses from 40 to 490 ns in 50-ns increments. Q2 and R1 control time interval of oscillations. Circuit will work at 20-MHz repetition rate. May be used to trigger time base of sampling oscilloscope.—J. Kalisz, Simple Gating Yields Phase-Locked Pulse Bursts, *Electronics*, Jan. 6, 1969, p 96.


1500 Ω
750 Ω
750 Ω
ZT2475
R = 75Ω
ZSS73B
HYBRID GATE
TRANSMISSION LINE

TRANSMISSION-LINE DRIVE—Uses third of Ferranti ZSS73B hybrid gate with single external transistor and one resistor to drive 150-ohm transmission line.—The Micronor II Range of Silicon Integrated Circuits, Ferranti Ltd., Oldham, Lancs., England, 1967, p 64.

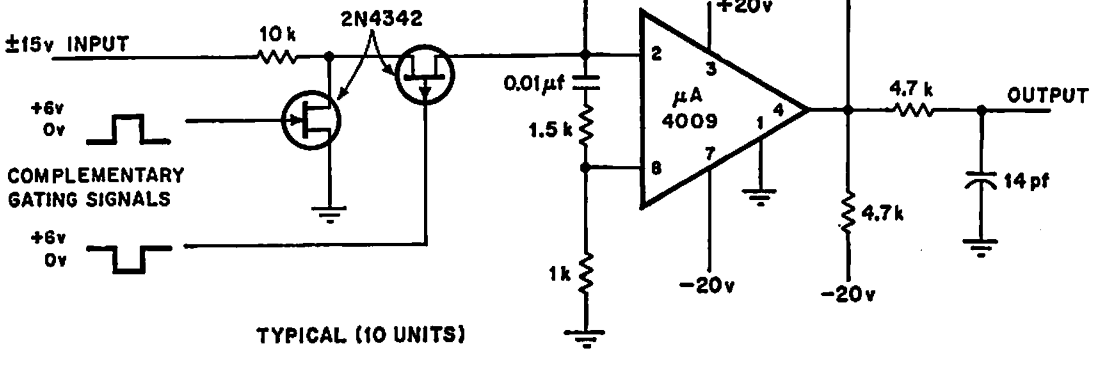

−15V
2
5
6
4
3K
RL
EXT. RL
CM647
220pf
IN914
V920
9
1.5K
150
2N3250
3
3K
10K
10
1
+15V
7
+5V
GND

HIGH-SPEED FET ANALOG GATE—Crystalonics CAG10 package provides spst action with switching speeds of 50 ns working directly from logic. Maximum ON resistance is about 50 ohms.—Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.

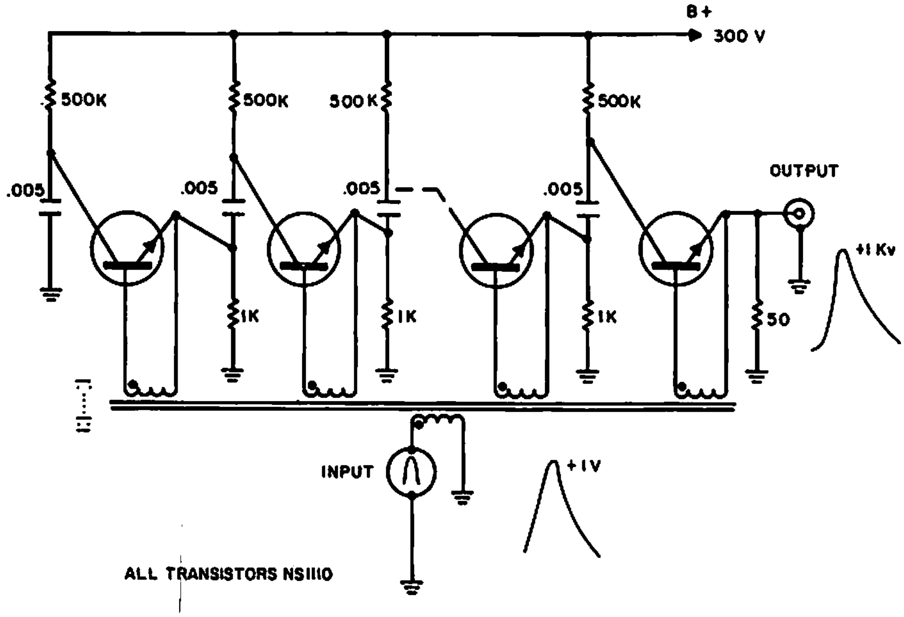

+5Vdc
@2.5mA
2kΩ
1kΩ
2.4kΩ
1kΩ
INPUT (es)
R1
2N976
Q1
1μF
5.1kΩ
D1
2N976
Q2
2N976
Q3
1μF
1μF
1μF
OUTPUT
es
ep
10kΩ
8.2kΩ
200
GATE INPUT
≈1.5V

FAST-PULSE TRANSMISSION GATE—Operates in current-switching mode to provide reliable isolation of signal input from output when gate is turned off. Positive pulse of about 1.5 V at gate input cuts off Q2, to turn on Q3 for transmitting input signal to output. Gate rejection is 100:1 for 1.5-ns pulses.—J. D. Nickell, High-Speed Pulse Transmission Gate, *EEE*, July 1967, p 130.

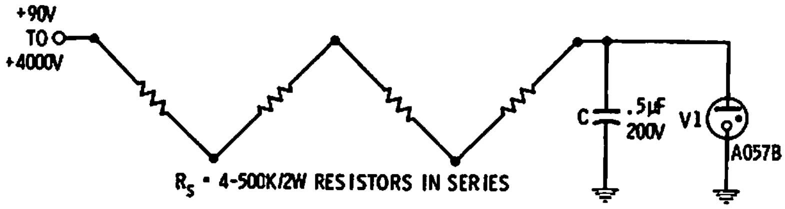
HIGH-VOLTAGE SWITCHING—Fet pair inserted at virtual ground input of opamp permits handling signal voltages limited only by maximum signal swing of opamp and its slew rate. Up to ten pairs of these fet switches may be stacked to give ten-input commutator for ten input signals. Will operate at switching rates up to 100 kHz.—F. J. Honey, DTL/TTL Controls Large Signals in Commutator, *Electronics*, March 16, 1970, p 90.


C
20 pf
10 k
+20v
±15v INPUT
10 k
2N4342
0.01μf
1.5 k
2
3
μA 4009
4
1
7
8
4.7 k
OUTPUT
+6v
0v
COMPLEMENTARY GATING SIGNALS
+6v
0v
14 pf
4.7k
1 k
−20v
−20v
TYPICAL (10 UNITS)

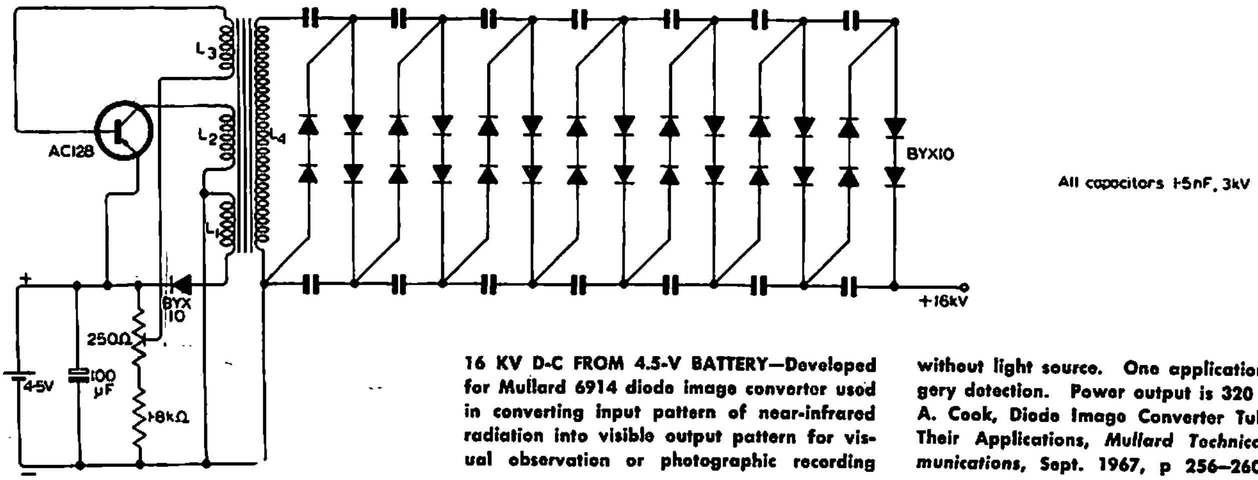
CHAPTER 37
High-Voltage Circuits


B+
300 V
500K
500K
500 K
500K
.005
.005
.005
.005
1K
1K
1K
50
OUTPUT
+1 Kv
INPUT
+1 V
ALL TRANSISTORS NS1110

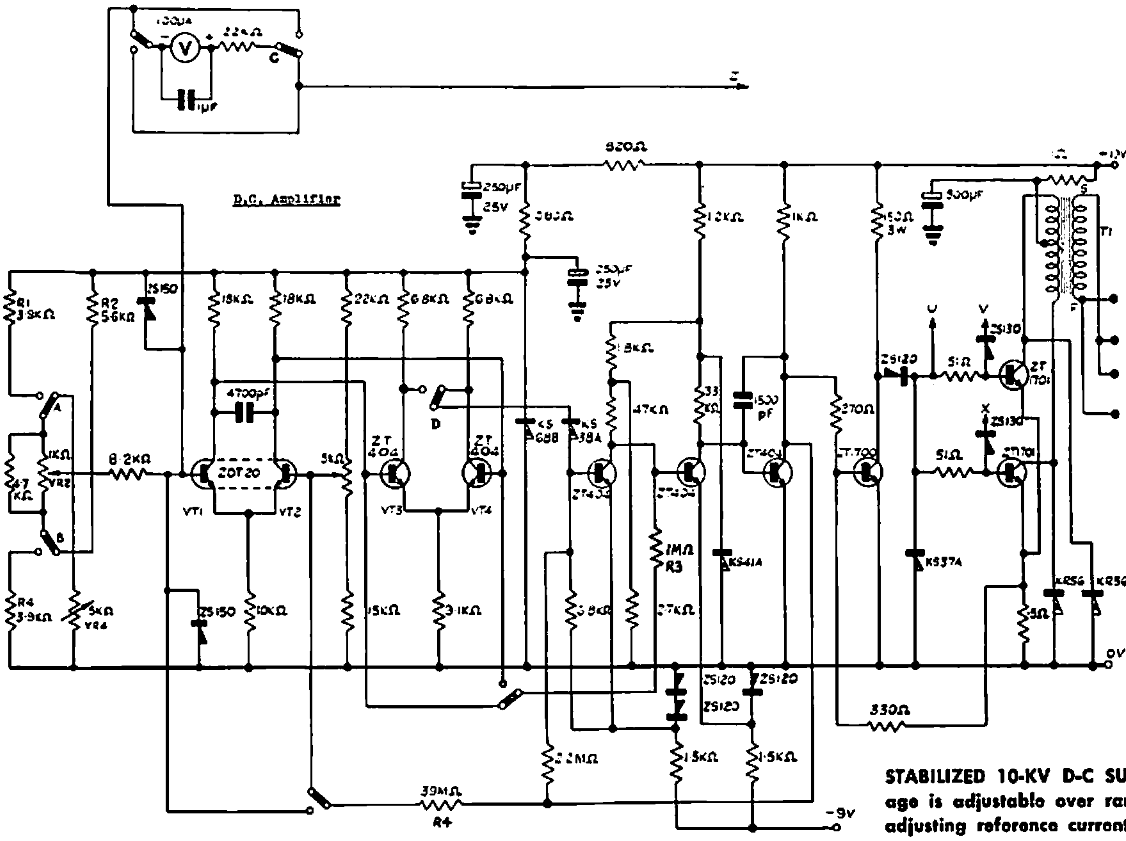
1,000-V PULSES—Combining of avalanche transistors as shown, for charging capacitors in parallel and discharging them into load in series, permits use of lower-voltage transistors for high-level pulse output stages. Load can be placed at either end of circuit, to give choice of polarity.—E. J. Snyder and A. Whetstone, Series-Parallel Connection Produces High-Level Pulses, *Electronic Design*, Dec. 6, 1965, p 52.


+90V
TO
+4000V
C
.5µF
200V
V1
A057B
R_S = 4-500K/2W RESISTORS IN SERIES

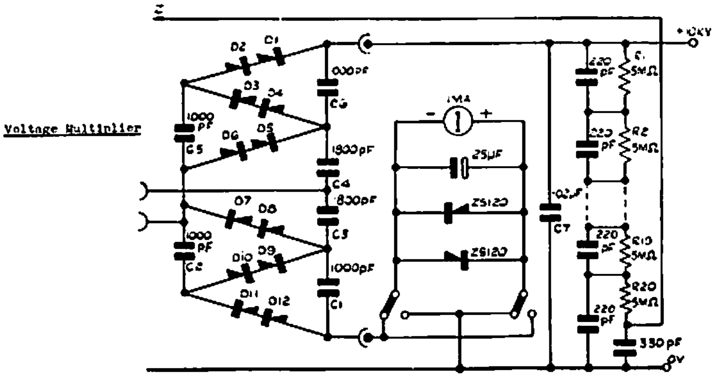
WIDE-RANGE INDICATOR—Neon gives visual indication of presence of voltages from 90 to 4,000 V. At about 500 V, circuit becomes relaxation oscillator and lamp will flash brightly.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 19.

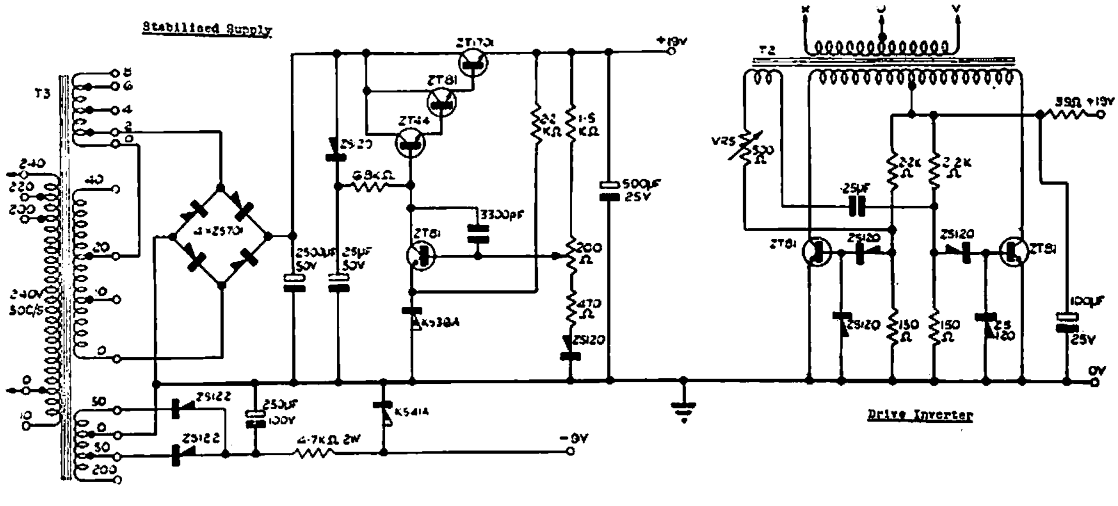

L_3
L_2
L_4
L_1
AC128
BYX10
All capacitors 1·5nF, 3kV
+
4·5V
100 µF
250Ω
1·8kΩ
BYX 10
+16kV

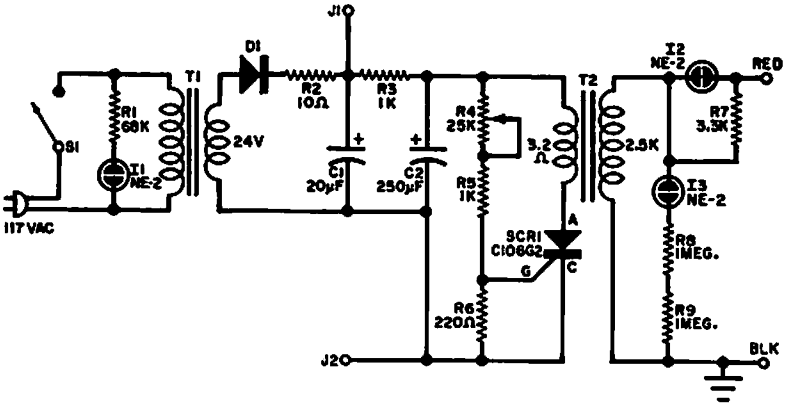
16 KV D-C FROM 4.5-V BATTERY—Developed for Mullard 6914 diode image convertor used in converting input pattern of near-infrared radiation into visible output pattern for visual observation or photographic recording without light source. One application is forgery detection. Power output is 320 µW.—K. A. Cook, Diode Image Converter Tubes and Their Applications, *Mullard Technical Communications*, Sept. 1967, p 256–260.


D.C. Amplifier
100µA
22kΩ
1µF
C
820Ω
250µF 25V
+19V
S
T1
F
R1 3·9kΩ
R2 56kΩ
ZS150
18kΩ
18kΩ
22kΩ
6·8kΩ
6·8kΩ
A
B
4·7kΩ
1kΩ VR2
8·2kΩ
4700pF
2OT20
VT1
VT2
VT3
VT4
ZT404
ZT404
D
KS68B
KS38A
ZT404
ZT404
47kΩ
1MΩ R3
1·8kΩ
1kΩ
12kΩ
1kΩ
1500pF
270Ω
ZT700
ZT701
ZT701
ZS120
ZS130
ZS130
51Ω
51Ω
U
V
X
KS41A
KS37A
KR56
KR56
5Ω
R4 3·9kΩ
5kΩ VR4
ZS150
10kΩ
15kΩ
3·1kΩ
5·6kΩ
27kΩ
0V
ZS120
ZS120
330Ω
2·2MΩ
1·5kΩ
1·5kΩ
39MΩ R4
-9V

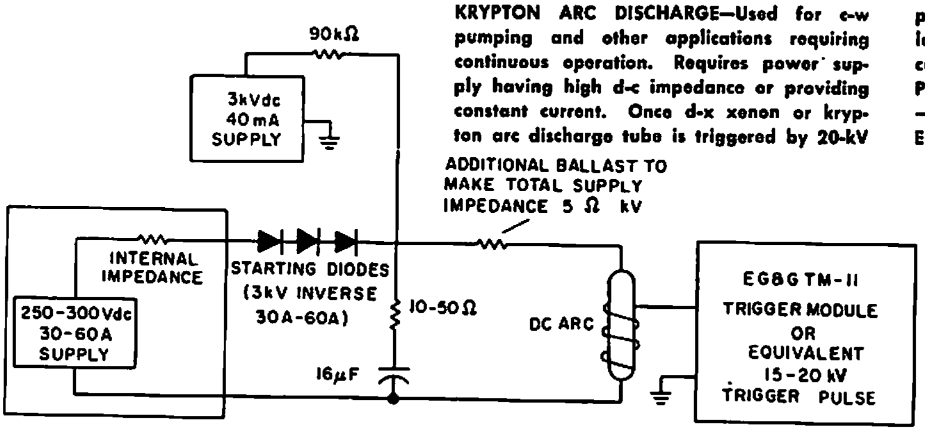
STABILIZED 10-KV D-C SUPPLY—Output voltage is adjustable over range of 5-10 kV by adjusting reference current at input stage of d-c amplifier. Maximum load current is 1 mA d-c. Voltage regulation is 5 V, or 0.05% at 10 kV. 9-V stabilized negative supply and 19-V positive regulated supply operate from a-c line and furnish operating voltages for drive inverter, output inverter, and d-c amplifier. Voltage multiplier steps up output of inverter to required 10 kV, and feeds back portion of output through attenuator to d-c amplifier that acts on input inverter to provide regulation. Report describes operation in detail, and gives both design and construction data.—10kV Stabilised E.H.T. Supply Using Silicon Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 24, 1964.


Voltage Multiplier
+10kV
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12
C1 C2 C3 C4 C5 C6 C7
1000pF
1000pF
1000pF
1MA
25µF
ZS120
ZS120
·02µF
220pF
5MΩ
R2 5MΩ
R19 5MΩ
R20 5MΩ
330pF
0V


Stabilised Supply
T3
240
220
200
240V 50C/S
4×ZS70I
2500µF 50V
25µF 50V
ZT701
ZT81
ZT44
ZS120
6·8kΩ
3300pF
ZT81
KS38A
22kΩ
1·5kΩ
200Ω
470Ω
ZS120
500µF 25V
+19V
ZS122
ZS122
250µF 100V
4·7kΩ 2W
KS41A
-9V
T2
X U V
VR5 500Ω
22k
2·2k
25µF
ZT81
ZS120
ZS120
ZT81
ZS120
150Ω
150Ω
ZS120
39Ω +19V
100µF 25V
0V
Drive Inverter

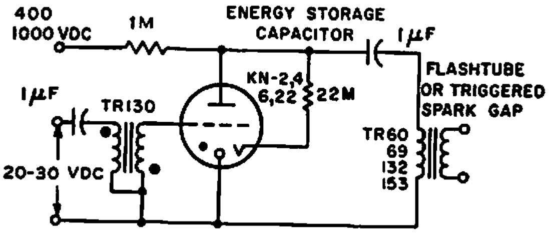

J1
D1
R2
10Ω
R3
1K
T1
R1
68K
S1
I1
NE-2
24V
C1
20μF
C2
250μF
R4
25K
R5
1K
3.2
Ω
T2
2.5K
I2
NE-2
RED
R7
3.3K
I3
NE-2
SCR1
C106G2
A
G
C
R6
220Ω
R8
1MEG.
R9
1MEG.
117VAC
J2
BLK

FENCE CHARGER—Solid-state circuit operates either from 45-V battery or a-c line. In addition to conventional charging of single-wire fence enclosing horse or cow pasture, may be used to keep dogs out of metal garbage can insulated from ground by dry wood or plastic. Delivers disturbing but harmless electrical sting to any person or animal touching charged metal, and should therefore be turned off on garbage collection day. If soil is very dry, moisture may be required for good ground contact.—L. E. Greenlee, Electric Fence, "Electronic Experimenter's Handbook," Ziff-Davis, N.Y., 1969 Spring Edition, p 15–18.

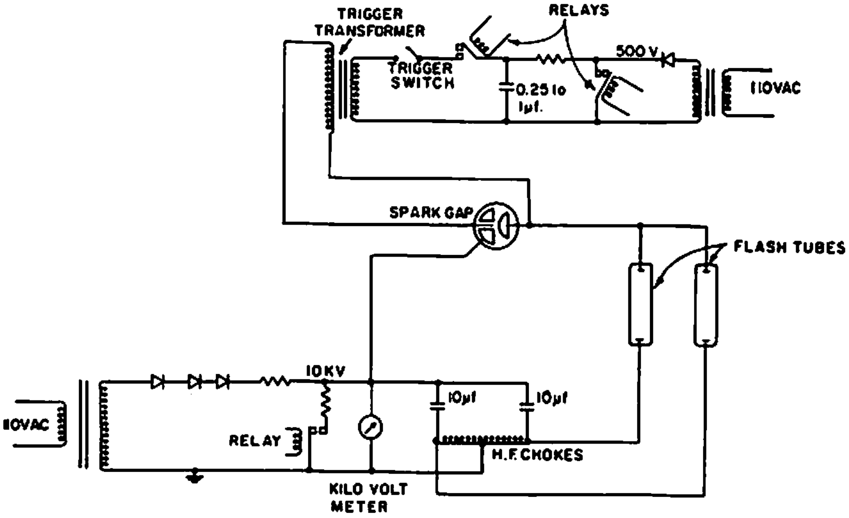

90kΩ
3kVdc
40mA
SUPPLY
ADDITIONAL BALLAST TO
MAKE TOTAL SUPPLY
IMPEDANCE 5 Ω kV
INTERNAL
IMPEDANCE
250-300Vdc
30-60A
SUPPLY
STARTING DIODES
(3kV INVERSE
30A-60A)
10-50Ω
16μF
DC ARC
EG&G TM-11
TRIGGER MODULE
OR
EQUIVALENT
15-20 kV
TRIGGER PULSE

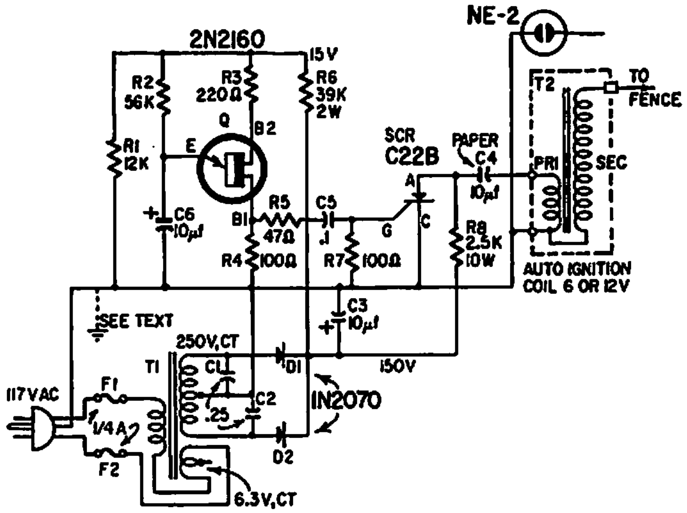
KRYPTON ARC DISCHARGE—Used for c-w pumping and other applications requiring continuous operation. Requires power supply having high d-c impedance or providing constant current. Once d-x xenon or krypton arc discharge tube is triggered by 20-kV pulse, high voltage across arc lamp drops below 200 V d-c so diodes in main supply circuit conduct and operate lamp continuously. Provides both infrared and ultraviolet output. —DC Xenon and Krypton Arc Discharge Tubes, EG&G, Boston, Mass., No. 1008, 1968.

KRYTRON-TRIGGERED SPARK GAP—Four-element cold-cathode gas-filled switch tube produces high peak current for short duration through trigger transformer, for developing 20 to 30 kV pulse for triggering spark gap or xenon flashtube.—Krytrons—Cold Cathode Switch Tubes, EG&G, Boston, Mass., KR-100, 1968.

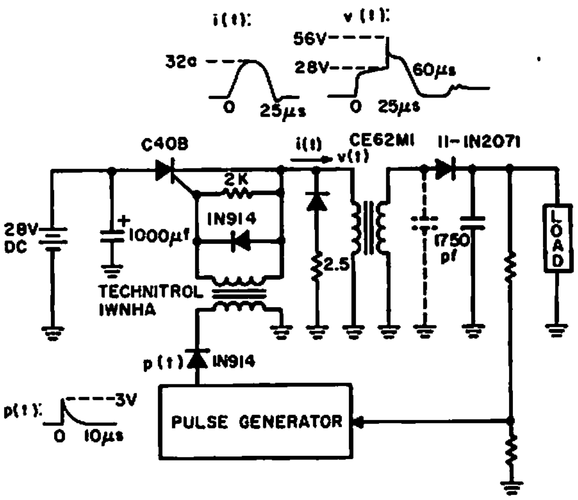

400
1000 VDC
1M
ENERGY STORAGE
CAPACITOR
1μF
KN-2,4
6,22
22M
FLASHTUBE
OR TRIGGERED
SPARK GAP
1μF
TR130
20-30 VDC
TR60
69
132
153

SPARK-GAP SWITCH—High-voltage trigger transformer turns on spark gap with 5 to 25 kV pulse when capacitor discharges through primary. When gap is triggered, full 10 kV of main storage capacitors is applied to two flashtubes, making them fire. Storage capacitors then begin charging automatically for next flash. Protective relays short storage and trigger capacitors through appropriate resistors when power is off, while relay in primary of trigger transformer prevents accidental firing of lamps. Used in studying excited-state processes in organic molecules. —D. N. Bailey and D. M. Hercules, Flash Photolysis—A Technique for Studying Fast Reactions, *Journal of Chemical Education*, Feb. 1965.

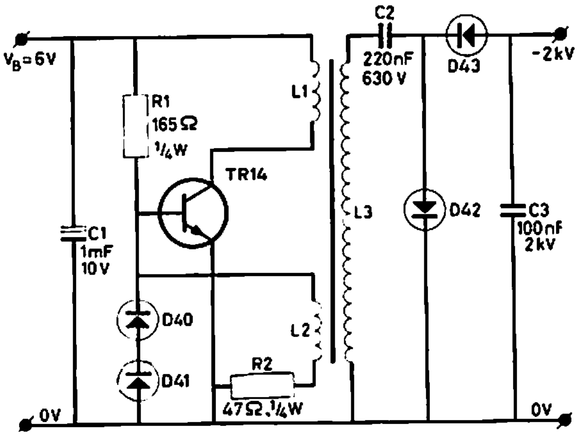

TRIGGER
TRANSFORMER
RELAYS
TRIGGER
SWITCH
0.25 to
1μf.
500 V
110VAC
SPARK GAP
FLASH TUBES
10KV
10μf
10μf
110VAC
RELAY
H.F. CHOKES
KILO VOLT
METER


NE-2
2N2160
15V
R2 56K
R3 220Ω
R6 39K 2W
Q
B2
E
R1 12K
C6 10µf
B1
R5 47Ω
R4 100Ω
C5 .1
R7 100Ω
SCR C22B
A
G
C
PAPER C4 10µf
R8 2.5K 10W
T2
PRI
SEC
TO FENCE
AUTO IGNITION COIL 6 OR 12V
SEE TEXT
C3 10µf
250V,CT
T1
C1
D1
150V
117VAC
F1
1/4A
F2
C2 .25
IN2070
D2
6.3V,CT

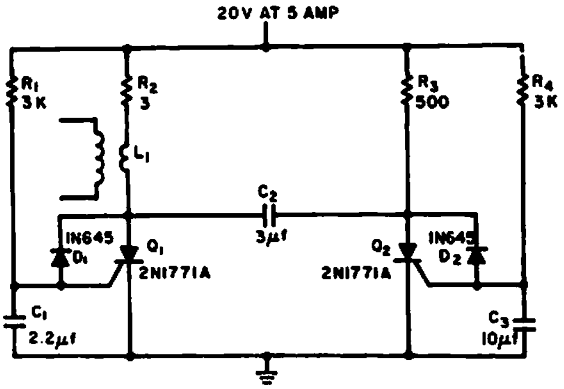
SCR ELECTRIC FENCE CHARGER—Generates 1-ms pulse once per second, with short-circuit current and total energy limited to safe value by characteristics of capacitor and automotive ignition coil used. Power transformer isolates a-c line from fence circuit. Will easily handle quarter-mile of fence. Power consumption is about 20 W. Grounding of line by sunflowers or other plants will not damage charger but will cause rfi and reduce strength of voltage pulses. Direct short will blow fuse in primary of transformer. Neon flashes once per second to indicate charger is working.—E. T. Hansen, SCR Electric Fence Charger, *Radio-Electronics*, July 1965, p 35–37.


i(t):
v(t):
32a
56V
28V
60µs
0 25µs
0 25µs
C40B
i(t)
CE62MI
v(t)
11-IN2071
2K
IN914
28V DC
1000µf
2.5
1750 pf
LOAD
TECHNITROL IWNHA
p(t)
IN914
p(t)
3V
0 10µs
PULSE GENERATOR

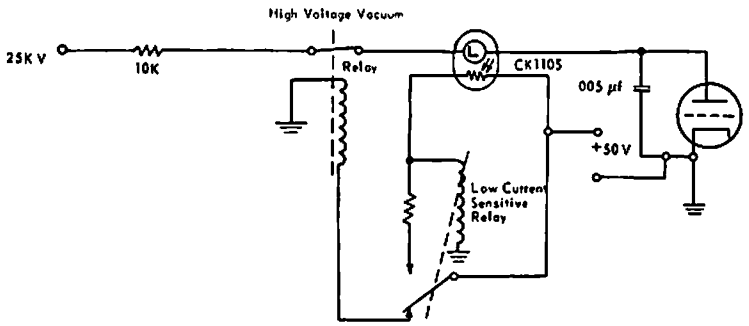
28 V TO 3,500 V—Only one scr is needed, because resonance of transformer primary forces scr to turn off. Pulse generator for triggering scr can be operated at up to 3 kHz. Load capacitor can be capacitance of pulse-forming network if load is thyratron for switching energy from network to 200-ohm load. With fixed resistive load, feedback from load to pulse generator for changing frequency can be used to regulate load voltage.—W. B. McCartney and E. O. Uhrig, Inverter Uses Only One Silicon-Controlled Rectifier, *Electronic Design*, Nov. 23, 1964, p 61–62.


V_B=6V
C2
220nF 630V
D43
-2kV
R1 165Ω 1/4W
L1
TR14
L3
D42
C3 100nF 2kV
C1 1mF 10V
D40
L2
D41
R2 47Ω,1/4W
0V
0V

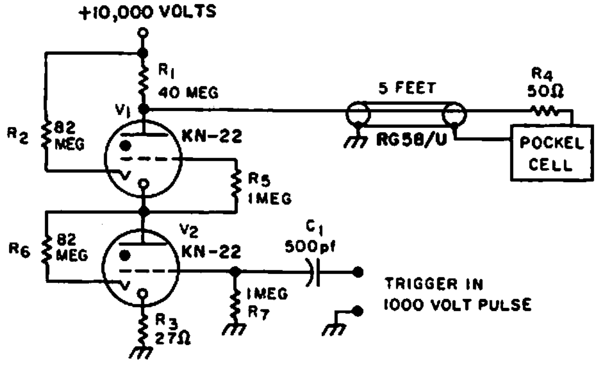
2-KV SUPPLY FOR CRT NUMERICAL DISPLAY—Uses d-c converter operating at 20 kHz with transistor BD121 to step up 6-V d-c supply to 2-kV accelerating voltage required by crt for figure-8 numerical character generator. Diodes D40 and D41 are BAY39 and other diodes are BY153.—A. P. Tanis, Numerical Display with Bar Matrix Character Generator, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966–1967, p 73–83.


20V AT 5 AMP
R_1 3K
R_2 3
R_3 500
R_4 3K
L_1
C_2 3µf
IN645 D_1
Q_1 2N1771A
Q_2 2N1771A
IN645 D_2
C_1 2.2µf
C_3 10µf

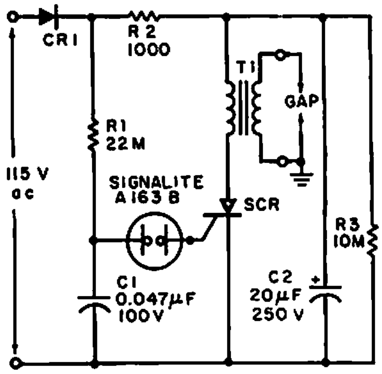
ARC-LAMP STARTER—Simple scr power supply boosts 20-V d-c input to 20 kV a-c for starting arc lamp having 2-cm gap. Inexpensive standard auto ignition coil, modified to give required 200:1 ratio, was used for L1. Duty cycle is less than 10%, permitting use of less expensive scr's than those shown.—D. Duffy, Low-Cost SCR Multivibrator Yields 20 Kv from 20-V Input, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 214.


High Voltage Vacuum
Relay
25KV
10K
CK1105
.005 µf
+50V
Low Current Sensitive Relay

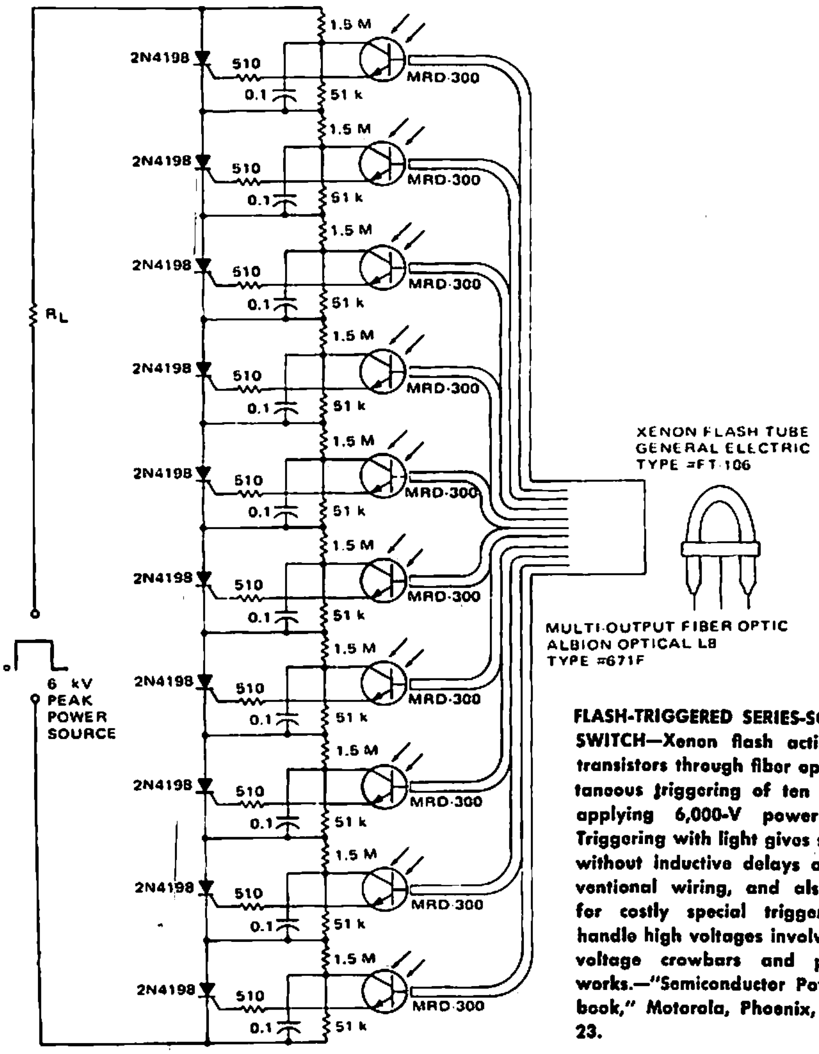
OPTOELECTRONIC OVERLOAD PROTECTION—Intermittent short-circuit in tube, or other overload that causes increase in average current through neon lamp of Raysistor, reduces resistance of its photocell, to energize low-current relay which in turn pulls in high-voltage vacuum relay to open circuit and prevent damage to components. Response time is rapid because current flows continuously through lamp circuit. For higher load current, change to CK1108 having filamentary lamp.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 15.


+10,000 VOLTS
R1
40 MEG
V1
R2
82 MEG
KN-22
5 FEET
RG58/U
R4
50Ω
POCKEL CELL
R5
1MEG
V2
R6
82 MEG
KN-22
C1
500pf
TRIGGER IN
1000 VOLT PULSE
1MEG
R7
R3
27Ω

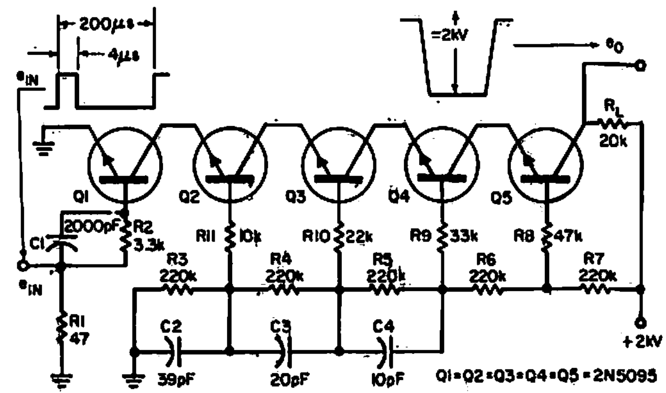
POCKEL CELL PULSER—Two EG&G Krytron gas-filled switch tubes generate up to 10-kV pulses at repetition rates from 50 to 750 pps for switching pockel cell crystals. Output coax serves as energy storage capacitor in series with R1, to permit locating pulser several feet away from cell.—Krytron Pockel Cell Pulser, EG&G, Boston, Mass., No. KN-22, 1968.


CR1
R2
1000
R1
22M
115 V
ac
T1
GAP
SIGNALITE
A163 B
SCR
R3
10M
C1
0.047µF
100V
C2
20µF
250 V

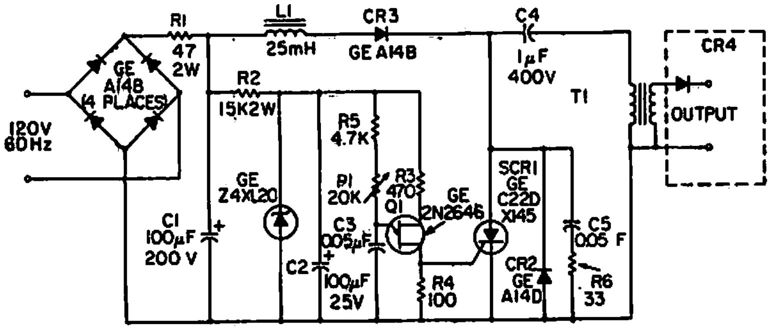
GAS IGNITION—Timing circuit, switching circuit, and high-voltage transformer, in unit called Electronic Match, produce 18,000-V spark at gap once per second, as substitute for pilot flame in gas appliances.—F. Egan, Whether It's Cold or Whether It's Hot . . . , *Electronic Design*, April 12, 1967, p 17–22.


2N4198
510
0.1
1.5 M
51 k
MRD-300
RL
6 kV
PEAK
POWER
SOURCE
XENON FLASH TUBE
GENERAL ELECTRIC
TYPE #FT-106
MULTI-OUTPUT FIBER OPTIC
ALBION OPTICAL LB
TYPE #671F

FLASH-TRIGGERED SERIES-SCR HIGH-VOLTAGE SWITCH—Xenon flash acting on ten phototransistors through fiber optics provides simultaneous triggering of ten scr's in series, for applying 6,000-V power pulse to load. Triggering with light gives simultaneous firing, without inductive delays occurring with conventional wiring, and also eliminates need for costly special trigger transformers to handle high voltages involved. Used in high-voltage crowbars and pulse-forming networks.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–23.

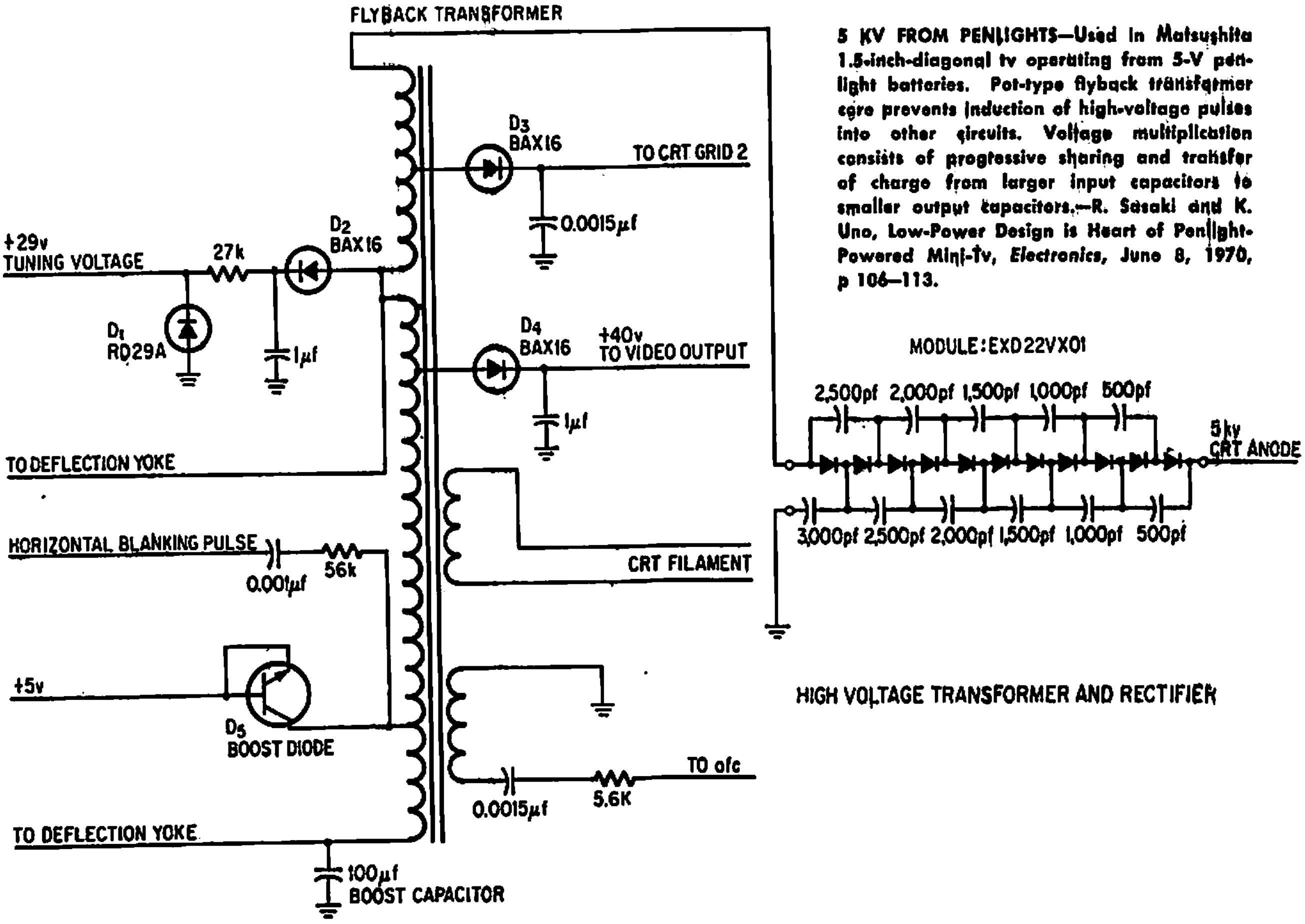

200μs
4μs
e_IN
=2kV
e_O
R_L
20k
Q1
Q2
Q3
Q4
Q5
C1
2000pF
R2
3.3k
R11 10k
R10 22k
R9 33k
R8 47k
R3
220k
R4
220k
R5
220k
R6
220k
R7
220k
R1
47
C2
39pF
C3
20pF
C4
10pF
+2kV
Q1=Q2=Q3=Q4=Q5=2N5095

2-KV PULSE-GENERATING SWITCH—When 5-V pulse is applied to input to turn on Q1, remaining four mesa transistors (connected in series and operating in avalanche mode) are turned on to serve as economical high-voltage switch for generating 2-kV negative-going output pulse.—S. A. Ritterman, A 2-KV 0.1-A Switch Uses Mesa Transistors, *Electronic Design*, Oct. 11, 1967, p 102.


R1
47
2W
L1
25mH
CR3
GE A14B
C4
1μF
400V
T1
CR4
OUTPUT
GE
A14B
(4 PLACES)
120V
60Hz
R2
15K2W
R5
4.7K
P1
20K
R3
470
Q1
GE
2N2646
SCR1
GE
C22D
X145
C5
0.05 F
GE
Z4XL20
C1
100μF
200 V
C3
.005μF
C2
100μF
25V
R4
100
CR2
GE
A14D
R6
33

HIGH VOLTAGE FOR NEON SIGNS—Cost, size, and weight are all much less than for conventional 60-Hz stepup transformer. Rectified 60-Hz line voltage is converted to 1,000 Hz with scr inverter, and ferrite-core transformer T1 then used to step voltage up to desired value at 1,000 Hz. If d-c output is required, selenium rectifier stack CR4 should be selected according to current and voltage requirements. For 7,500 V d-c and capacitive load up to 4 mA d-c in half-wave circuit, CR4 can be General Electric 6RS9PH25DPHB1. Can also be used for electrostatic precipitators and copying machines.—A. Adem, High Voltage Power Supply for Low Current Applications, General Electric, Syracuse, N.Y., No. 201.18, 1966.

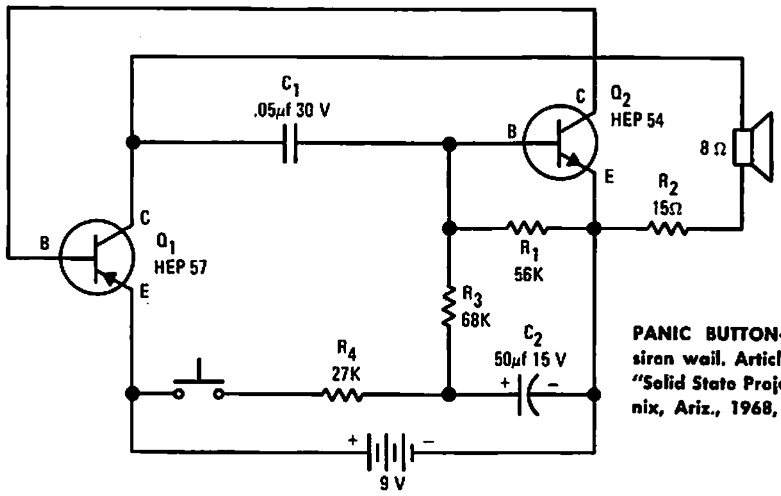
5 KV FROM PENLIGHTS—Used in Matsushita 1.5-inch-diagonal tv operating from 5-V penlight batteries. Pot-type flyback transformer core prevents induction of high-voltage pulses into other circuits. Voltage multiplication consists of progressive sharing and transfer of charge from larger input capacitors to smaller output capacitors.—R. Sasaki and K. Uno, Low-Power Design is Heart of Penlight-Powered Mini-Tv, *Electronics*, June 8, 1970, p 106–113.


FLYBACK TRANSFORMER
D3
BAX16
TO CRT GRID 2
0.0015μf
+29v
TUNING VOLTAGE
27k
D2
BAX16
D1
RD29A
1μf
D4
BAX16
+40v
TO VIDEO OUTPUT
1μf
MODULE: EXD22VX01
2,500pf 2,000pf 1,500pf 1,000pf 500pf
5kv
CRT ANODE
3,000pf 2,500pf 2,000pf 1,500pf 1,000pf 500pf
TO DEFLECTION YOKE
HORIZONTAL BLANKING PULSE
0.001μf
56k
CRT FILAMENT
+5v
D5
BOOST DIODE
TO afc
0.0015μf
5.6K
TO DEFLECTION YOKE
100μf
BOOST CAPACITOR

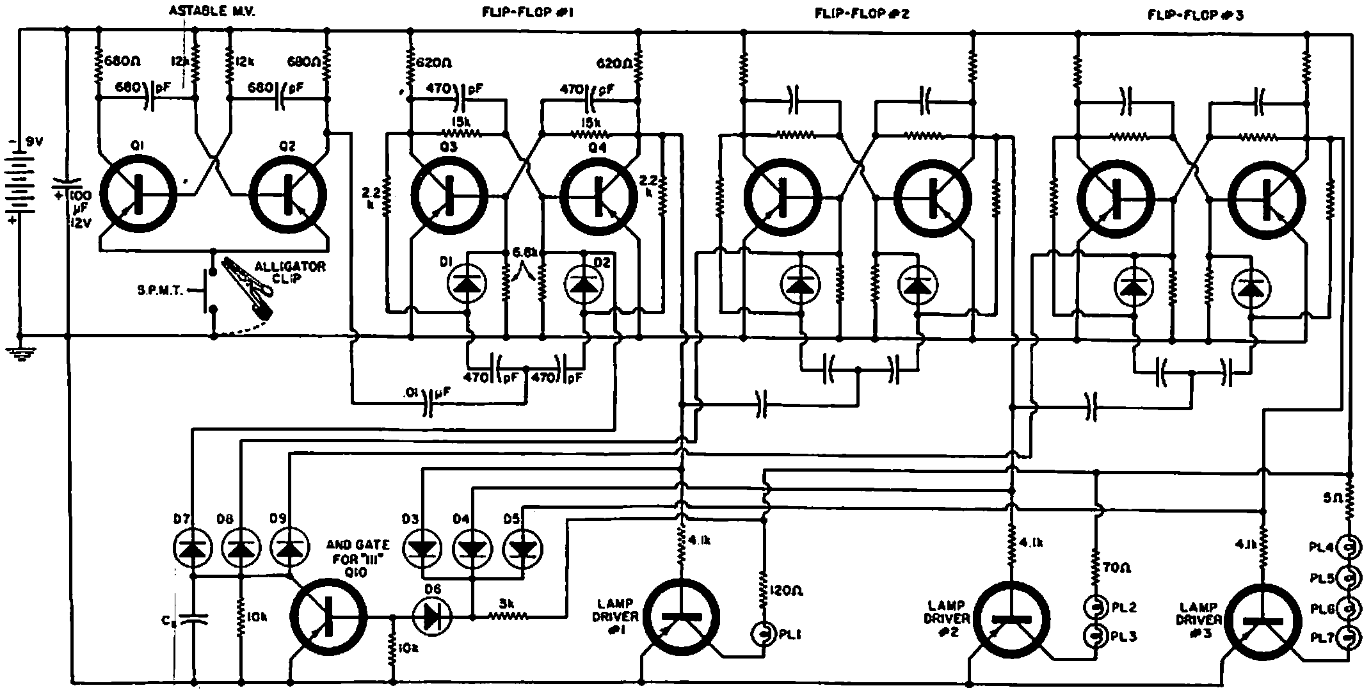
HIGH VOLTAGE TRANSFORMER AND RECTIFIER

CHAPTER 38

Hobby Circuits

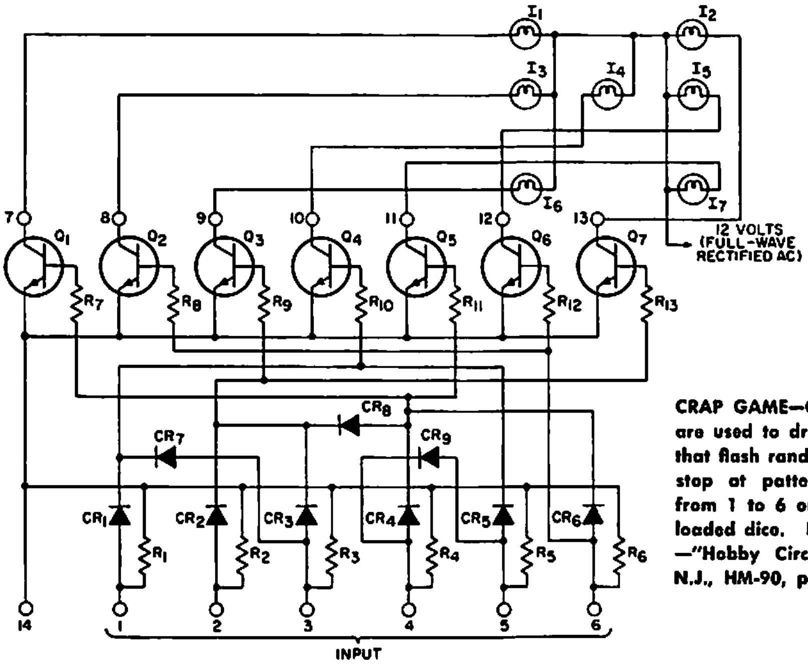

C1
.05μf 30 V
C
B
Q2
HEP 54
E
8 Ω
R2
15Ω
R1
56K
B
C
Q1
HEP 57
E
R3
68K
C2
50μf 15 V
R4
27K
+
−
+
−
9 V

PANIC BUTTON—Press button and get true siren wail. Article gives construction details.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 17–20.


ASTABLE M.V.
FLIP-FLOP #1
FLIP-FLOP #2
FLIP-FLOP #3
9V
680Ω
12k
12k
680Ω
680 pF
680 pF
Q1
Q2
100 μF 12V
S.P.M.T.
ALLIGATOR CLIP
620Ω
620Ω
470 pF
470 pF
15k
15k
Q3
Q4
2.2k
2.2k
6.8k
D1
D2
470 pF
470 pF
.01 μF
D7
D8
D9
AND GATE FOR "III" Q10
D3
D4
D5
D6
3k
C1
10k
10k
4.1k
120Ω
LAMP DRIVER #1
PL1
4.1k
70Ω
LAMP DRIVER #2
PL2
PL3
5Ω
4.1k
LAMP DRIVER #3
PL4
PL5
PL6
PL7

ALL TRANSISTORS - 2N404 ALL DIODES - IN34/A OR IN118 OR EQUIV. ALL PL'S - #48, 2V AT 60mA

CRAPS—Three-stage binary counter drives seven pilot lamps arranged like dots on dice. Counter is driven by free-running multivibrator (above 60 kHz) that is started and stopped by single-pole momentary-throw switch or by touching alligator clip to terminal. Breaking circuit makes counter stop at one of its six possible states, in true random fashion corresponding to rolling of hand-thrown dice in crap game. First and eighth states of counter are inhibited, to eliminate unwanted decimal numbers 0 and 7. For actual game, switch can be actuated twice to simulate rolling two dice, or two identical circuits can be built.—A. L. Plevy, Electronic Dice, *Electronics World*, Oct. 1968, p 82–84.


I1
I2
I3
I4
I5
I6
I7
7
8
9
10
11
12
13
Q1
Q2
Q3
Q4
Q5
Q6
Q7
12 VOLTS (FULL-WAVE RECTIFIED AC)
R7
R8
R9
R10
R11
R12
R13
CR8
CR7
CR9
CR1
CR2
CR3
CR4
CR5
CR6
R1
R2
R3
R4
R5
R6
14
1
2
3
4
5
6
INPUT

CRAP GAME—Gate and driver circuits shown are used to drive seven lamps at upper right that flash randomly for few seconds and then stop at pattern corresponding to numbers from 1 to 6 on dice. Eliminates problem of loaded dice. Book gives construction details. —"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 131.

CR_1 through CR_9 = silicon rectifier, type 1N270

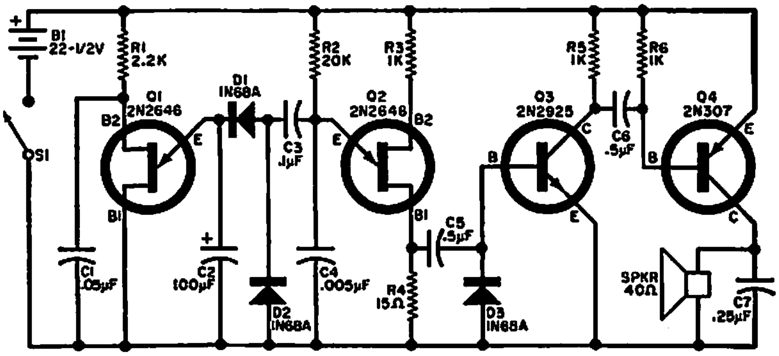
I_1 through I_7 = any 12-volt lamp drawing 150 milliamperes or less

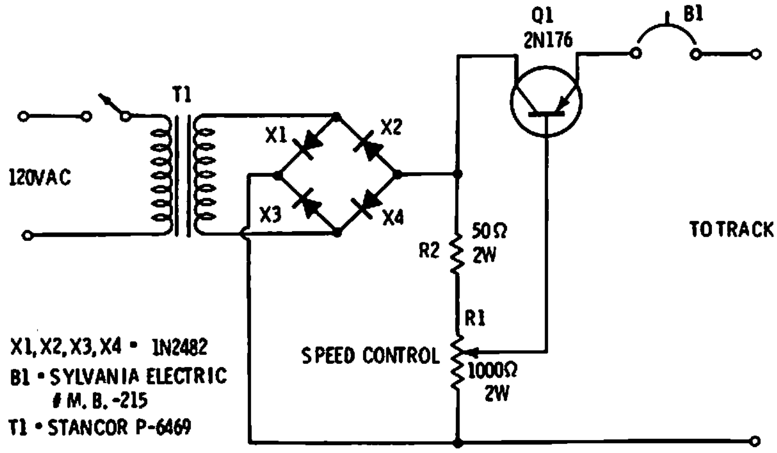
Q_1 through Q_7 = transistor, RCA SK3020

R_1 through R_6 = 1200 ohms, 1/2 watt, 10%

R_7 through R_{13} = 680 ohms, 1/2 watt, 10%

OBNOXIOUS NOISEMAKER—Q1-Q2 start with loud low-pitch wail that increases in frequency to very high shriek, then suddenly drops back to low tone and starts over again. Q3-Q4 provides sufficient amplification for speaker to disturb entire apartment building. May be used either to break lease or collect hospitalization for broken nose.—S. Breskend, "The Lease-Breaker" and "The Drip," *Popular Electronics*, Feb. 1968, p 33–35.

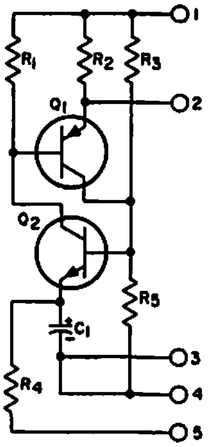

+
B1 22-1/2V
S1
R1 2.2K
Q1 2N2646
B2
E
B1
C1 .05µF
D1 1N68A
C2 100µF
D2 1N68A
C3 .1µF
R2 20K
C4 .005µF
R3 1K
Q2 2N2646
E
B2
B1
R4 15Ω
C5 .5µF
D3 1N68A
Q3 2N2925
B
C
E
R5 1K
C6 .5µF
R6 1K
Q4 2N307
B
E
C
SPKR 40Ω
C7 .25µF


Q1
2N176
B1
T1
120VAC
X1
X2
X3
X4
TO TRACK
R2
50Ω
2W
R1
SPEED CONTROL
1000Ω
2W

X1, X2, X3, X4 • 1N2482
B1 • SYLVANIA ELECTRIC # M. B. -215
T1 • STANCOR P-6469

MODEL TRAIN CONTROL—Provides smoother control of speed than conventional wire-wound rheostat. D-c output of about 25 V is applied to tracks through miniature self-resetting circuit breaker B1.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Inc., Indianapolis, Ind., 1968, p 15.

RUNNING OSCILLATOR FOR SLOT MACHINE—Electronic slot machine uses three vertical columns of lights instead of spinning wheels. Oscillator circuit shown is used in two versions, as running oscillator producing pulses at rapid rate when power is applied, and for three stop oscillators each producing a pulse about once every 4 s but at different rates for as long as power is on. Book tells how to connect oscillators with flip-flops, NAND gates, shift registers, and lamps for completely random scoring action.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 121.



Running Oscillator (1 req'd)

C_1 = 2 microfarads, 15 volts, electrolytic

Q_1 = transistor, RCA SK3005

Q_2 = transistor, RCA SK3020

R_1 = 1500 ohms, 1/2 watt, 10%

R_2 = 47 ohms, 1/2 watt, 10%

R_3 = 1000 ohms, 1/2 watt, 10%

R_4 = 15,000 ohms, 1/2 watt, 10%

R_5 = 4700 ohms, 1/2 watt, 10%

Stop Oscillator (3 req'd)

C_1 = 100 microfarads, 15 volts, electrolytic

Q_1 = transistor, RCA SK3005

Q_2 = transistor, RCA SK3020

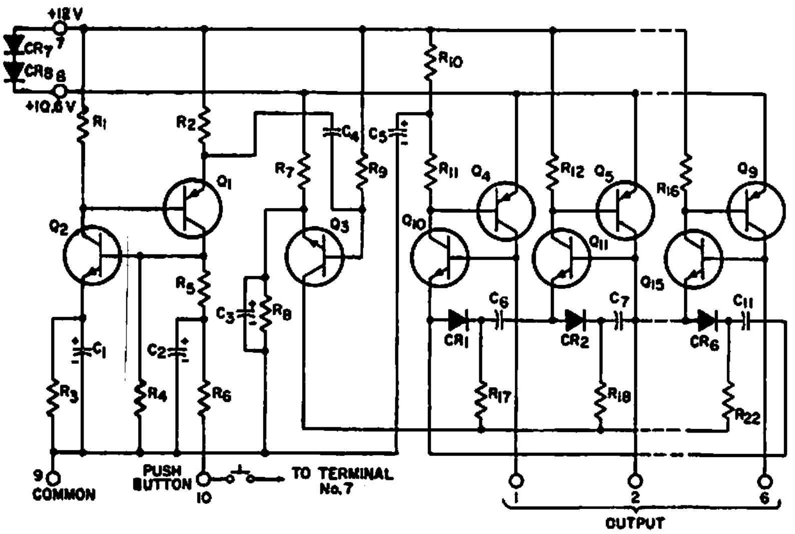
R_1 = 1000 ohms, 1/2 watt, 10%

R_2 = 68 ohms, 1/2 watt, 10%

R_3 = 1000 ohms, 1/2 watt, 10%

R_4 = 27,000 ohms, 33,000 ohms, 39,000 ohms, one in each of 3 oscillators

R_6 = 470 ohms, 1/2 watt, 10%



CRAP GAME—Digital pulser and six-stage shift register are used in circuit for actuating arrangement of seven lamps that flash randomly for few seconds and then stop at pattern corresponding to numbers from 1 to 6 on dice. Book gives construction details.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 132.

C_1 = 1 microfarad, 25 volts, electrolytic

C_2 = 500 microfarads, 25 volts, electrolytic

C_3 = 100 microfarads, 6 volts, electrolytic

C_4 C_6 through C_{11} = 0.05 microfarad, 25 volts or greater, ceramic

C_5 = 10 microfarads, 25 volts, electrolytic

CR_1 through CR_6 = silicon rectifier, type 1N270

CR_7 CR_8 = silicon rectifier, RCA SK3030

Q_1 Q_4 through Q_9 = transistors, RCA SK3005

Q_2 = transistor, RCA SK3020

Q_3 Q_{10} through Q_{15} = transistor, RCA SK3010

R_1 = 1500 ohms, 1/2 watt, 10%

R_2 R_8 = 47 ohms, 1/2 watt, 10%

R_3 = 27,000 ohms, 1/2 watt, 10%

R_4 R_7 R_{12} through R_{16} = 1000 ohms, 1/2 watt, 10%

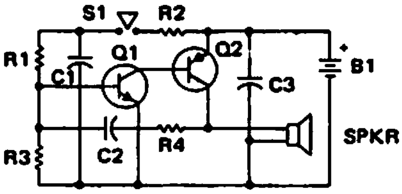
R_5 = 3300 ohms, 1/2 watt, 10%

R_6 = 15 ohms, 1/2 watt, 10%

R_9 = 5600 ohms, 1/2 watt, 10%

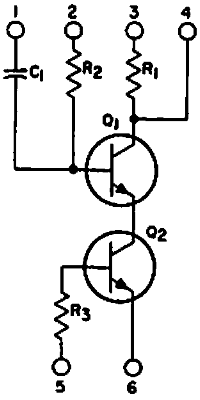
R_{10} R_{11} = 470 ohms, 1/2 watt, 10%

R_{17} through R_{22} = 270 ohms, 1/2 watt, 10%



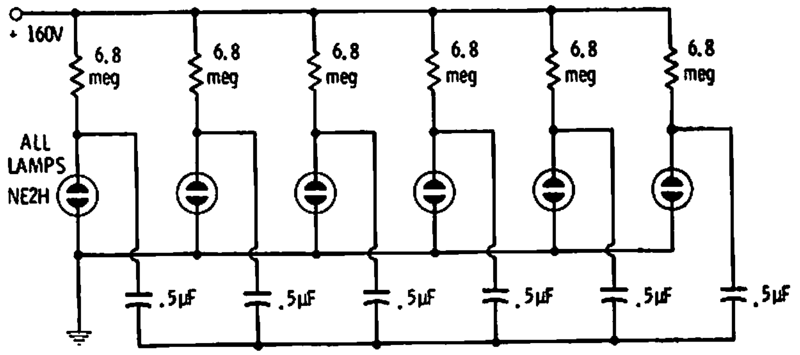
Q1	NPN Transistor
Q2	PNP Transistor
R1,R3	68,000 Ω Resistor ½ watt 10%
R2	22,000 Ω Resistor ½ watt 10%
R4	47 Ω Resistor ½ watt 10%
C1	50 μF 12V Electrolytic
C2	0.05 μF Disc. Ceramic
C3	100 μF 12V Electrolytic

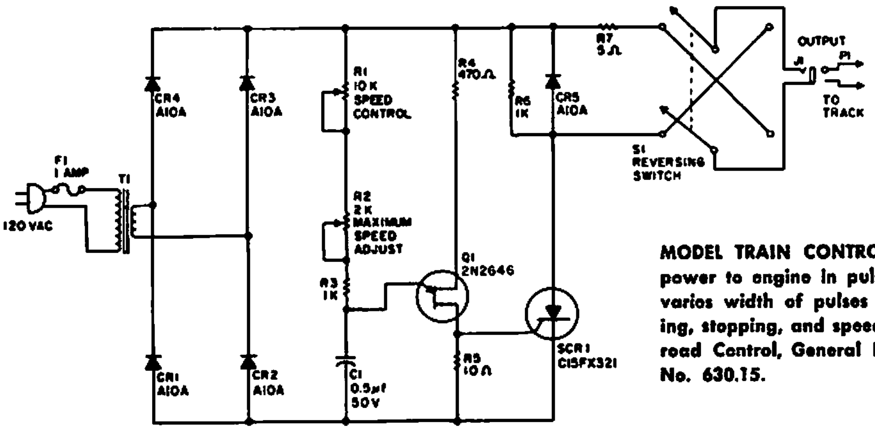
SIREN—Operates from 9-V transistor radio battery, driving speaker to produce piercing wail that rises and falls. Can be used as home or garage burglar alarm, auto theft alarm, or for enlivening dull party.—Calectro Handbook, GC Electronics, Rockford, Ill., FR-69-C, p 42.



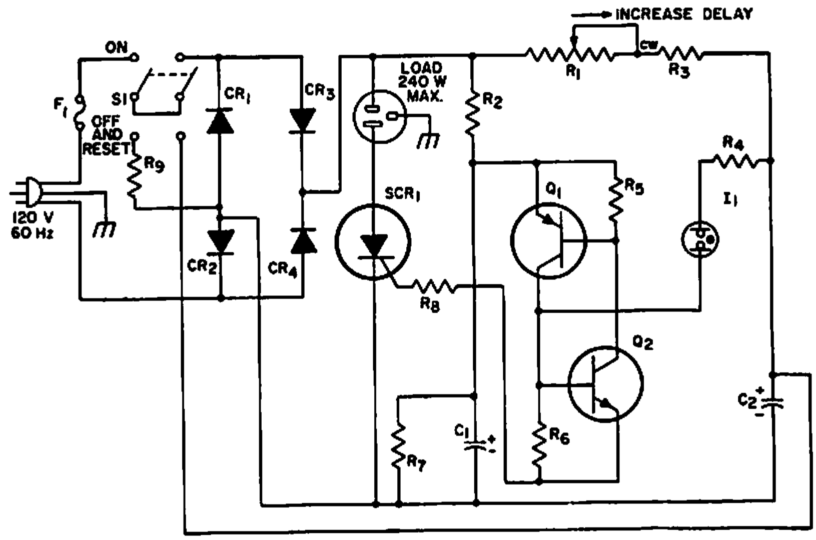
ELECTRONIC SLOT MACHINE—Circuit is one of three identical NAND gates used with other digital circuits to simulate random action of spinning-wheel slot machine, with three columns of lamps indicating score. Book gives construction data. Values: R1 1K; R2-R3 10K; C1 0.1 μF; Q1-Q2 SK3020.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 122.

RANDOM NEON—Flashing sequence is totally unpredictable.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 48.


+ 160V
6.8 meg
6.8 meg
6.8 meg
6.8 meg
6.8 meg
6.8 meg
ALL LAMPS NE2H
.5μF
.5μF
.5μF
.5μF
.5μF
.5μF


F1 1 AMP
T1
120 VAC
CR4 A10A
CR3 A10A
CR1 A10A
CR2 A10A
R1 10 K SPEED CONTROL
R2 2 K MAXIMUM SPEED ADJUST
R3 1K
C1 0.5μf 50V
R4 470Ω
Q1 2N2646
R5 10Ω
R6 1K
CR5 A10A
SCR1 C15FX321
R7 5Ω
S1 REVERSING SWITCH
OUTPUT
J1
P1
TO TRACK

MODEL TRAIN CONTROL—Uses scr to apply power to engine in pulses through rails. R1 varies width of pulses to give smooth starting, stopping, and speed control.—Model Railroad Control, General Electric, Auburn, N.Y., No. 630.15.

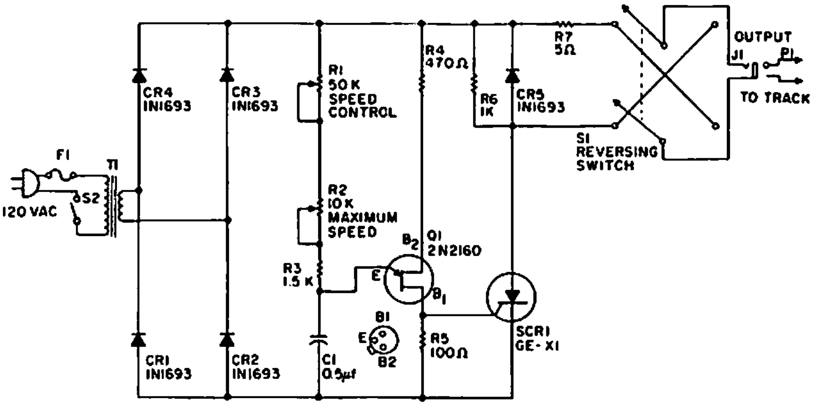

INCREASE DELAY
ON
OFF AND RESET
S1
F1
120 V 60 Hz
R9
CR1
CR2
CR3
CR4
LOAD 240 W MAX.
SCR1
R8
R1
R2
R3
R4
R5
R6
R7
CW
Q1
Q2
I1
C1
C2

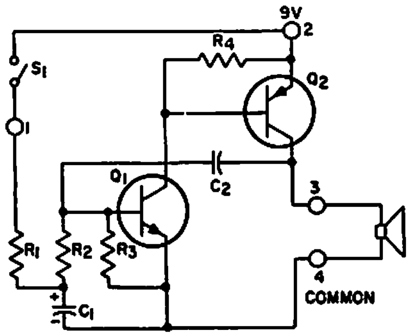
CHESS-PLAYER TIMER—Signals end of predetermined interval agreed upon as thinking time for chess or card players. May also be used to provide electronic delay that allows photographer to get into picture before camera clicks. With values shown for R1, R3, and C2, delay range is 5—120 s. Will handle loads up to 2 A or 240 W.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 162.

C_1 = 50 microfarads, 15 volts, electrolytic
C_2 = 50 microfarads, 150 volts, electrolytic
$CR_1CR_2CR_3CR_4$* = diode, RCA SK3016 mounted in fuse clip for heat sinking
F_1 = fuse, 125 volts, 3 amperes
I_1 = lamp, neon, NE-83 or equivalent
Q_1 = transistor, RCA SK3004
Q_2 = transistor, RCA SK3020
R_1 = potentiometer, 1 megohm, 2 watts, linear taper
R_2 = 3000 ohms, 5 watts, 10%
R_3 = 47,000 ohms, 1/2 watt, 10%
R_4 = 10,000 ohms, 1/2 watt, 10%
R_5 = 150 ohms, 1/2 watt, 10%
R_6 = 470 ohms, 1/2 watt, 10%
R_7 = 180 ohms, 1/2 watt, 10%
R_8 = 100 ohms, 1/2 watt, 10%
R_9 = 33 ohms, 1/2 watt, 10%
S_1 = switch, 125 volts, 3 amperes, double-pole, double-throw, toggle
SCR_1* = silicon controlled rectifier, RCA KD2100

*These components are available in SCR Silicon Controlled Rectifier Experimenter's Kit KD2105.

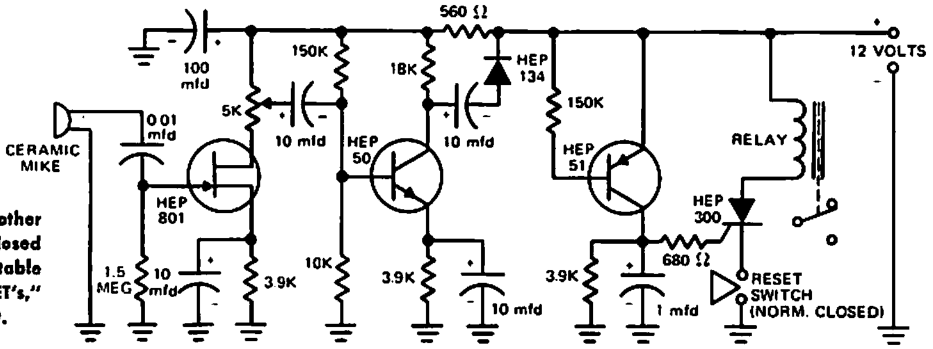
SCR CONTROL FOR MODEL TRAIN—Applies power to engine through rails in controllable-width pulses to give smooth starting and stopping along with reversing. Will handle up to 1.2 A continuously. Transformer is Stancor P-6469 having 25-V secondary.—Hobby Manual, General Electric Co., Owensboro, Ky., 1965, p 98.


F1
T1
S2
120 VAC
CR4 IN1693
CR3 IN1693
R1 50 K SPEED CONTROL
R2 10 K MAXIMUM SPEED
R3 1.5 K
R4 470Ω
R6 1K
CR5 IN1693
R7 5Ω
OUTPUT
J1
P1
TO TRACK
S1 REVERSING SWITCH
B2
Q1 2N2160
E
B1
B1
E
B2
R5 100Ω
SCR1 GE-X1
CR1 IN1693
CR2 IN1693
C1 0.5μf

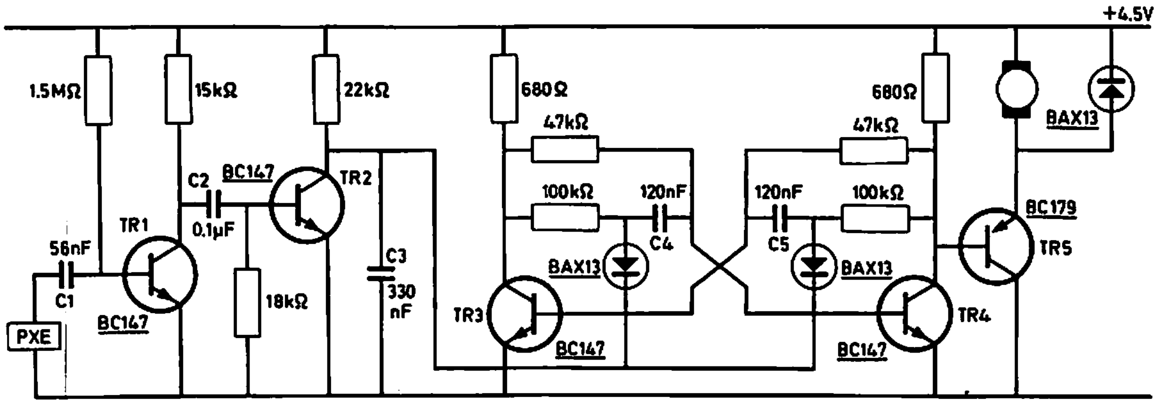

9V
2
R4
Q2
S1
1
Q1
C2
3
R1
R2
R3
4
COMMON
+
C1

C_1 = 50 microfarads, 12 volts, electrolytic
C_2 = 0.018 microfarad, 25 volts or greater
Q_1 = transistor, RCA SK3020
Q_2 = transistor, RCA SK3005
R_1 = 27,000 ohms, 1/2 watt, 10%
R_2 = 68,000 ohms, 1/2 watt, 10%
R_3 = 56,000 ohms, 1/2 watt, 10%
R_4 = 470 ohms, 1/2 watt, 10%
S_1 = switch, any single-pole push-button type
Speaker = 3.2-ohms or 8-ohms

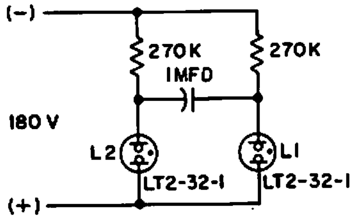
POLICE SIREN—Pressing S1 produces wailing sound that slowly increases in frequency. When switch is released, sound slowly decreases in frequency. Increasing value of R1 or C1 lengthens rate at which frequency of oscillation increases. Battery drain is only 400 μA with S1 open, so power switch is not normally necessary.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 117.


100 mfd
150K
560 Ω
18K
HEP 134
+
12 VOLTS
-
5K
10 mfd
.001 mfd
CERAMIC MIKE
HEP 50
10 mfd
150K
HEP 51
RELAY
HEP 801
HEP 300
1.5 MEG
10 mfd
3.9K
10K
3.9K
10 mfd
680 Ω
3.9K
1 mfd
RESET SWITCH (NORM. CLOSED)

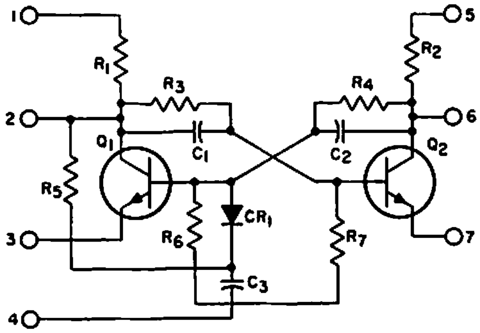
SOUND-ACTIVATED—Clap of hands or other sharp sound closes relay, which remains closed until manually reset. Sensitivity is adjustable with 5K potentiometer.—"Tips on Using FET's," Motorola, Phoenix, Ariz., HMA-33, 1969.


+4.5V
1.5MΩ
15kΩ
22kΩ
680Ω
47kΩ
680Ω
47kΩ
BAX13
C2
BC147
TR2
0.1μF
100kΩ
120nF
120nF
100kΩ
BC179
TR5
TR1
56nF
C1
C3
330 nF
18kΩ
C4
C5
BAX13
BAX13
TR3
TR4
BC147
BC147
BC147
PXE

WHISTLE CONTROL—PXE (piezoxide) ceramic material in detector serves for converting sound waves of ordinary whistle into audio signals for controlling motor-driven toy. If first whistle note makes TR4 conducting in mvbr, TR5 will also conduct and motor will get full supply voltage. Next whistle command will make bistable mvbr switch over and stop motor. Frequency of whistle should match that of PXE detector, in which case output of PXE detector will be about 50 mV when whistle is blown firmly about 20 feet away. Working range can be somewhat greater because mvbr will switch over for input signal of about 25 mV.—PXE Detector, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 43, 1969.

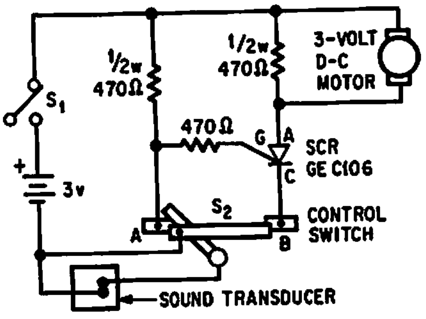

(−)
270K
270K
1MFD
≅ 180V
L2
L1
LT2-32-1
LT2-32-1
(+)

FLICKERING-NEON FLASHER—Uses two neon lamps which light alternately, with light flickering from electrode to electrode on each to get attention.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 154.

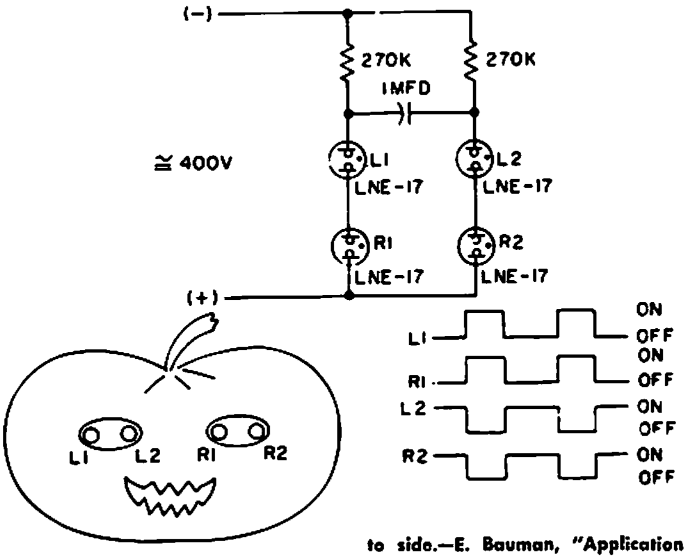

1
2
3
4
5
6
7
R1
R2
R3
R4
R5
R6
R7
C1
C2
C3
CR1
Q1
Q2

ELECTRONIC SLOT MACHINE—Three identical flip-flops are used with other digital circuits to simulate random action of spinning-wheel slot machine, but with three columns of lamps for indicating score. Book gives detailed construction data.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 122.

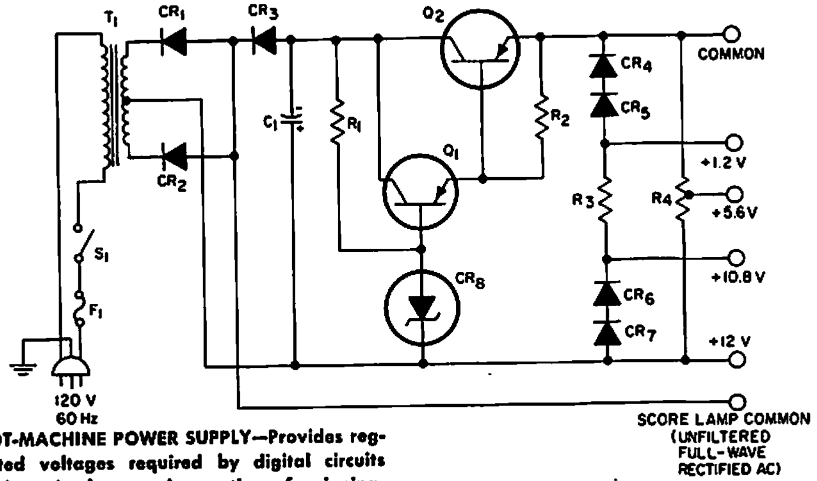
C_1 C_2 = 560 picofarads, 25 volts or greater
C_3 = 0.01 microfarad, 25 volts or greater
CR_1 = silicon rectifier, type 1N270
Q_1 Q_2 = transistor, RCA SK3020
R_1 R_2 = 1500 ohms, 1/2 watt, 10%
R_3 R_4 R_5 = 10,000 ohms, 1/2 watt, 10%
R_6 R_7 = 6800 ohms, 1/2 watt, 10%


S1
1/2w 470Ω
1/2w 470Ω
3-VOLT D-C MOTOR
470Ω
G
A
C
SCR GE C106
+
3v
S2
A
B
CONTROL SWITCH
SOUND TRANSDUCER

SOUND-CONTROLLED TURTLE—Inexpensive scr is turned on and off alternately by loud shouts of "Go!" and "Stop!", to drive or stop small d-c motor inside toy turtle. Sound picked up by transducer momentarily breaks ground on scr gate, turning on scr to energize motor. When motor starts, it trips shaft that moves lever of make-before-break switch S2 from A to B. Next shout then turns off motor and resets switch lever to A. Requires two D cells for 40 hours operation.—Toying With SCR's, *Electronics*, Sept. 18, 1967, p 46 and 48.

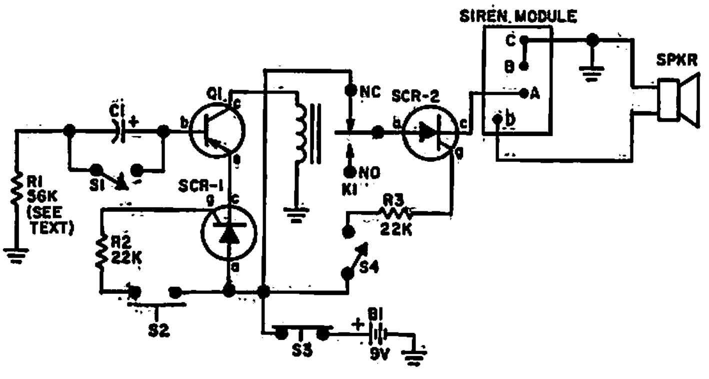

(−)
270K
270K
1MFD
≅ 400V
L1
LNE-17
L2
LNE-17
R1
LNE-17
R2
LNE-17
(+)
L1
L2
R1
R2
L1
R1
L2
R2
ON
OFF
ON
OFF
ON
OFF
ON
OFF

PUMPKIN BLINKER—When neon lamps are installed as shown, the lights blink from side to side.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 154.


T1
CR1
CR3
Q2
CR4
CR5
COMMON
C1
R1
R2
Q1
+1.2 V
R3
R4
+5.6V
CR8
+10.8 V
CR6
CR7
+12 V
CR2
S1
F1
120 V
60 Hz
SCORE LAMP COMMON
(UNFILTERED
FULL-WAVE
RECTIFIED AC)

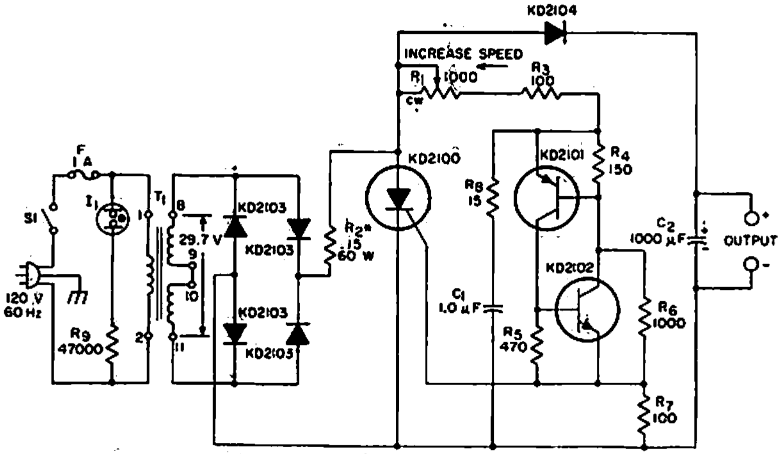
SLOT-MACHINE POWER SUPPLY—Provides regulated voltages required by digital circuits used to simulate random action of spinning-wheel slot machine, with three columns of lamps indicating score. Book gives construction data.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 123.

C_1 = 2000 microfarads, 15 volts, electrolytic
CR_1 through CR_7 = silicon rectifier, RCA SK3030
CR_8 = zener diode, 13 volts, 1 watt
F_1 = fuse, 1 ampere, 3AG
Q_1 = transistor, RCA SK3005
Q_2 = transistor, RCA SK3009
R_1 = 1800 ohms, 1/2 watt, 10%
R_2 = 68 ohms, 1/2 watt, 10%
R_3 = 470 ohms, 1/2 watt, 10%
R_4 = 100 ohms, 25 watts, adjustable
S_1 = toggle switch, single-pole single-throw
T_1 = transformer, primary 117 volts, secondary 25 volts at 1 ampere, Stancor No. P6469 or equivalent

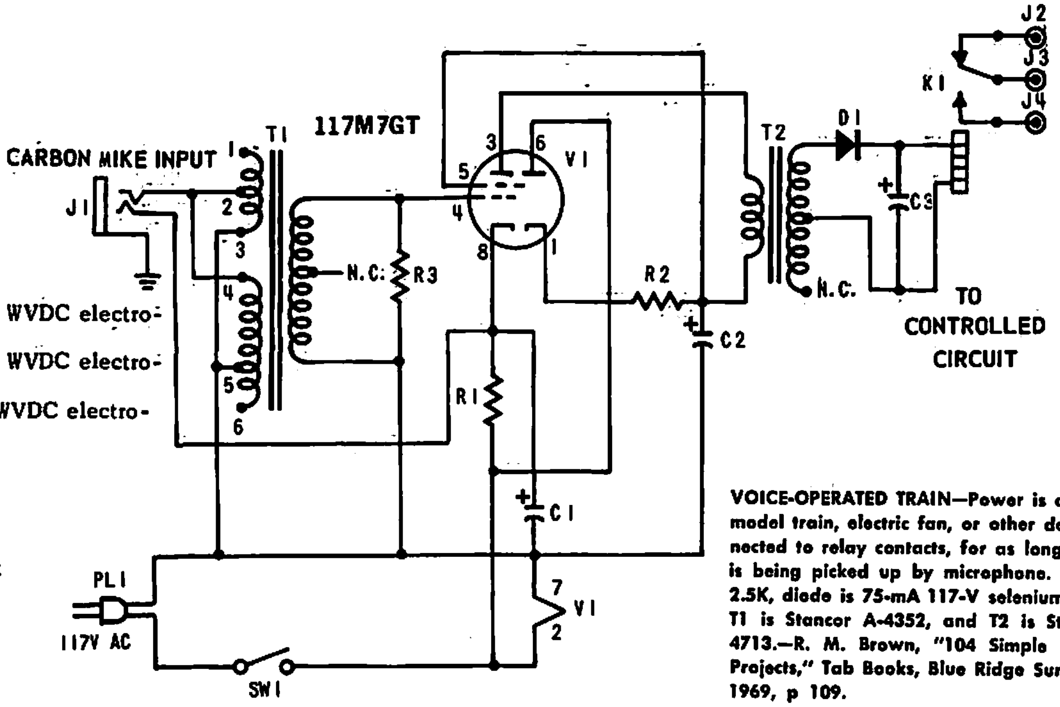

SIREN MODULE
C
B
A
b
SPKR
C1
+
Q1
b
c
e
R1
56K
(SEE
TEXT)
S1
SCR-1
g
c
a
R2
22K
S2
NC
NO
K1
SCR-2
R3
22K
S4
S3
B1
9V

SIREN IN BOX—Solid-state electronic timer is combined with electronic siren. Once a curious person turns it on, either instantly by flipping S4 or after 40-s delay if he flips S2 first, siren can be stopped only by pushing concealed switch S3 through hole in perfboard case. Will enliven dull party or conference, but should be recovered and turned off before someone throws it out window. Siren module is Lafayette 19E55053 or equivalent. Speaker is 8 ohms and 2½ inches. C1 is 100 μF, 6 V. Value shown for R1 gives timing delay of about 40 s for Q1-C1-R1-K1 delay circuit. Q1 is HEP250 and scr's are GE 10EY1.—S. Daniels, Interval Screamer, *Elementary Electronics*, Mar.-Apr. 1970, p 62–65 and 102.

MODEL-TRAIN SPEED CONTROL—Single scr provides smooth full-wave control of speed, along with regulation, over complete range from zero to full speed, for model trains or track-guided model race cars requiring up to 12 V d-c.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 84.


KD2104
INCREASE SPEED
R1 1000
CW
R3 100
F
1A
S1
I1
T1
8
29.7 V
9
10
11
1
2
120 V
60 Hz
R9
47000
KD2103
KD2103
KD2103
KD2103
R2* 15 60 W
KD2100
R8 15
KD2101
R4 150
C1 1.0 μF
R5 470
KD2102
C2 1000 μF
OUTPUT
+
-
R6 1000
R7 100

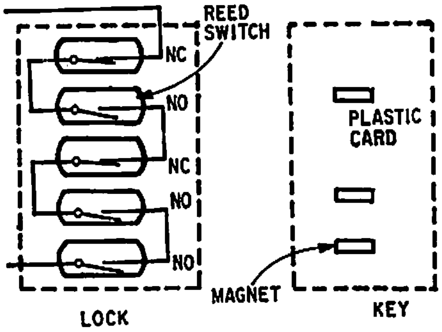
* USE THREE 5 OHM/20 W RESISTORS IN SERIES


117M7GT
T1
CARBON MIKE INPUT
J1
1
2
3
4
5
6
N.C.
R3
3
6
5
4
8
1
V1
R2
C2
R1
C1
T2
N.C.
D1
C3
K1
J2
J3
J4
TO CONTROLLED CIRCUIT
PL1
117V AC
SW1
7
V1
2

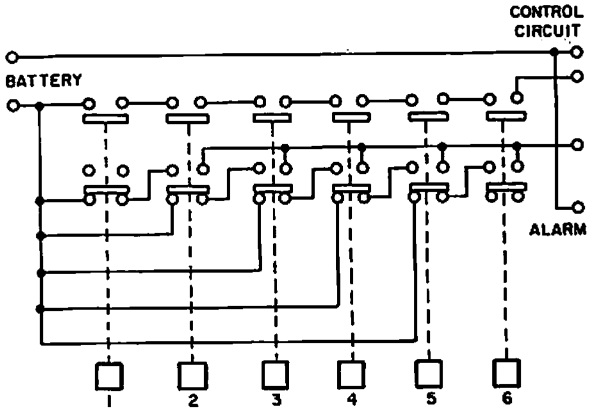
C1 - 40 mfd, 250 WVDC electrolytic
C2 - 30 mfd, 250 WVDC electrolytic
C3 - 5 mfd, 250 WVDC electrolytic

R1 - 150, 2-watt
R2 - 18
R3 - 470K

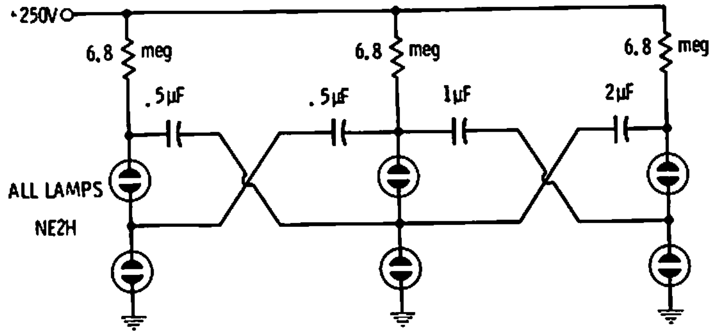
VOICE-OPERATED TRAIN—Power is applied to model train, electric fan, or other device connected to relay contacts, for as long as voice is being picked up by microphone. Relay is 2.5K, diode is 75-mA 117-V selenium rectifier, T1 is Stancor A-4352, and T2 is Stancor A-4713.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 109.


REED SWITCH
NC
NO
NC
NO
NO
PLASTIC CARD
MAGNET
LOCK
KEY

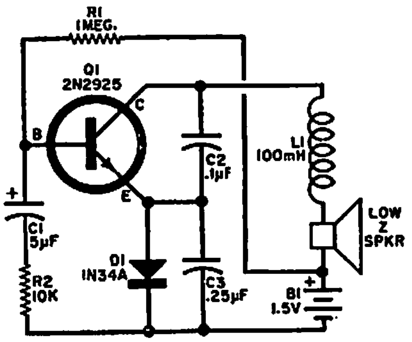
MAGNETIC COMBINATION LOCK—Combination of normally open and normally closed magnetic reed switches can be activated only by correct pattern of small permanent magnets on card. Security factor increases with number of switches used. Normally closed switches are used to prevent operation with single large magnetic field.. Switches should be concealed by nonmagnetic material. Can be used with electric door latch or as auto ignition switch.—R. M. Zilberstein, Reed Switches Form a Nonmechanical Lock, *Electronics,* Oct. 28, 1968, p 92.


CONTROL CIRCUIT
BATTERY
ALARM
1
2
3
4
5
6

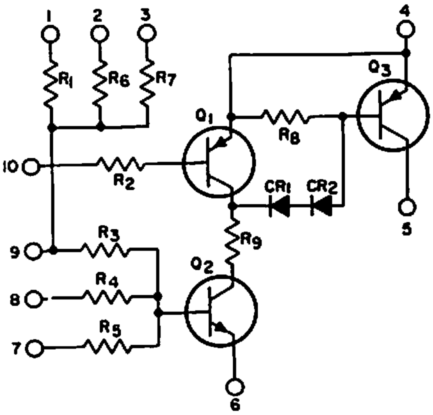
ELECTRIC COMBINATION LOCK—Power is applied to control circuit only if toggle, lever, or self-latching pushbutton switches are closed in one correct sequence. For all other sequences, alarm circuit goes off. Additional switches can be used to increase difficulty of finding correct combination even if alarm is somehow disabled. Manual or other means should be provided for releasing all switches.—K. C. Herrick, Circuit Determines Correct Operating Sequence, *Electronic Design,* Nov. 23, 1964, p 62.


+250V
6.8 meg
6.8 meg
6.8 meg
.5μF
.5μF
1μF
2μF
ALL LAMPS
NE2H

SIX-LAMP RANDOM—Gives interesting and unpredictable pattern of blinking neon lights, using few parts.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 48.


R1
1MEG.
Q1
2N2925
B
C
E
C2
.1μF
L1
100mH
LOW
Z
SPKR
+
C1
5μF
R2
10K
D1
1N34A
C3
.25μF
+
B1
1.5V

INSANITY GENERATOR — Produces gentle-sounding chirp about once per second, for annoying next-door neighbors without incurring risk of having lease broken. Sound is comparable to Chinese torture in which water drips slowly on forehead of victim strapped to floor. Use either small speaker or low-impedance earphone.—S. Broskond, "The Lease-Breaker" and "The Drip", *Popular Electronics,* Feb. 1968, p 33–35.

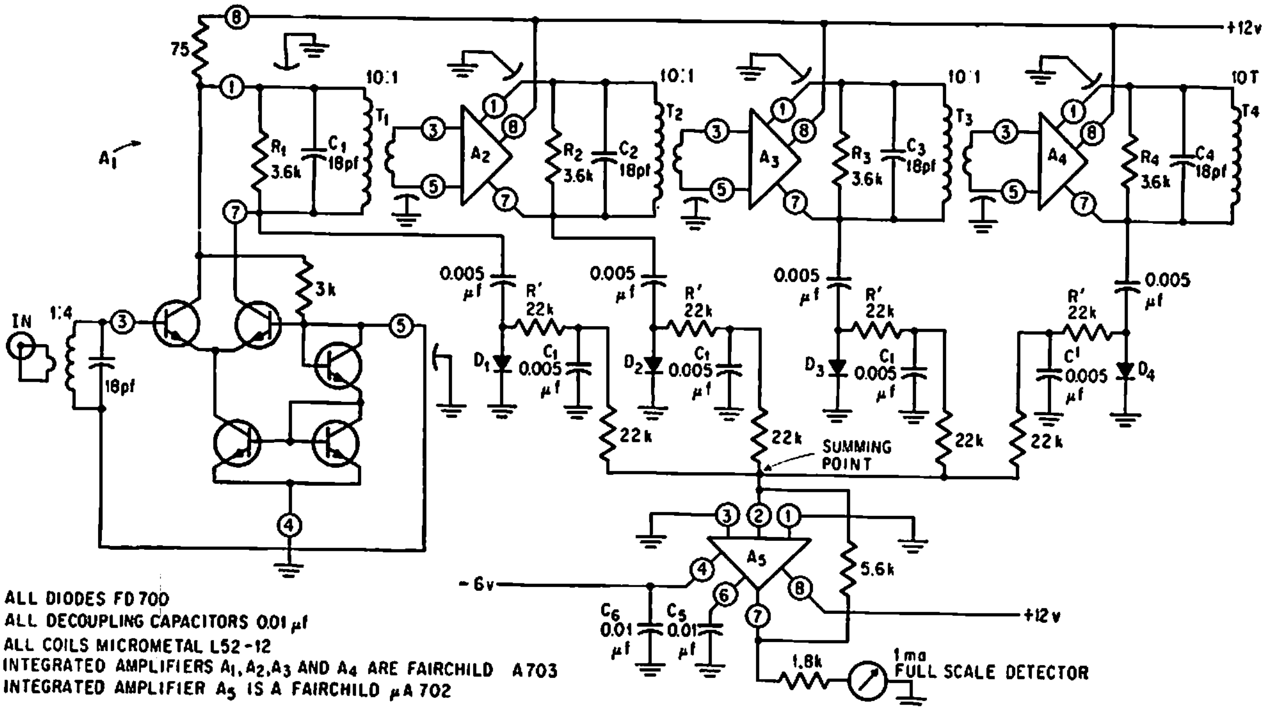

1
2
3
4
R1
R6
R7
Q3
Q1
R8
10
R2
CR1
CR2
5
R3
9
R9
Q2
R4
8
R5
7
6

NOR GATE FOR SLOT MACHINE—Circuit is one of scoring gates used with other digital circuits to simulate random action of spinning-wheel slot machine, with three columns of lamps indicating score. Book gives construction data. Values: R1-R6 4.7K; R7 3.9K; R8-R9 180; CR1-CR2 SK3030; Q1, Q3 SK3005; Q2 SK3010.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 122.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 39

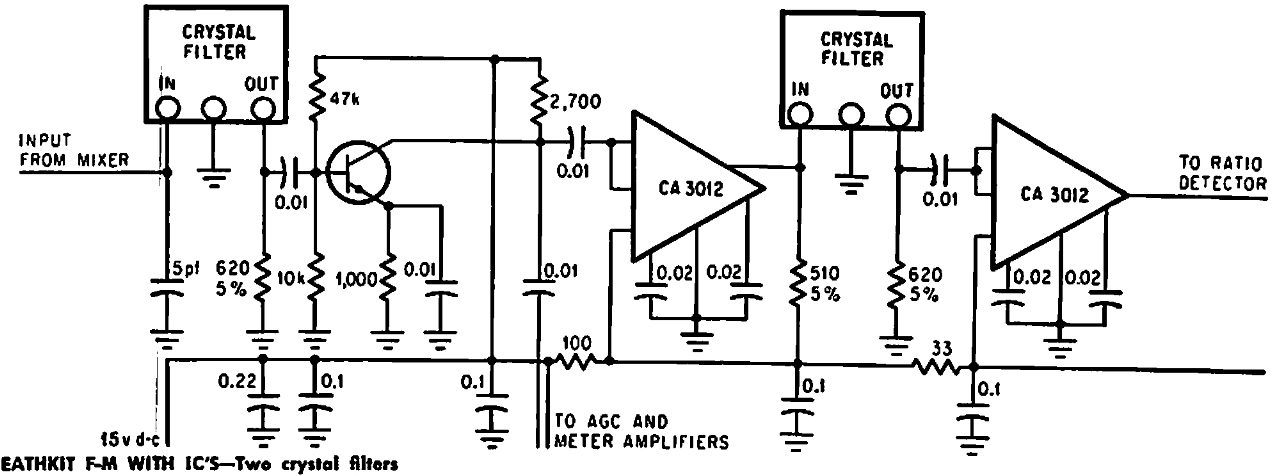
I-F Amplifier Circuits



+12v
75
10:1
T_1
T_2
T_3
10T
T_4
A_1
A_2
A_3
A_4
A_5
R_1 3.6k
C_1 18pf
R_2 3.6k
C_2 18pf
R_3 3.6k
C_3 18pf
R_4 3.6k
C_4 18pf
IN
1:4
18pf
3k
0.005 μf
R' 22k
D_1
D_2
D_3
D_4
C_1 0.005 μf
C' 0.005 μf
22k
SUMMING POINT
5.6k
-6v
C_6 0.01 μf
C_5 0.01 μf
+12v
1.8k
1 ma FULL SCALE DETECTOR

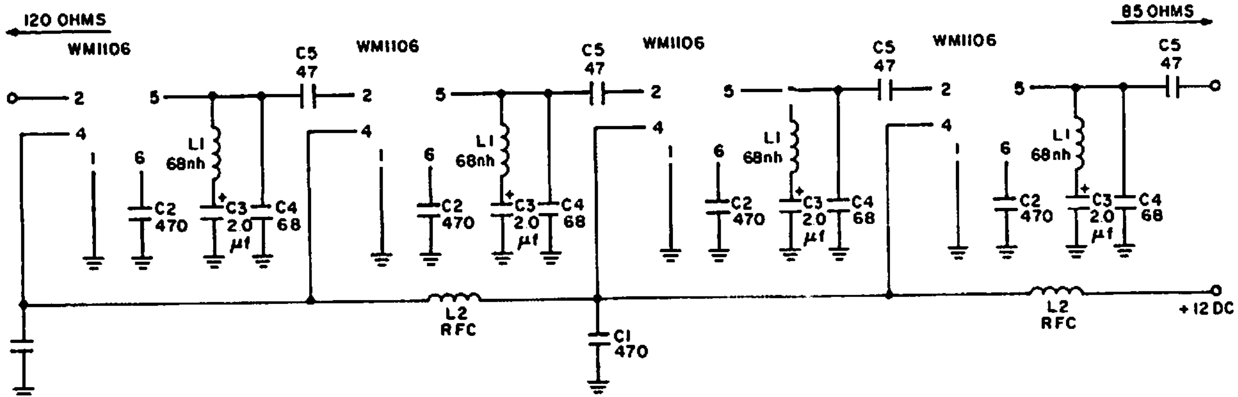
ALL DIODES FD 700
ALL DECOUPLING CAPACITORS 0.01 μf
ALL COILS MICROMETAL L52-12
INTEGRATED AMPLIFIERS A_1, A_2, A_3 AND A_4 ARE FAIRCHILD A703
INTEGRATED AMPLIFIER A_5 IS A FAIRCHILD μA 702

45-MHZ I-F WITH IC'S FOR BRIDGE—Gives low-cost detector for bridge network. Logarithmic transfer characteristic is generated by sampling outputs of cascaded IC amplifiers A1, A2, A3, and A4 and combining samples in video summing amplifier A5. Large input signal forces successive stages to limit in sequence, dropping slope of transfer characteristic 20 dB. Circuit is highly stable, but slow logging makes it unsuitable for radar.—R. Q. Lane, Low-Cost IC's Improve 45-MHz I-f Amplifier, *Electronics*, March 20, 1967, p 88–89.

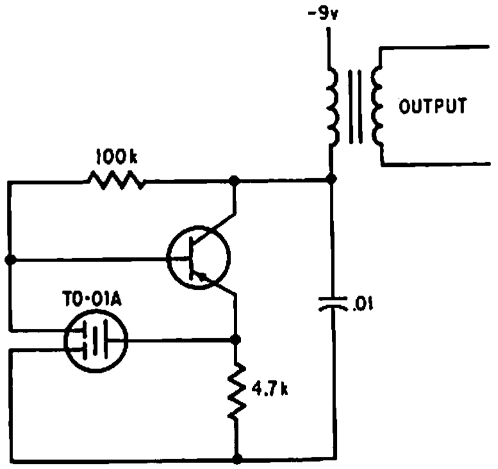


CRYSTAL FILTER
IN
OUT
INPUT FROM MIXER
47k
2,700
0.01
CA 3012
5pf
620 5%
10k
1,000
0.01
0.02
510 5%
620 5%
100
33
0.22
0.1
TO AGC AND METER AMPLIFIERS
15v d-c
TO RATIO DETECTOR

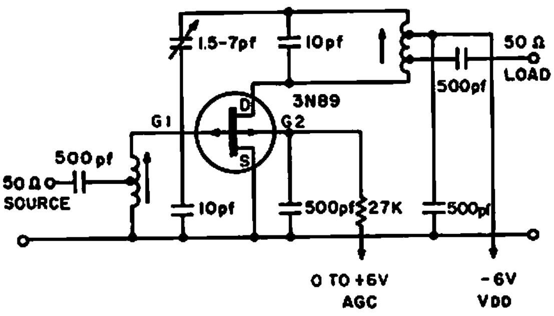
HEATHKIT F-M WITH IC'S—Two crystal filters and two RCA wideband high-gain amplifier-limiters improve performance of f-m i-f. Overall gain is 120 dB, capture ratio is reduced to 1.8 dB, and adjacent-channel selectivity is 70 dB. Four-pole lattice-design quartz crystal filters together give selectivity comparable to that of eight single-tuned transformer-coupled circuits.—IC's Sound Better, *Electronics*, January 23, 1967, p 41–42.


120 OHMS
85 OHMS
WM1106
C5
47
L1
68nh
C2
470
C3
2.0
µf
C4
68
L2
RFC
C1
470
+12 DC

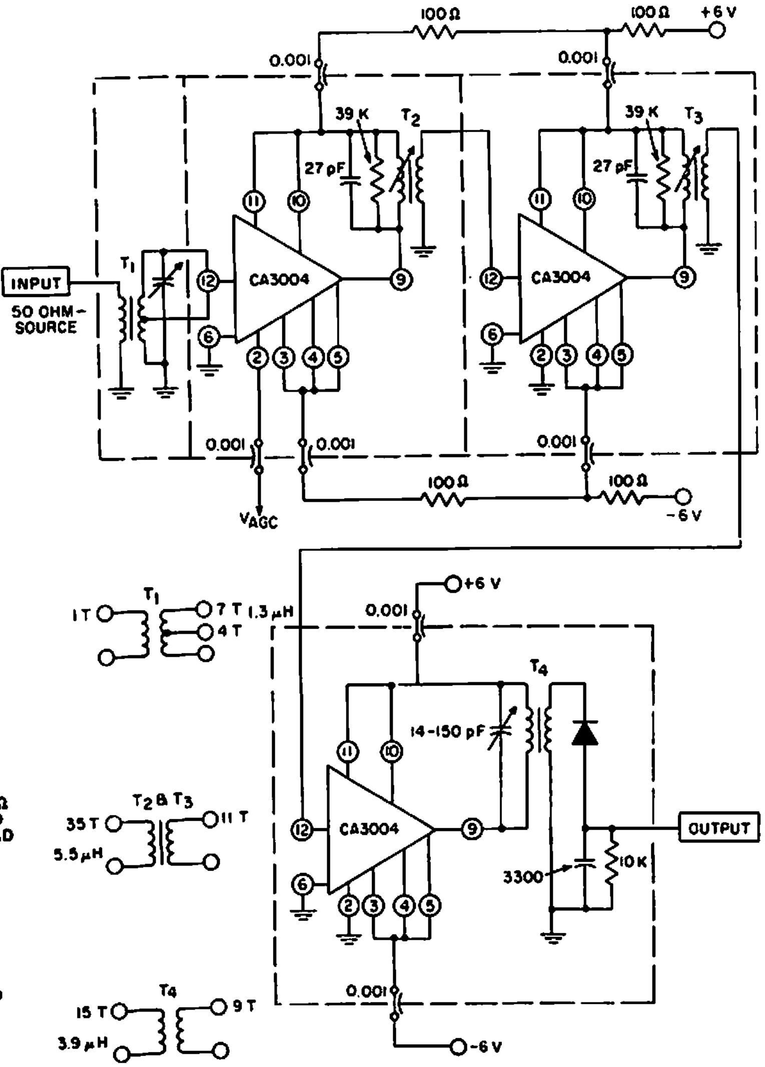
60 MHZ WITH FOUR IC STAGES—Four stages provide total gain up to 43 dB, depending on IC used, with bandwidth of 8.4 MHz overall. —S. G. Shepherd and A. E. Seman, Design With Integrated Circuits at 60 Mc, *Electronic Design*, July 19, 1965, p 32–35.


-9v
OUTPUT
100k
TO-01A
.01
4.7k

TRANSFILTER—Ceramic transfilter serves in place of transformer as coupling element, and also forms oscillating element in 455-kHz i-f system. Frequency stability is 0.1% from 20 to 60 C. Transistor can be either pnp or npn, depending on power supply, but should have beta of 50 to 100 and cutoff of 10 MHz. —C. Hartley, Oscillator Has a Transfilter As The Resonant Device, *Electronics*, Feb. 3, 1969, p 78.

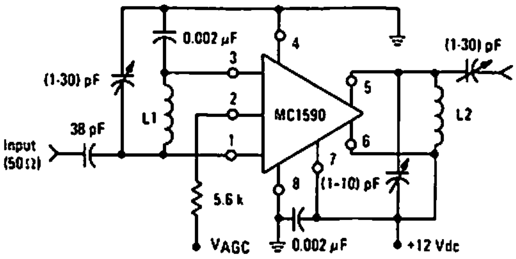

1.5-7pf
10pf
50 Ω
LOAD
500pf
3N89
G1
D
G2
S
500pf
50 Ω
SOURCE
10pf
500pf
27K
500pf
0 TO +6V
AGC
-6V
VDD

TETRODE FET WITH 40-DB AGC—Power gain is 15 dB in 45-MHz single stage shown. Can also be used as video amplifier having linear gain control.—J. S. Sherwin, Need High Z and Low C? Turn to the Tetrode FET for HF Design, *Electronic Design*, June 7, 1965, p 20–25.


100Ω
100Ω
+6V
0.001
39K
T2
T3
27pF
CA3004
INPUT
50 OHM-SOURCE
T1
VAGC
-6V
1T
7T 1.3µH
4T
T2 & T3
35T
11T
5.5µH
T4
15T
9T
3.9µH
14-150 pF
OUTPUT
3300
10K

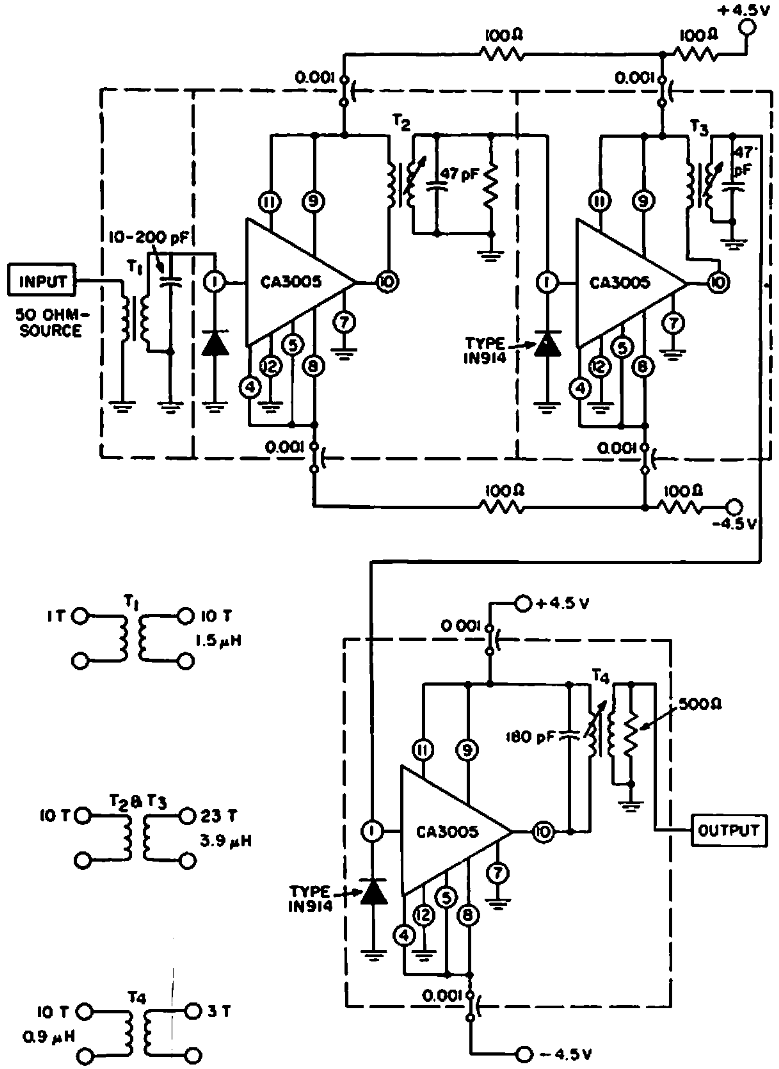
Notes:
1. Transformers T_1 and T_4 are Ferramic Q-2 Toroid Types (unloaded Q = 200).
2. Transformers T_2 and T_3 are slug-tuned with carbonyl IT-71 material (unloaded Q = 70).

12-MHZ GAIN-CONTROLLED A-M I-F—Uses three IC r-f amplifiers in cascade to provide 25 dB gain per stage. Agc range for first stage is 60 dB and 3-dB bandwidth is 160 kHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 214.


0.002 μF
4
3
2
1
(1-30) pF
L1
38 pF
Input (50 Ω)
MC1590
5
6
7
8
5.6 k
VAGC
0.002 μF
(1-10) pF
+12 Vdc
(1-30) pF
Output (50 Ω)
L2

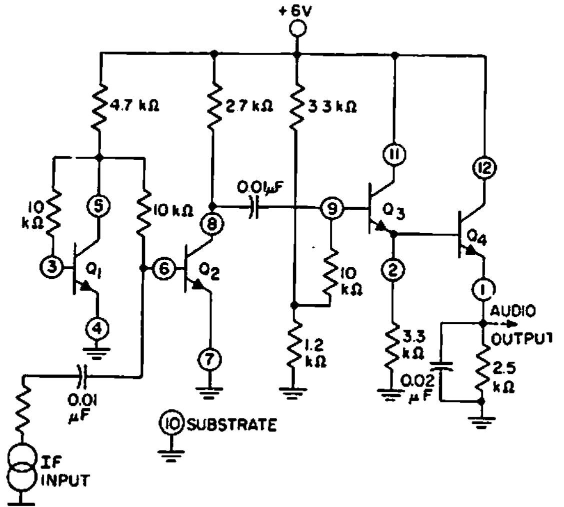
L1 = 12 Turns #22 AWG Wire on a Toroid Core.
(T37-6 Micro Metal or Equiv)
L2 = 17 Turns #20 AWG Wire on a Toroid Core.
(T44-6 Micro Metal or Equiv)

30-MHz IC—Single-ended coupling at input and output eliminates transformers. Power gain is 50 dB. Uses Motorola direct-coupled high-gain IC amplifier.—R. Hejhall and B. Trout, Integrated Circuits for the World of High Frequency, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 21–26.

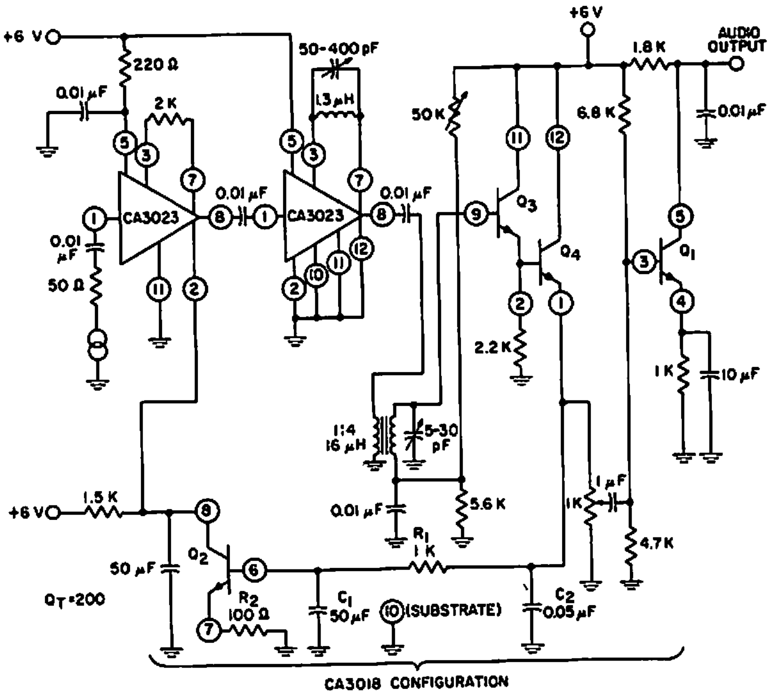

+4.5V
100Ω
100Ω
0.001
0.001
T2
T3
47 pF
47 pF
10-200 pF
T1
INPUT
50 OHM-SOURCE
CA3005
CA3005
CA3005
1
4
5
7
8
9
10
11
12
TYPE IN914
TYPE IN914
0.001
0.001
100Ω
100Ω
-4.5V
+4.5 V
0.001
T4
180 pF
500Ω
OUTPUT
0.001
-4.5V
1T
T1
10 T
1.5 μH
10 T
T2 & T3
23 T
3.9 μH
10 T
T4
3 T
0.9 μH

Notes: 1. Transformer T_1 is a Ferramic Q-2 Type (unloaded Q = 200).
2. Transformers T_2, T_3, and T_4 are slug-tuned with carbonyl IT-75 material (unloaded Q = 75).

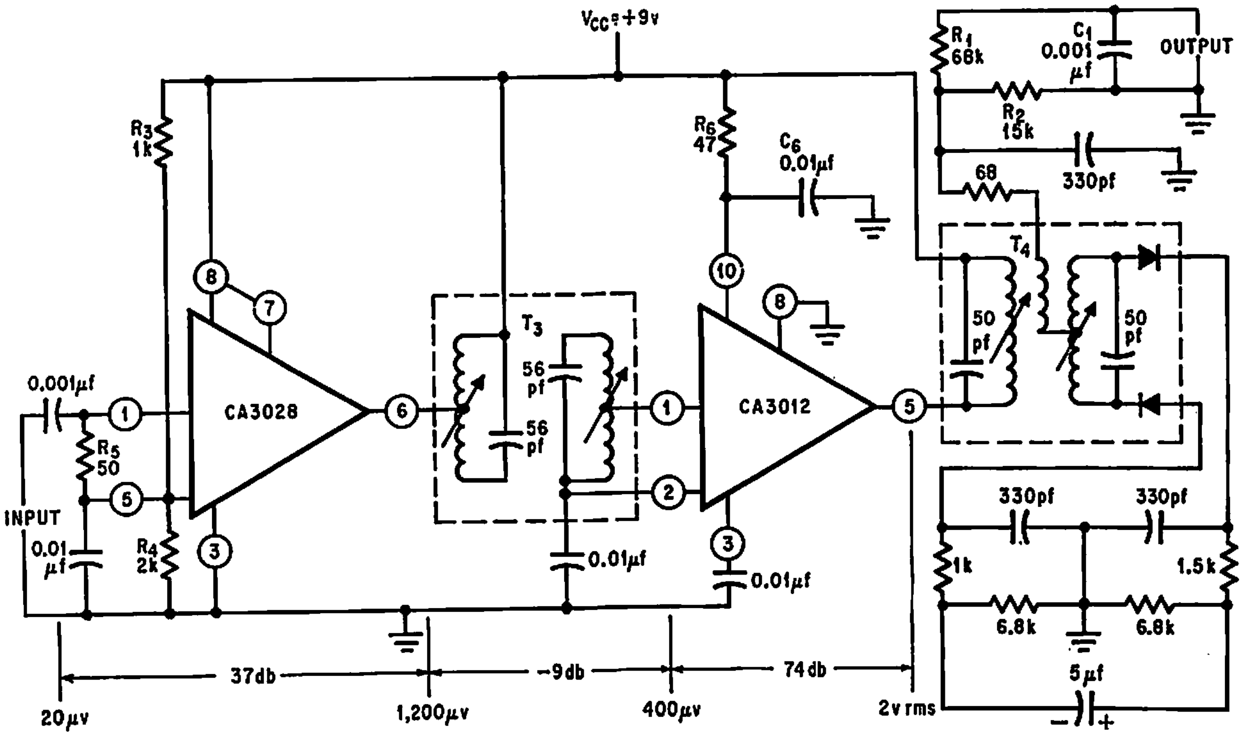
12-MHZ LIMITING I-F AMPLIFIER—Uses three IC r-f amplifiers in cascade to provide 26 dB gain per stage for f-m use. Limiting action begins at about 30 μV.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 213.


+6V
4.7 kΩ
2.7 kΩ
3.3 kΩ
10 kΩ
5
Q1
3
4
10 kΩ
6
Q2
8
7
0.01μF
9
Q3
11
12
Q4
2
1
10 kΩ
1.2 kΩ
3.3 kΩ
0.02 μF
2.5 kΩ
AUDIO OUTPUT
0.01 μF
IF INPUT
10 SUBSTRATE

30 DB AT 1 MHZ—Uses RCA CA3018 IC transistor array as final i-f amplifier stage and cascaded emitter-follower Q3-Q4 as second detector.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 314.

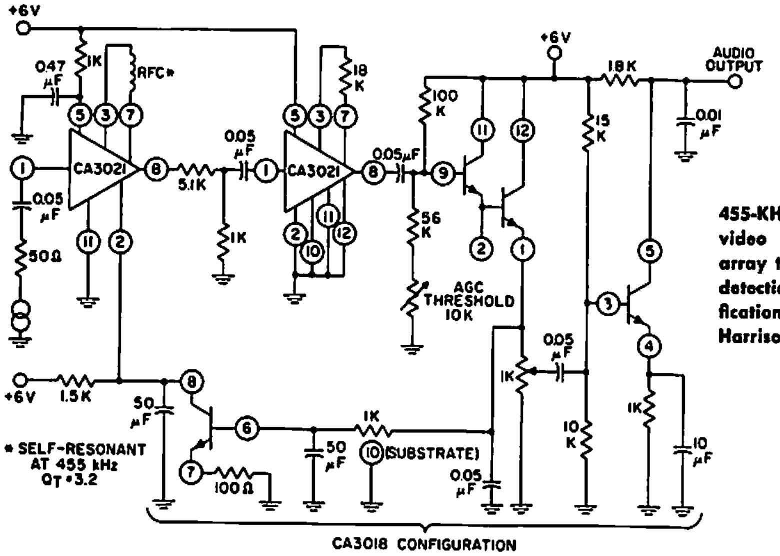

+6 V
220 Ω
0.01 µF
2 K
CA3023
0.01 µF
50 Ω
50-400 pF
1.3 µH
CA3023
0.01 µF
+6 V
1.8 K
AUDIO OUTPUT
0.01 µF
50 K
6.8 K
Q3
Q4
Q1
2.2 K
1 K
10 µF
1:4
16 µH
5-30 pF
0.01 µF
5.6 K
1 µF
1 K
4.7 K
+6 V
1.5 K
50 µF
Q2
R1
1 K
QT=200
R2
100 Ω
C1
50 µF
(SUBSTRATE)
C2
0.05 µF
CA3018 CONFIGURATION

10-MHZ TWO-STAGE IC I-F—Uses two IC video amplifiers and CA3018 IC transistor array to provide required 86-dB i-f voltage gain at 10 MHz along with detection, audio amplification, and d-c amplification.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 177.


Vcc=+9v
R3
1k
R6
47
C6
0.01µf
R1
68k
C1
0.001 µf
OUTPUT
R2
15k
330pf
68
T4
50 pf
50 pf
T3
56 pf
56 pf
0.001µf
CA3028
CA3012
R5
50
INPUT
0.01 µf
R4
2k
0.01µf
0.01µf
330pf
330pf
1k
1.5k
6.8k
6.8k
5µf
37db
-9db
74db
20µv
1,200µv
400µv
2v rms

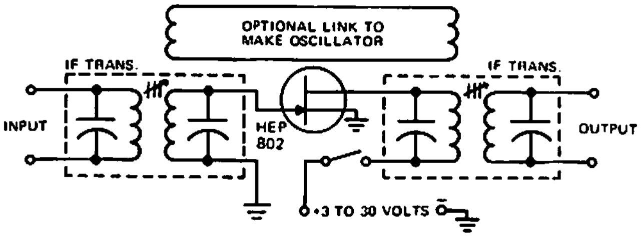
T3: INTERSTAGE TRANSFORMER TRW NO. 22486 OR EQUIVALENT
T4: RATIO DETECTOR TRW NO. 22516 OR EQUIVALENT

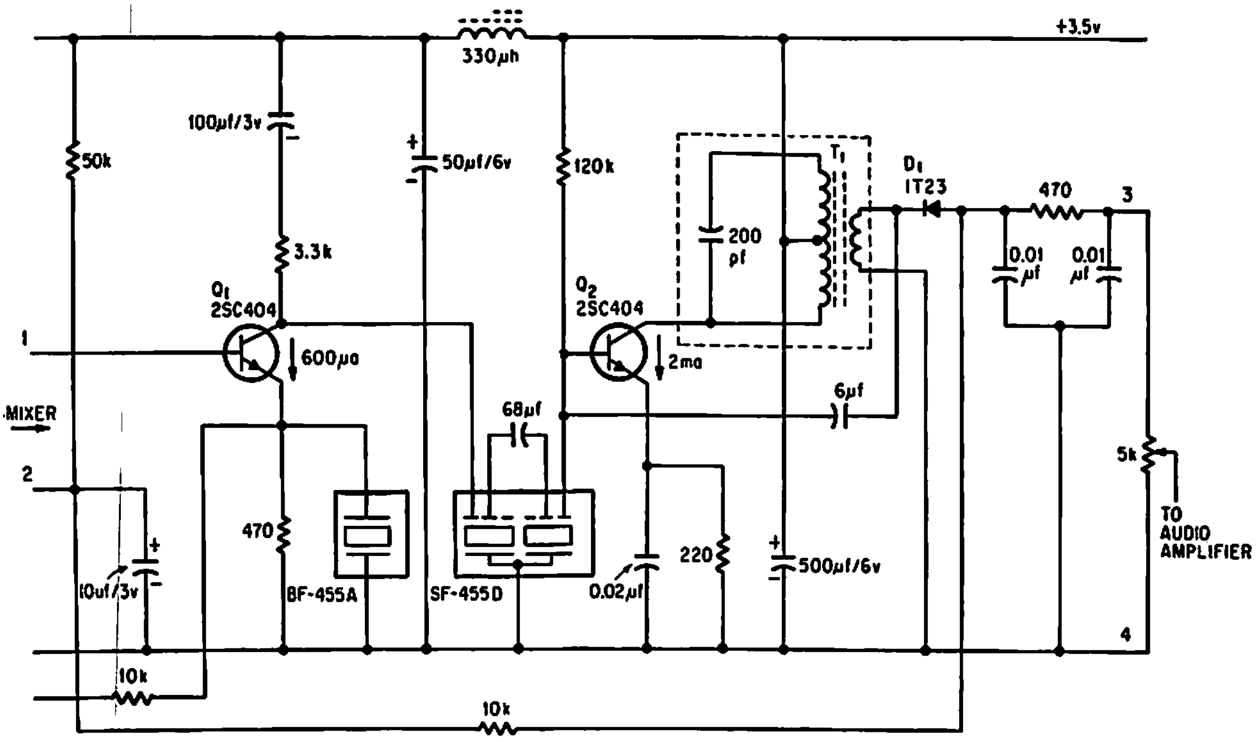
10.7-MHZ I-F WITH TWO IC'S—Two RCA IC's provide 100 dB of gain for complete i-f strip. First IC is differential amplifier, and second provides limiting action along with gain.—J. P. Keller, Linear IC's: Part 3—Differential Amplifiers At Work, *Electronics*, Sept. 18, 1967, p 96–104.


+6V
.047 µF
1K
RFC*
CA3021
0.05 µF
50Ω
5.1K
0.05 µF
1K
CA3021
18 K
0.05µF
100 K
56 K
AGC THRESHOLD 10K
+6V
18K
AUDIO OUTPUT
0.01 µF
15 K
0.05 µF
1K
10 K
1K
10 µF
+6V 1.5K
50 µF
1K
50 µF
(10)(SUBSTRATE)
100Ω
0.05 µF
* SELF-RESONANT AT 455 kHz QT=3.2
CA3018 CONFIGURATION

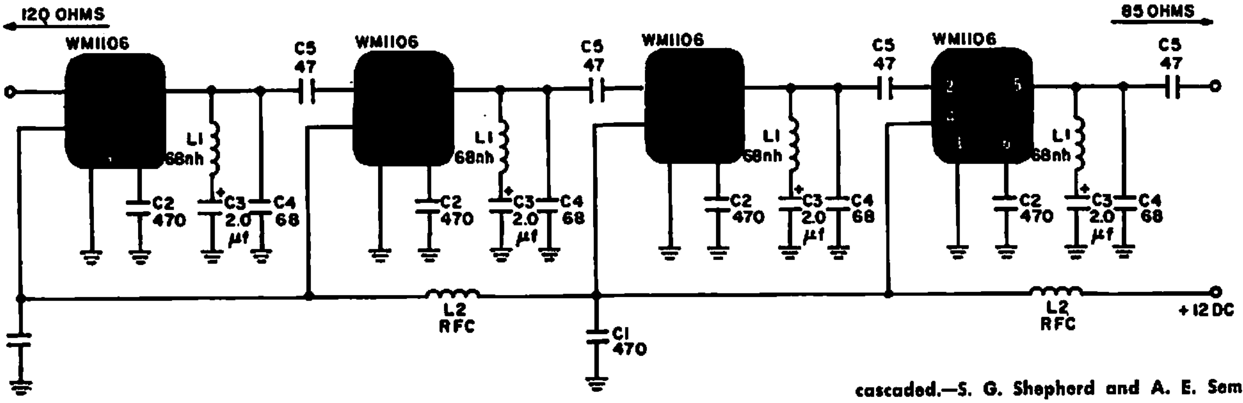
455-KHZ TWO-STAGE IC I-F—Uses two IC video amplifiers and CA3018 IC transistor array to provide required i-f gain along with detection, audio amplification, and d-c amplification.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 178.

FET AMPLIFIER OR OSCILLATOR—Choose i-f transformers for 50 kHz, 455 kHz, or 10.7 MHz. Add link coupling to convert to stable oscillator; use 6 turns of wire at each end.—"Tips on Using FET's," Motorola, Phoenix, Ariz., HMA-33, 1969.

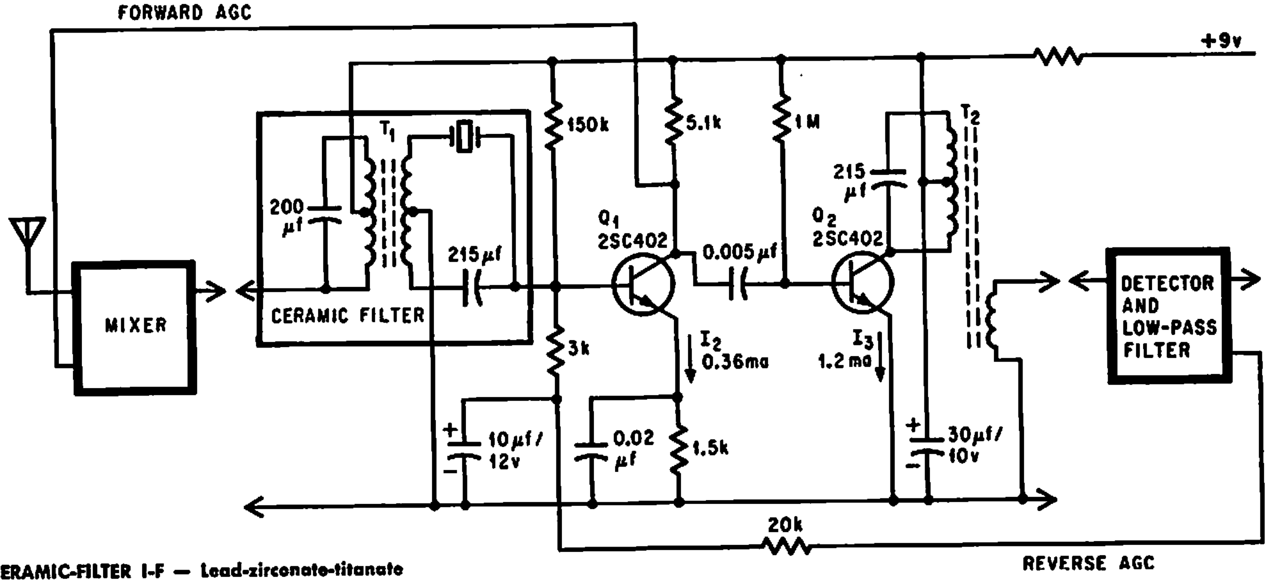

OPTIONAL LINK TO MAKE OSCILLATOR
IF TRANS.
IF TRANS.
INPUT
HEP 802
OUTPUT
+3 TO 30 VOLTS


330µh
+3.5v
50k
100µf/3v
50µf/6v
120k
T1
D1 1T23
470
3
200 pf
0.01 µf
0.01 µf
3.3k
Q1 2SC404
Q2 2SC404
1
600µa
2ma
MIXER
6µf
68µf
5k
2
TO AUDIO AMPLIFIER
470
220
500µf/6v
10uf/3v
BF-455A
SF-455D
0.02µf
4
10k
10k

I-F WITH TWO CERAMIC FILTERS—Used in Sony model TR-1000 ten-transistor multiband portable radio to reduce number of components, simplify production and cut costs. First filter is tuned to 455 kHz and provides emitter-to-ground bypassing for first i-f transistor Q1. Other filter is double-tuned to 455 kHz, and provides interstage coupling.—Ceramic Filters Edge Out Costly I-F Transformers, *Electronics*, Nov. 14, 1966, p 160–163.


120 OHMS
85 OHMS
WM1106
WM1106
WM1106
WM1106
C5 47
C5 47
C5 47
C5 47
L1 68nh
C2 470
C3 2.0 μf
C4 68
L2 RFC
L2 RFC
C1 470
+12 DC

60-MHZ FOUR-IC WITH 43 DB GAIN—Bandwidth is 8.4 MHz and power gain 13.1 dB for four-stage amplifier. Article presents empirical approach, involving d-c measurements, for selecting external components that will not cause oscillation when four stages are cascaded.—S. G. Shepherd and A. E. Seman, Design with Integrated Circuits at 60 Mc, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 90–97.

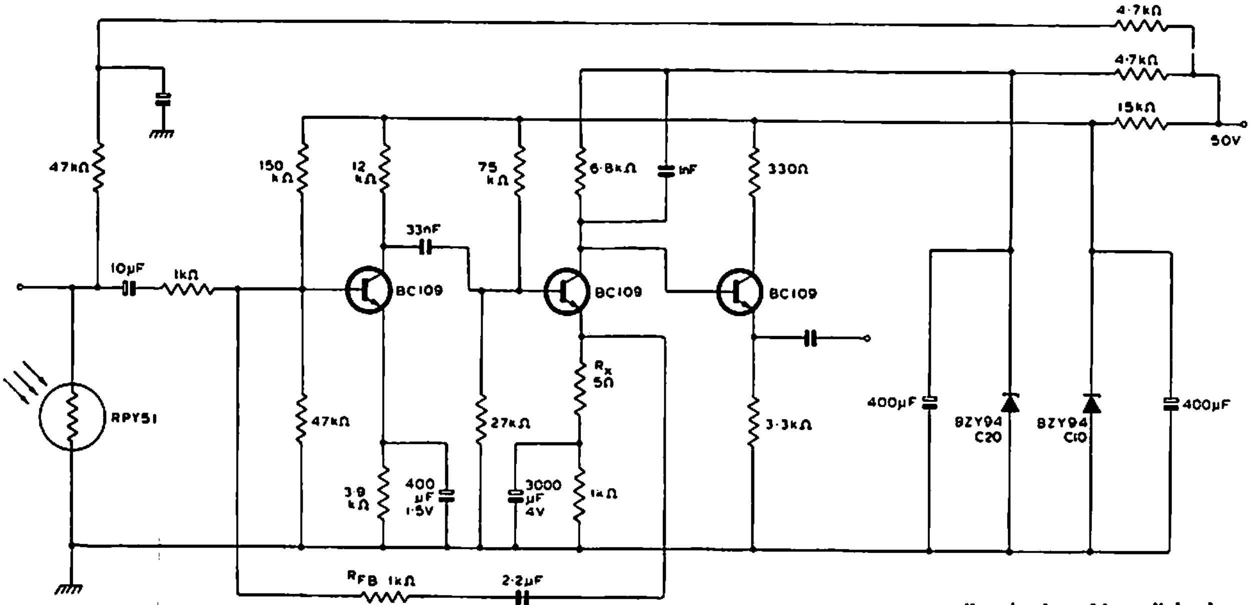

FORWARD AGC
+9v
MIXER
CERAMIC FILTER
T1
200 μf
215μf
150k
5.1k
1M
Q1 2SC402
0.005μf
Q2 2SC402
215 μf
T2
DETECTOR AND LOW-PASS FILTER
3k
I2 0.36ma
I3 1.2 ma
10μf/12v
0.02 μf
1.5k
30μf/10v
20k
REVERSE AGC

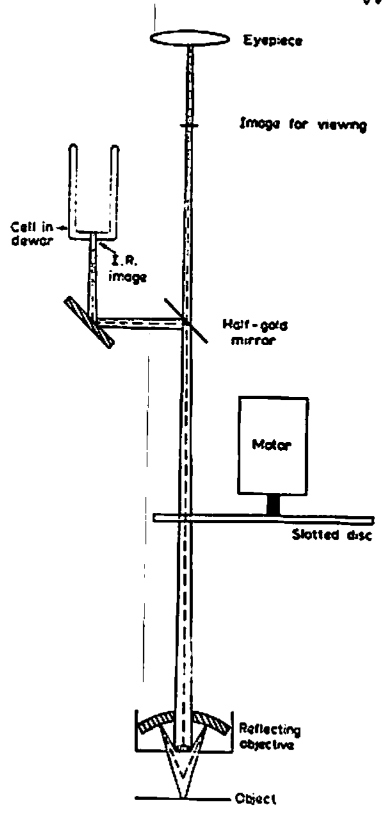
CERAMIC-FILTER I-F — Lead-zirconate-titanate piezoelectric ceramic filter in i-f stage of low-cost a-m portable radio provides selectivity comparable to that of three single-tuned transformer stages, eliminates need for alignment during production, and cuts number of components. Used in Sony model 2R-27 radio.—Ceramic Filters Edge Out Costly I-F Transformers, *Electronics*, Nov. 14, 1966, p 160–163.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

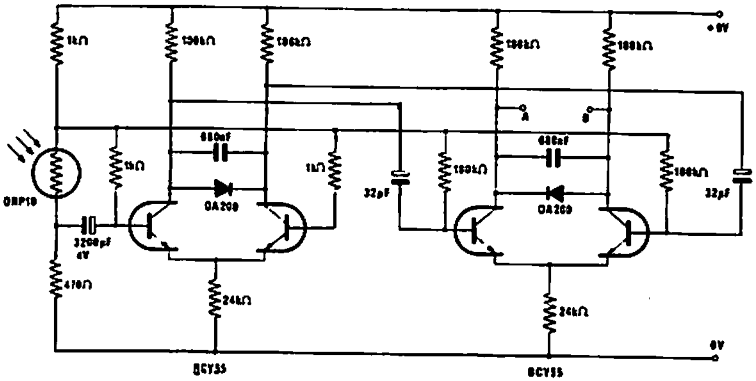
CHAPTER 40

Infrared Circuits


4·7kΩ
4·7kΩ
15kΩ
50V
47kΩ
150 kΩ
12 kΩ
75 kΩ
6·8kΩ
1nF
330Ω
33nF
10μF
1kΩ
BC109
BC109
BC109
RPY51
47kΩ
27kΩ
R_x 5Ω
3·3kΩ
400μF
BZY94 C20
BZY94 C10
400μF
3·9 kΩ
400 μF 1·5V
3000 μF 4V
1kΩ
R_{FB} 1kΩ
2·2μF

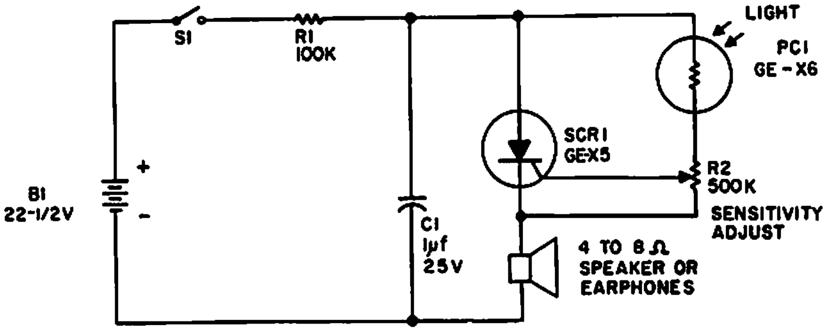

Eyepiece
Image for viewing
Cell in dewar
I.R. image
Half-gold mirror
Motor
Slotted disc
Reflecting objective
Object

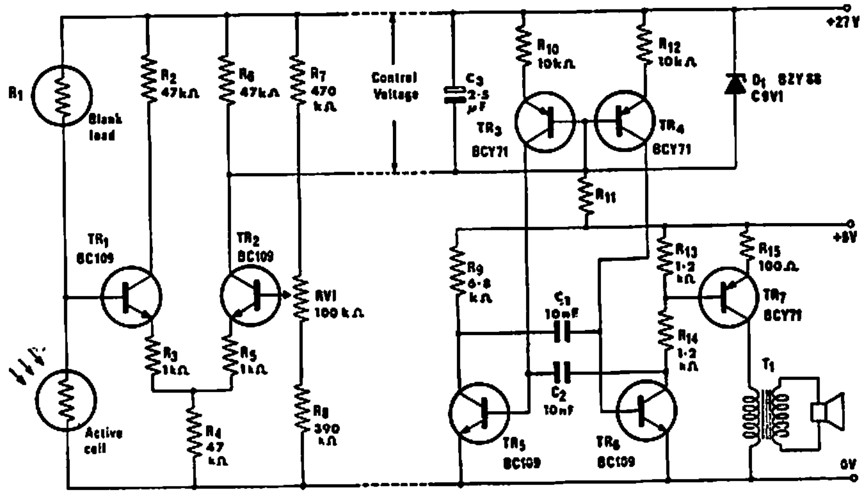
IC TEMPERATURE DISTRIBUTION—Infrared microscope uses Mullard RPY51 indium antimonide detector cooled by liquid nitrogen for measuring temperature of extremely small area, such as portion of integrated-circuit chip. Motor-driven chopper converts radiation from target to about 800 Hz with 3,000-rpm disc having 16 radial slots. Circuit features low noise and high gain stability. Article gives design equations and other circuits required for complete thermal microscope system.—T. J. Jarratt, Infrared Microscope for Temperature Measurement of Small Areas, *Mullard Technical Communications*, May 1968, p 101–107.


1kΩ
150kΩ
150kΩ
150kΩ
150kΩ
+6V
A
B
680nF
680nF
1kΩ
1kΩ
150kΩ
150kΩ
32μF
32μF
OA200
OA200
ORP10
3200μF 4V
470Ω
24kΩ
24kΩ
0V
BCY35
BCY35

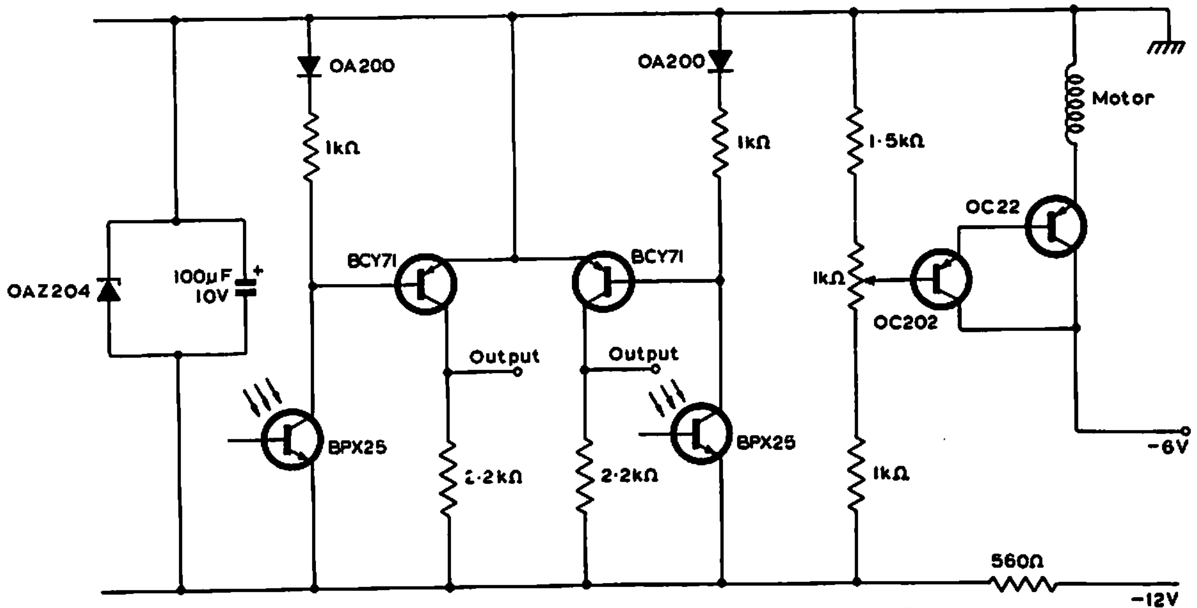
IR INTRUSION ALARM—Uses Mullard ORP10 uncooled indium antimonide photocell in unchopped system to detect objects with temperatures above 10 deg C moving across field of view against steady background at room temperature. Detector is a-c coupled to low-drift differential amplifier driving alarm circuit. Responds to minimum angular speed of about 1 milliradian per second by intruder.—R. A. Lockett, Passive Intruder Alarm Using Infrared Detector, *Mullard Technical Communications*, May 1968, p 88–90.

INTRUSION ALARM—When R2 is adjusted just below maximum ambient illumination, slight increase in light falling on photocell makes scr oscillate and produce loud clicking sounds in speaker. Frequency of clicks increases with illumination. Will respond to flashlight of intruder or to turning on of room lights in vacant office or home. Uses GE-X6 cadmium sulfide photoconductor. For infrared detection or fire alarm, use cadmium selenide cell.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 124.

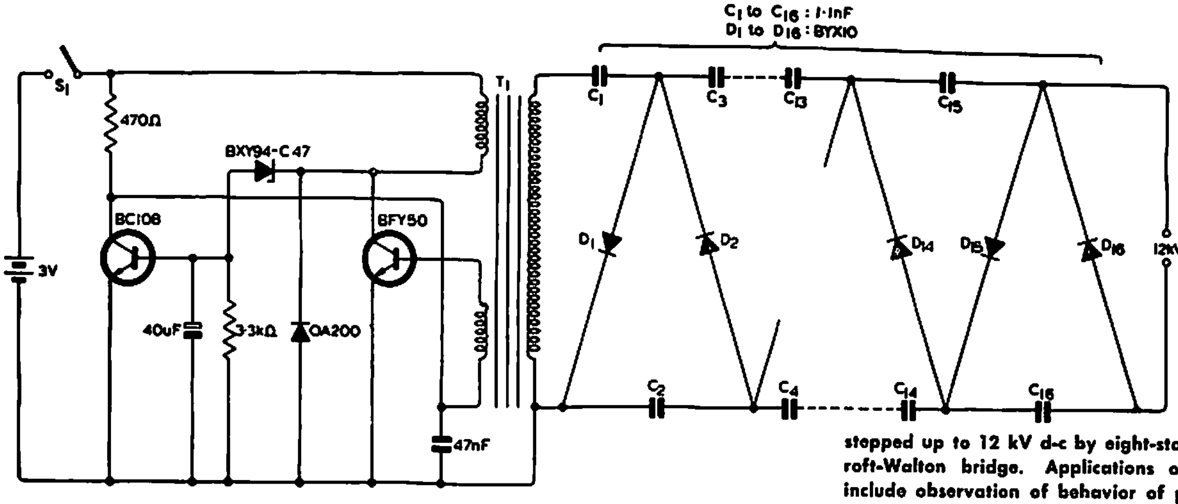

S1
R1
100K
LIGHT
PC1
GE-X6
SCR1
GEX5
B1
22-1/2V
+
-
R2
500K
SENSITIVITY
ADJUST
C1
1µf
25V
4 TO 8 Ω
SPEAKER OR
EARPHONES


+27V
R1
Blank
load
R2
47kΩ
R6
47kΩ
R7
470
kΩ
Control
Voltage
C3
2·5
µF
R10
10kΩ
R12
10kΩ
D1 BZY88
C9V1
TR3
BCY71
TR4
BCY71
R11
+9V
TR1
BC109
TR2
BC109
RV1
100 kΩ
R9
6·8
kΩ
C1
10nF
R13
1·2
kΩ
R15
100Ω
TR7
BCY71
R3
1kΩ
R5
1kΩ
C2
10nF
R14
1·2
kΩ
T1
Active
cell
R4
47
kΩ
R8
390
kΩ
TR5
BC109
TR6
BC109
0V

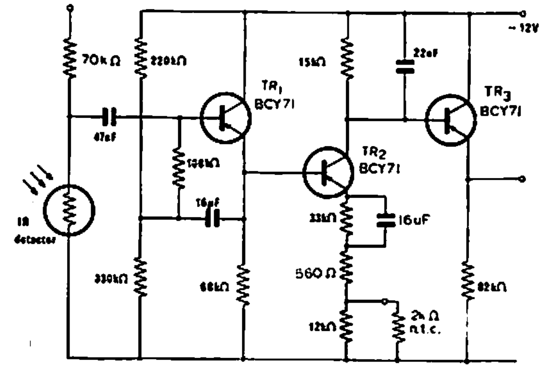
LOCATING FIRE IN SMOKE—Uses uncooled lead sulfide cell with lens to pick up source of fire or heat when visibility is completely obscured by smoke, dust, or fumes. Cell is Mullard developmental type 119CPY. Additional cell R1 is blacked out and serves as temperature-compensating load for active cell, which drives adjustable-gain preamp that controls base currents of square-wave relaxation oscillator TR5-TR6. Emitter-follower TR7 provides necessary current gain for driving speaker which gives low note of about 100 Hz for no fire and increasing pitch up to 10 kHz for increasing infrared radiation from fire. Unit is portable and battery-operated, to permit use by firemen in aiming hose.—P. R. D. Colaby, Simple Heat Locator Using Infrared Detector, *Mullard Technical Communications*, May 1968, p 86–88.


OA200
OA200
1kΩ
1kΩ
1·5kΩ
Motor
OC22
OAZ204
100µF
10V
+
BCY71
BCY71
1kΩ
OC202
Output
Output
BPX25
BPX25
2·2kΩ
2·2kΩ
1kΩ
-6V
560Ω
-12V

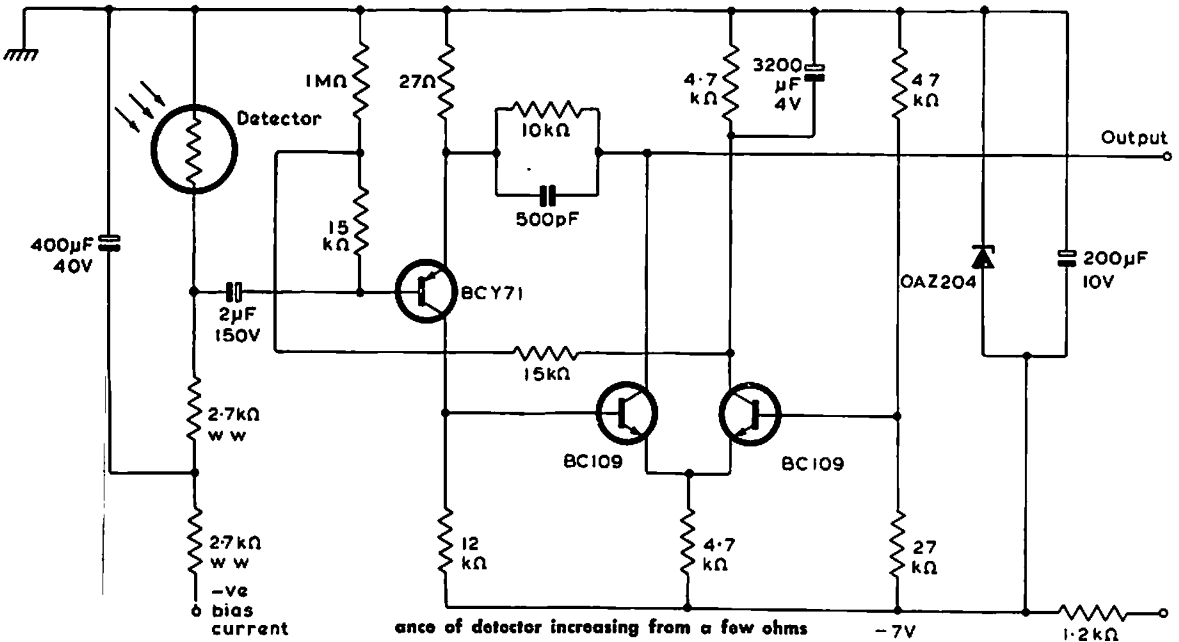
IR CAMERA PULSE AMPLIFIER—Uses pair of BPX25 silicon phototransistors receiving light pulses through rotating 30-hole Nipkow scanning disc on which infrared image is focused. One phototransistor receives sync pulses from uniformly spaced holes on disc, and other receives pulses from scanning spiral of holes. Resulting electrical pulses are squared, amplified, and applied to time bases of camera feeding standard oscilloscope. Motor drive circuit at right, for disc, applies constant voltage to motor, with 1K pot providing 10% range of speed control. Used for examining patients for cancerous growths, locating hot spots on circuit boards, and detecting flaws in glass furnace walls.—M. H. Jervis, Closed Circuit Infrared Television System, Mullard Ltd., London, TP950, 1967.


C1 to C16 : 1·1nF
D1 to D16 : BYX10
S1
470Ω
BXY94-C47
BC108
BFY50
3V
40uF
3·3kΩ
OA200
47nF
T1
C1
C3
C13
C15
D1
D2
D14
D15
D16
12kV
C2
C4
C14
C16

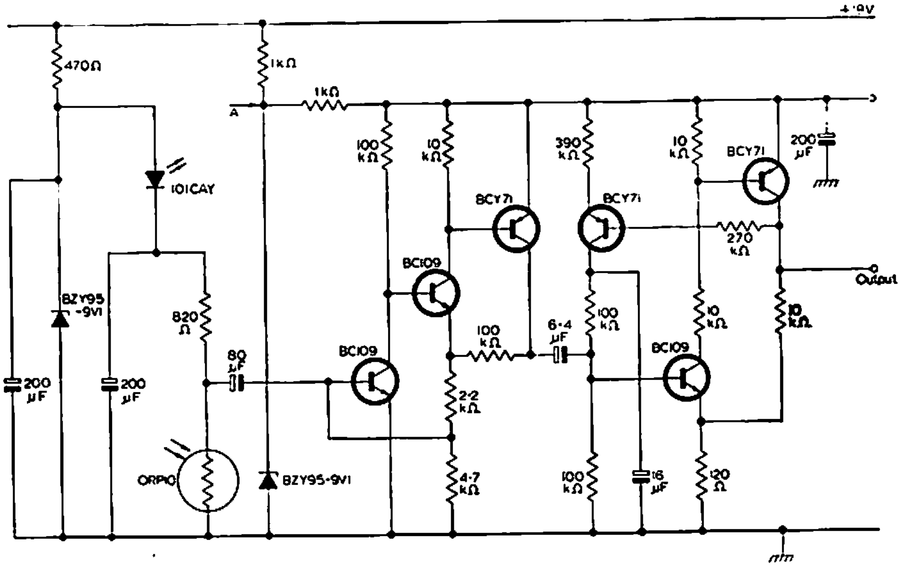
12 KV D-C—Used with Mullard 6929-1 image converter tube for converting near-infrared radiation to visible yellow-green emitted radiation. Uses simple blocking oscillator operating from 3-V battery to drive high-ratio transformer giving 1.5-kV pulses. These are stepped up to 12 kV d-c by eight-stage Cockroft-Walton bridge. Applications of system include observation of behavior of people in the dark, animals at night, scatter from laser beams, and hot-spots on defective high-voltage insulators.—Infrared Image Convertor, Mullard Ltd., London, TP898, 1967.


−12V
70kΩ
220kΩ
47nF
TR1
BCY71
15kΩ
22nF
TR3
BCY71
130kΩ
TR2
BCY71
IR
detector
16μF
33kΩ
16uF
330kΩ
68kΩ
560Ω
82kΩ
12kΩ
2k Ω
n.t.c.

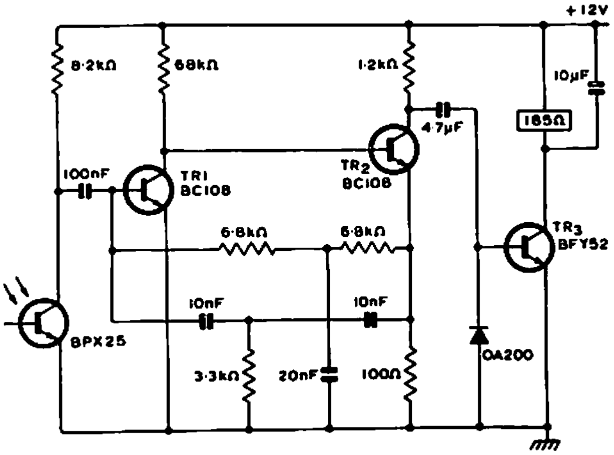
RADIATION THERMOMETER—Covers 100 to 500 C in five ranges, using linear amplification. Detector is Mullard 615V lead sulfide cell having high infrared sensitivity at room temperature, for measuring radiant energy from surface of target. Energy from target is conducted to chopper wheel by light pipe, for a-c input to head amplifier that provides necessary transformation from high to low impedance and compensates for decrease in cell sensitivity with increasing ambient temperature.—P. R. D. Coleby, Radiation Thermometer for Temperatures Greater than 100 deg C, *Mullard Technical Communications*, May 1968, p 91–98.


Detector
IMΩ
27Ω
10kΩ
500pF
4·7 kΩ
3200 μF 4V
47 kΩ
Output
400μF 40V
15 kΩ
BCY71
2μF 150V
OAZ204
200μF 10V
15kΩ
2·7kΩ w w
BC109
BC109
2·7kΩ w w
12 kΩ
4·7 kΩ
27 kΩ
−ve bias current
−7V
1·2kΩ

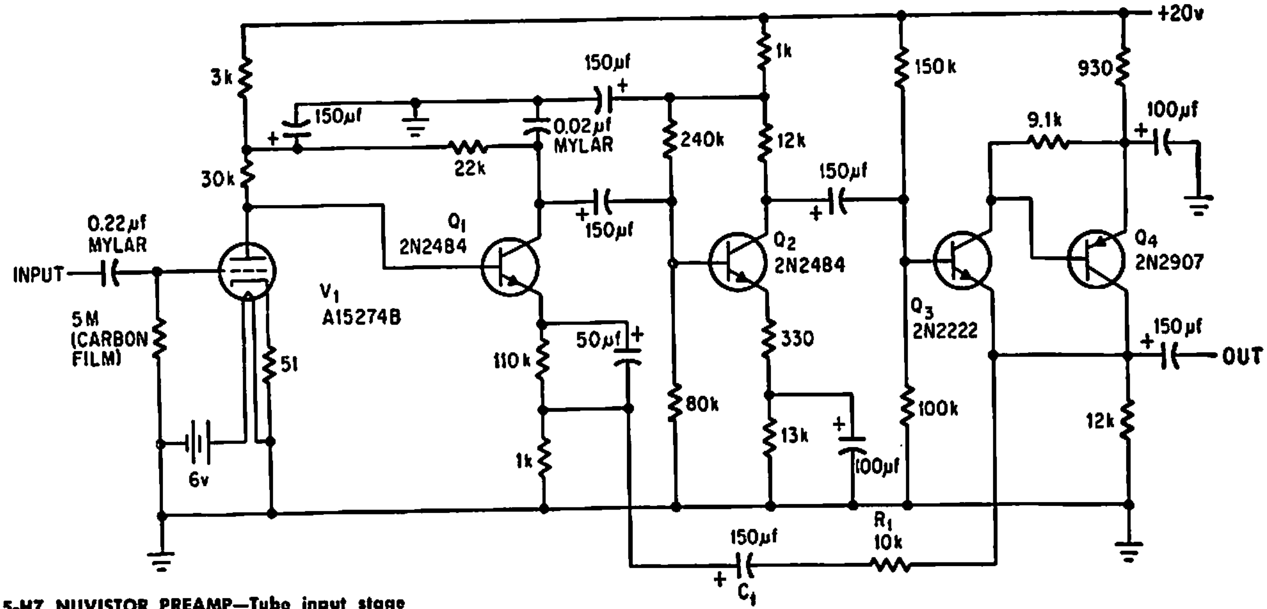
INDIUM ANTIMONIDE DETECTOR PREAMP—Will detect temperature changes from room temperature down to 77 deg K, with impedance of detector increasing from a few ohms at room temperature to about 200 ohms when back of detector is cooled by liquid nitrogen drip-feed system. Used in industrial and medical thermal scanning systems employing 30-hole Nipkow scanning disc.—M. H. Jervis, Closed Circuit Infrared Television System, Mullard Ltd., London, TP950, 1967.


+9V
470Ω
1kΩ
1kΩ
A
101CAY
BZY95 -9V1
200 μF
200 μF
820 Ω
80 μF
ORP10
BZY95-9V1
100 kΩ
10 kΩ
BC109
BC109
BCY71
100 kΩ
2·2 kΩ
4·7 kΩ
390 kΩ
BCY71
6·4 μF
100 kΩ
100 kΩ
16 μF
10 kΩ
BCY71
200 μF
270 kΩ
10 kΩ
BC109
10 kΩ
120 Ω
Output

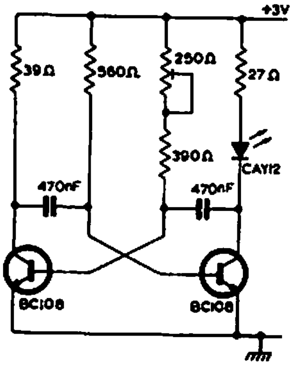
IR CLINICAL THERMOMETER—Covers range of 30 to 40 C, for measuring temperature of external auditory canal. Closely approximates oral measurements. Uses Mullard ORP10 uncooled indium antimonide cell for which radiation is interrupted at about 600 Hz by motor-driven chopper. Resulting a-c signal is amplified by flat-response wideband amplifier, mixed with signal corresponding to room temperature, then fed to phase-sensitive rectifier that derives its reference signal from interruption of secondary beam of radiation (between 101CAY emitter and BPX25 detector) by same chopper blade. Direct current from rectifier drives indicating meter. Article gives all circuits.—R. A. Lockett, Room Temperature Radiation Thermometer, *Mullard Technical Communications*, May 1968, p 98–101.


+12V
8·2kΩ
68kΩ
1·2kΩ
10μF
4·7μF
185Ω
100nF
TR1 BC108
TR2 BC108
TR3 BFY52
6·8kΩ
6·8kΩ
10nF
10nF
3·3kΩ
20nF
100Ω
OA200
BPX25

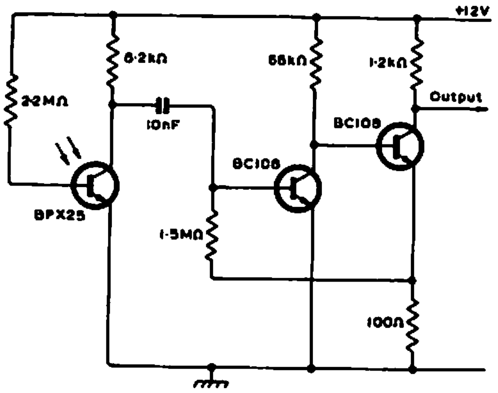
CODED-LIGHT DETECTOR—Tuned amplifier following phototransistor has twin-T network that greatly attenuates all signals more than 1 Hz off from 2.7 kHz. Only light within this narrow passband will turn on TR3 and energize load. One application is in photoelectric safety devices, where stray light might negate interruption of safety beam.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.


+20v
3k
150μf
150μf
0.02μf MYLAR
22k
30k
1k
240k
12k
150k
930
100μf
9.1k
150μf
0.22μf MYLAR
INPUT
150μf
Q1 2N2484
Q2 2N2484
Q3 2N2222
Q4 2N2907
V1 A15274B
5M (CARBON FILM)
51
110k
50μf
330
80k
13k
100μf
100k
150μf
OUT
12k
1k
6v
150μf
C1
R1 10k

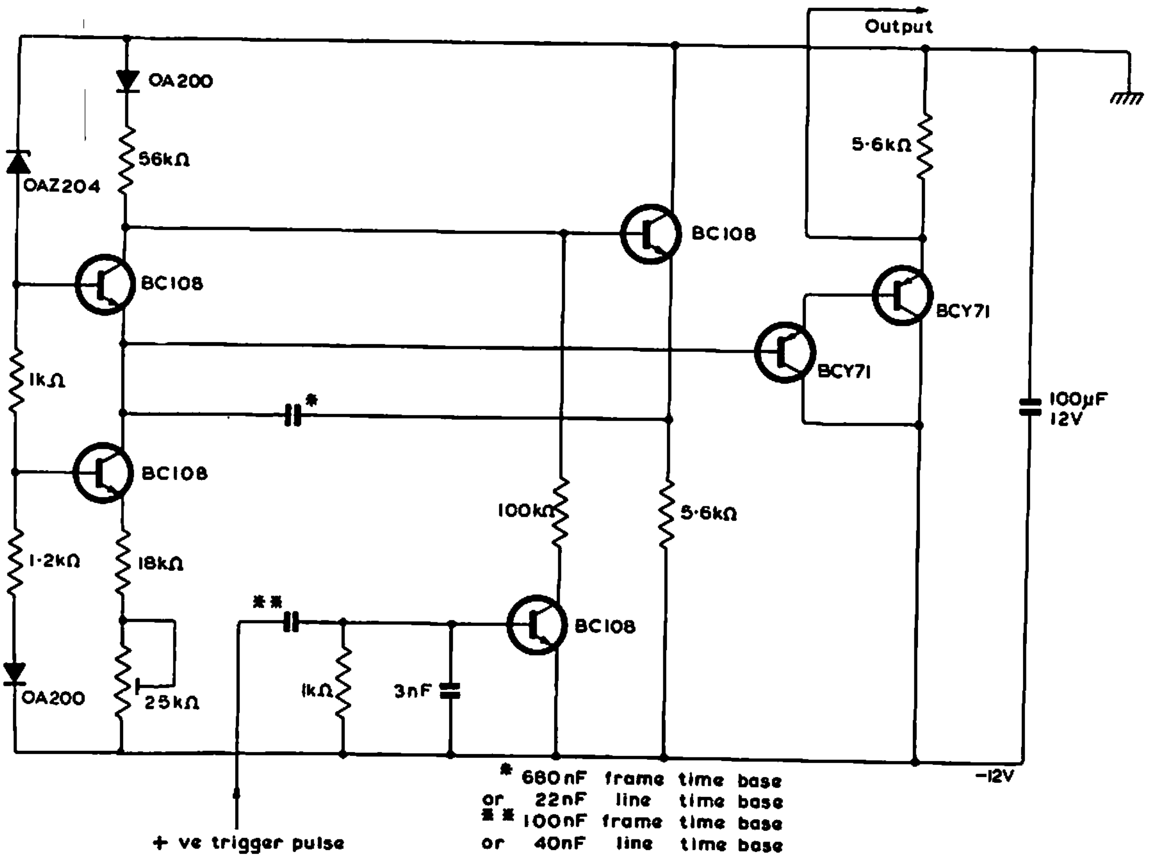
15-HZ NUVISTOR PREAMP—Tube input stage has much lower internal noise than bipolar transistor, and provides sufficient amplification to overcome noise of following transistor stages. Used in narrow-band signal processor for infrared radiometer. Gain overall is 40 dB, with less than 0.1 dB variation from −40 C to 60 C.—G. C. Kuipers, Front-End Nuvistor Lowers Transistor Amplifier Noise, *Electronics*, Oct. 31, 1966, p 71–72.


+3V
39Ω
560Ω
250Ω
27Ω
390Ω
CAY12
470nF
470nF
BC108
BC108

CODED INFRARED SOURCE—Used when unmodulated visible or infrared beam may be subject to interference from nearby stray light sources. Gallium arsenide light-emitting diode is energized by mvbr whose frequency is adjusted to match that of coded infrared source. Although mvbr modulator gives square-wave output, typically at 2.7 kHz, coded-beam detector responds to fundamental frequency.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.

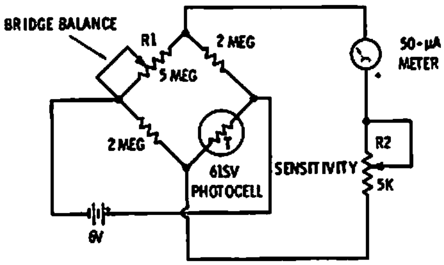

+12V
6·2kΩ
68kΩ
1·2kΩ
Output
2·2MΩ
10nF
BC108
BC108
BPX25
1·5MΩ
100Ω

INFRARED DETECTOR—Uses BPX25 phototransistor which has good sensitivity to near infrared wavelengths. With two amplifier stages, peak input of 1 lux will produce peak output of 400 mV. Response at 4 kHz is 3 dB below that at 1 kHz. Provides compact communication system giving secrecy and freedom from interference at ranges up to 100 ft when using either f:2 collimating lenses or parabolical reflectors at light source and at phototransistor. For near infrared, ordinary glass lenses are satisfactory.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, Netherlands, No. 316, 1967.

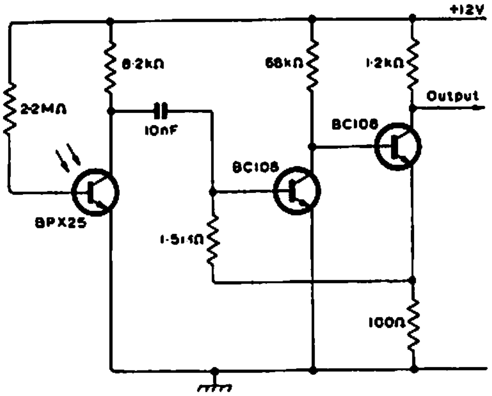

Output
OA200
56kΩ
OAZ204
BC108
BC108
1kΩ
BCY71
BCY71
*
100µF 12V
BC108
1·2kΩ
18kΩ
100kΩ
5·6kΩ
5·6kΩ
**
BC108
OA200
25kΩ
1kΩ
3nF
-12V
+ ve trigger pulse

* 680nF frame time base
or 22nF line time base
** 100nF frame time base
or 40nF line time base

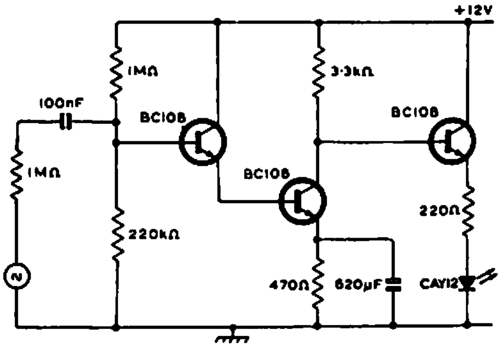
IR CAMERA TIME BASES—Circuits for X and Y inputs of display crο for infrared Nipkow-disc scanning camera are identical sawtooth generators except for timing capacitor changes indicated below diagram. Trigger pulses are obtained from pulse amplifier fed by phototransistor. Used in medical and industrial infrared applications.—M. H. Jervis, Closed Circuit Infrared Television System, Mullard Ltd., London, TP950, 1967.


BRIDGE BALANCE
R1
5 MEG
2 MEG
2 MEG
T
61SV PHOTOCELL
6V
SENSITIVITY
R2
5K
50-µA METER

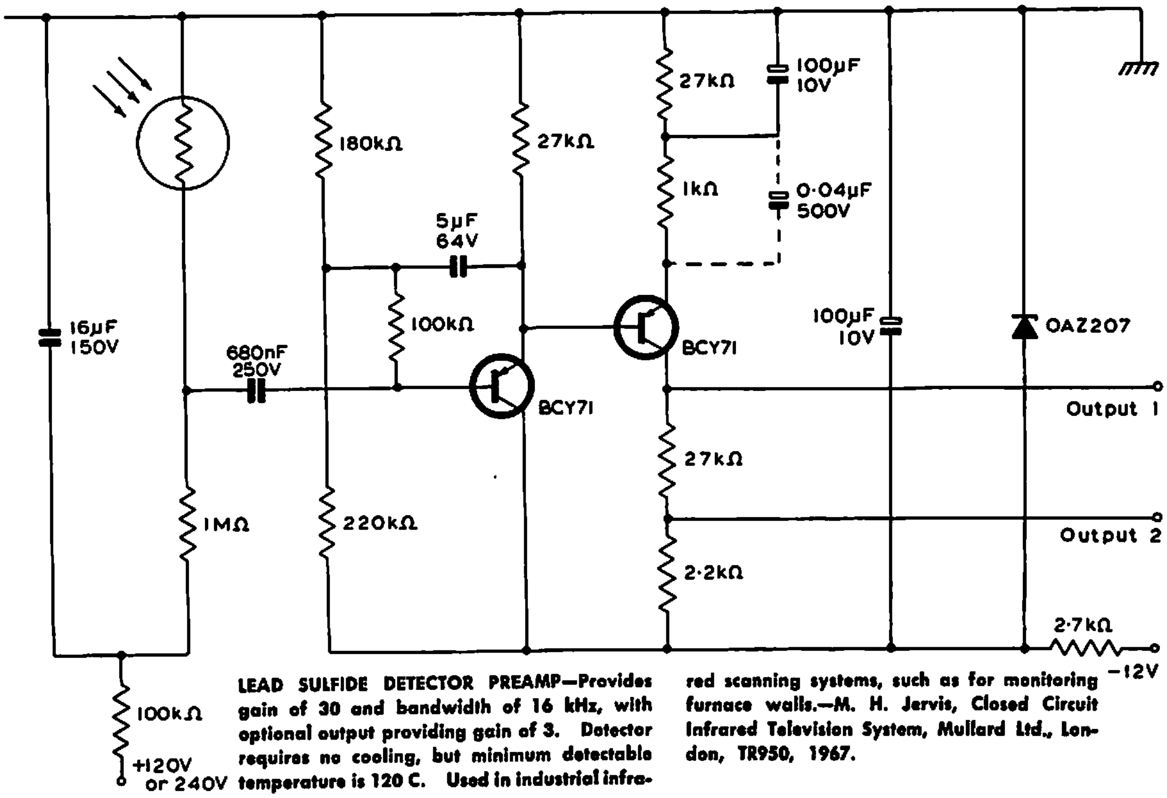
NONCONTACTING TEMPERATURE SENSOR—Simple resistance bridge having Amperex 61SV infrared photocell in one leg permits measuring temperature of furnace, flat iron, or other heated objects from distance of several feet. When bridge is balanced, meter will read upscale when cell resistance is decreased by exposure to infrared radiation. —J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 11.


+12V
8·2kΩ
68kΩ
1·2kΩ
Output
2·2MΩ
10nF
BC108
BC108
BPX25
1·5kΩ
100Ω

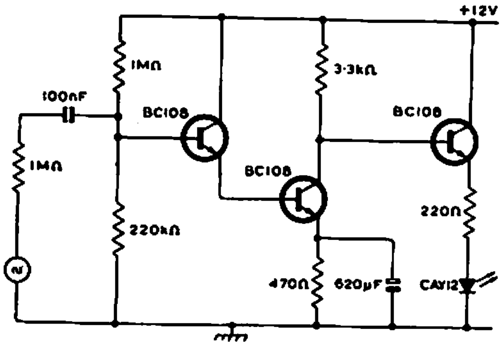
IR COMMUNICATION DETECTOR—Uses BPX25 phototransistor followed by two amplifying stages to pick up modulated infrared radiation in communication system. Range is over 100 ft when using modulated gallium arsenide diode as light source.—Silicon Planar Phototransistors, Mullard Ltd., London, TP1000, 1968.


+12V
1MΩ
3·3kΩ
100nF
BC108
BC108
BC108
1MΩ
220kΩ
220Ω
470Ω
620µF
CAY12

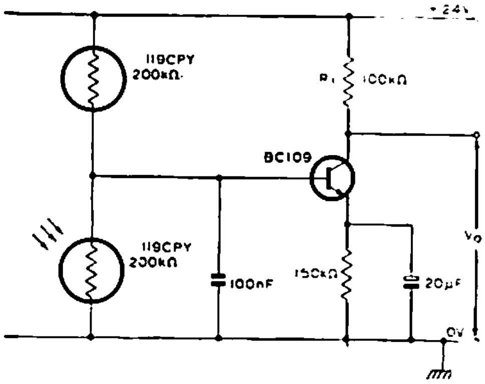
IR COMMUNICATION SOURCE—Gallium arsenide light-emitting diode is fed by microphone or other signal source driving three-stage amplifier. Response at 80 kHz is 3 dB below that at 1 kHz. Range is up to about 100 ft when using BPX25 phototransistor at receiving end.—Silicon Planar Phototransistors, Mullard Ltd., London, TP1000, 1968.


27kΩ
100µF 10V
180kΩ
27kΩ
1kΩ
0·04µF 500V
5µF 64V
100kΩ
16µF 150V
680nF 250V
BCY71
BCY71
100µF 10V
OAZ207
Output 1
27kΩ
Output 2
1MΩ
220kΩ
2·2kΩ
2·7kΩ
−12V
100kΩ
+120V or 240V

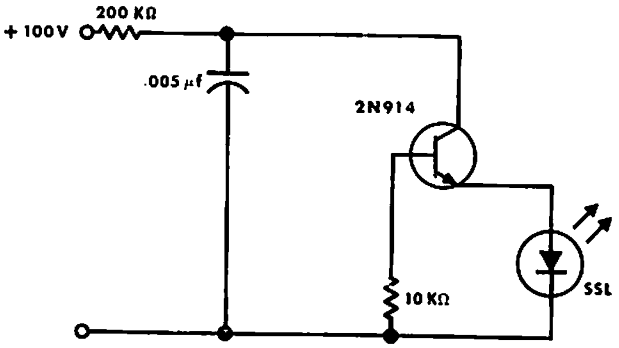
LEAD SULFIDE DETECTOR PREAMP—Provides gain of 30 and bandwidth of 16 kHz, with optional output providing gain of 3. Detector requires no cooling, but minimum detectable temperature is 120 C. Used in industrial infrared scanning systems, such as for monitoring furnace walls.—M. H. Jervis, Closed Circuit Infrared Television System, Mullard Ltd., London, TR950, 1967.



INFRARED MODULATOR—Serves as transmitter for short-range communication system using modulated infrared radiation. Light source at output of audio amplifier is CAY12 gallium arsenide diode. Can be used well above audio range, because response at 80 kHz is only 3 dB below that at 1 kHz. Peak diode current at 10 mA is obtained with input of 150 mV peak from microphone or other source.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.



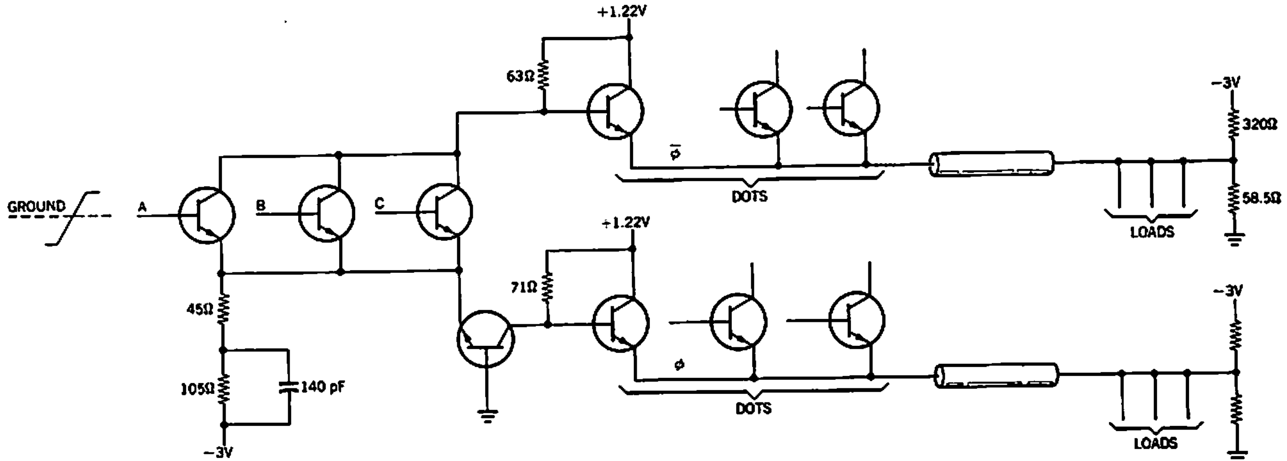
FIRE ALARM—Infrared flame detector produces voltage for actuating alarm as soon as flame occurs in field of view of Mullard 61SV lead sulfide detector which contains two 119CPY cells. Upper cell is covered, and serves to provide tracking with temperature changes. Circuit feeds bistable circuit (shown in article) that drives audible alarm such as Mallory Sonalert.—P. R. D. Coleby, Fire Alarm System Using Infrared Flame Detector, *Mullard Technical Communications*, May 1968, p 82–86.



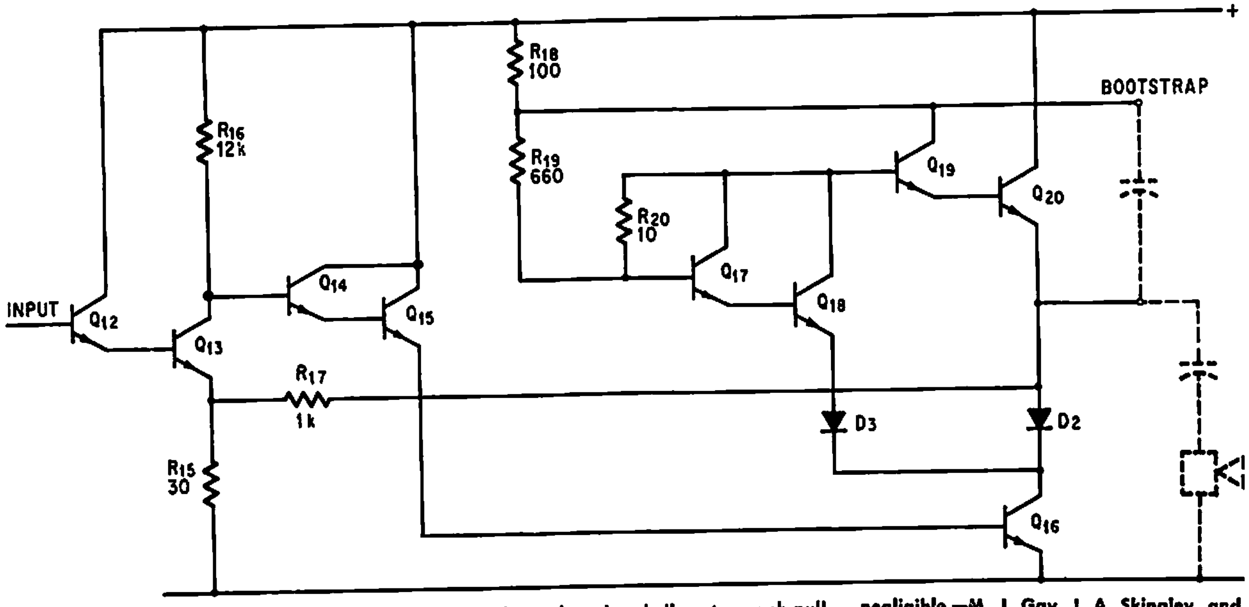
SSL OSCILLATOR—Gallium arsenide solid-state lamp in avalanche-transistor oscillator produces IR pulse durations in nanosecond range, with infrared power output of a few mW and pulse repetition rates of several kHz.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 7.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

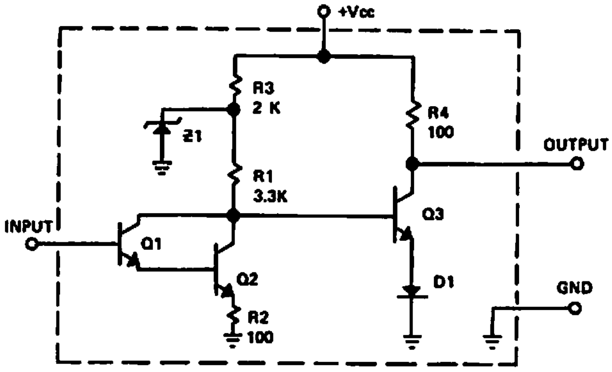
CHAPTER 41
Integrated Circuits


+1.22V
63Ω
−3V
320Ω
$\bar{\phi}$
DOTS
58.5Ω
LOADS
GROUND
A
B
C
+1.22V
71Ω
45Ω
−3V
105Ω
140 pF
ϕ
DOTS
LOADS
−3V

ASLT IC FOR IBM 360/91—Double-level logic block with high fan power, predictable delays, and 5-ns propagation time utilizes full switching-speed potential of high-performance 1-GHz transistors by incorporating phase-compensating network in emitter current source. Article covers design procedure for module.—R. F. Sechler, A. R. Strube, and J. R. Turnbull, ASLT Circuit Design, *IBM Journal*, Jan. 1967, p 74–85.

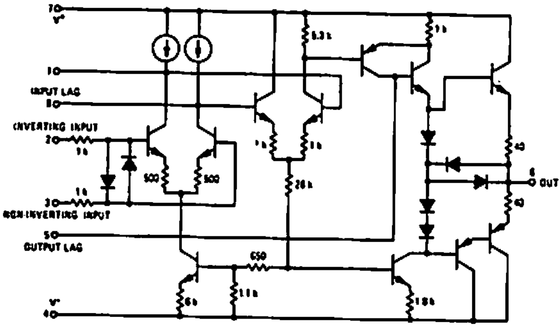

+
R18
100
BOOTSTRAP
R16
12k
R19
660
Q19
Q20
R20
10
Q17
Q14
INPUT
Q12
Q13
Q15
Q18
R17
1k
D3
D2
R15
30
Q16

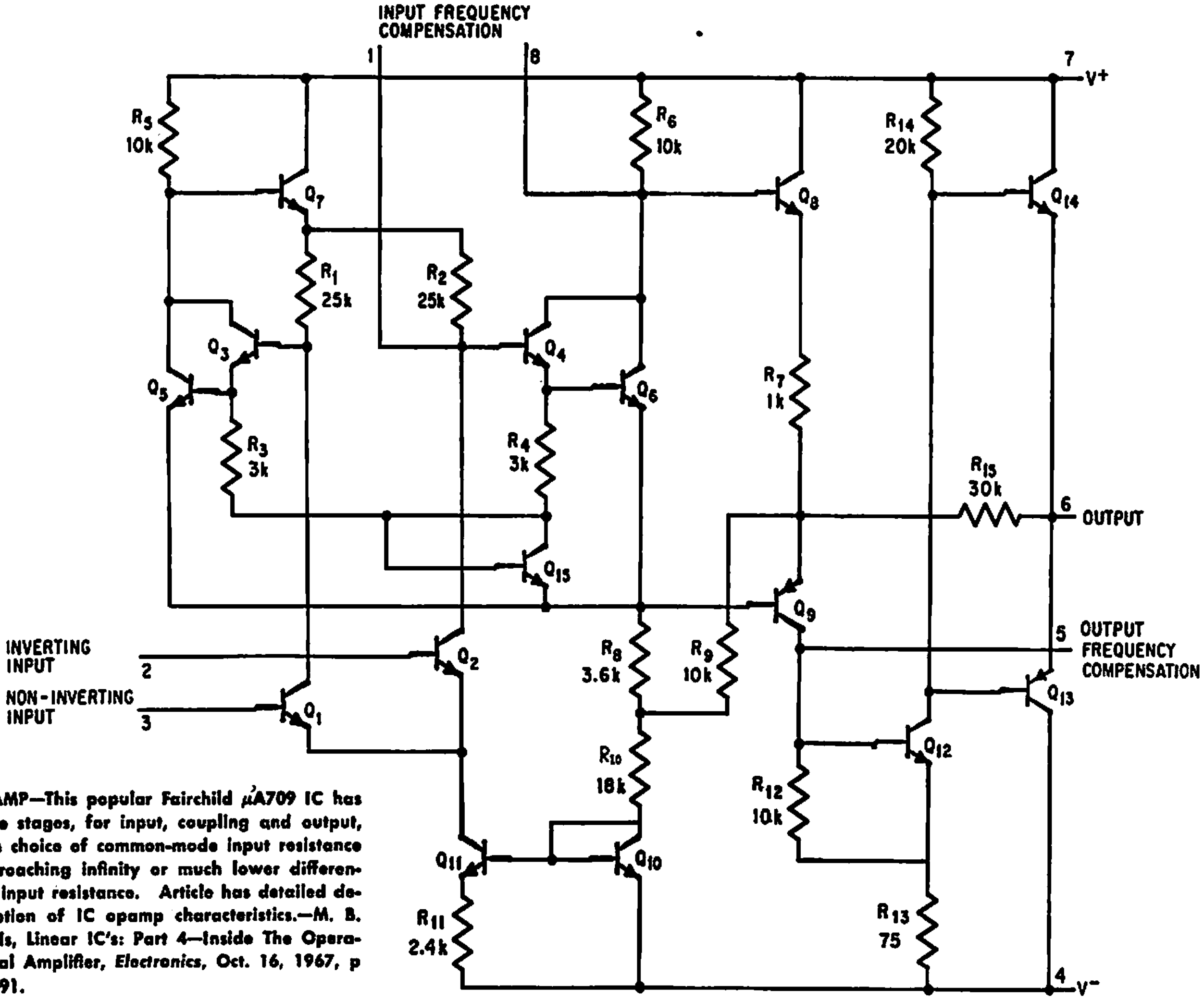
AUDIO AMPLIFIER—Circuit shown is portion of single 20-pin IC containing all circuits for 3-W British car radio except i-f filter and r-f tuner. Handles up to 1.5 A to produce 3-W output. Operation is similar to push-pull circuit but without phase splitter and output transformer. Uses large negative feedback for good linearity. Crossover distortion is negligible.—M. J. Gay, J. A. Skingley, and M. C. Sucker, Lots of Radio on Just One IC, *Electronics*, Aug. 5, 1968, p 124–129.


+Vcc
R3
2 K
Z1
R1
3.3K
R4
100
OUTPUT
INPUT
Q1
Q2
R2
100
Q3
D1
GND

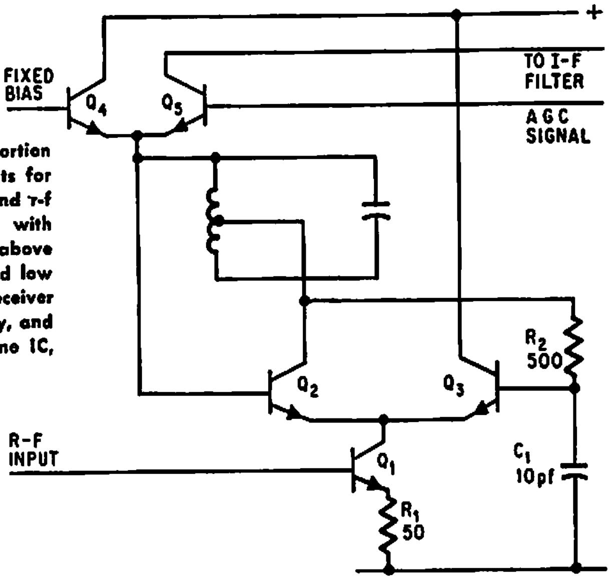
MIC0201 AUDIO DRIVER—Designed to drive single-ended pnp germanium power output transistors. Consists of Darlington input stage Q1-Q2 providing high input impedance with both voltage and current gain, feeding common-emitter amplifier Q3. Requires 12 V d-c supply.—M. L. Deschler, Integrated Circuit Audio Driver Amplifier, Mallory, Indianapolis, Ind., APPN-1, 1968.

MC1539 OPAMP—Motorola IC features open-loop gain of 120,000, high slew rate of 34 V per μs, input diode limiting for overvoltage protection, and output current-limiting protection.—K. Huehne, The Continuing Dominance of the Operational Amplifier, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 5–13.

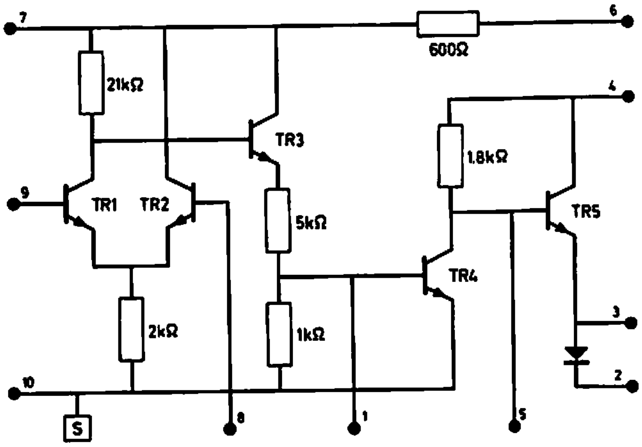

7
V+
1
INPUT LAG
8
INVERTING INPUT
2
NON-INVERTING INPUT
3
5
OUTPUT LAG
V-
4
6
OUTPUT


INPUT FREQUENCY COMPENSATION
1
8
7
V+
R5
10k
Q7
R6
10k
Q8
R14
20k
Q14
R1
25k
R2
25k
Q3
Q4
Q5
Q6
R7
1k
R3
3k
R4
3k
R15
30k
6
OUTPUT
Q15
Q9
INVERTING INPUT
2
NON-INVERTING INPUT
3
Q2
Q1
R8
3.6k
R9
10k
5
OUTPUT FREQUENCY COMPENSATION
Q13
Q12
R10
18k
R12
10k
Q11
Q10
R11
2.4k
R13
75
4
V-

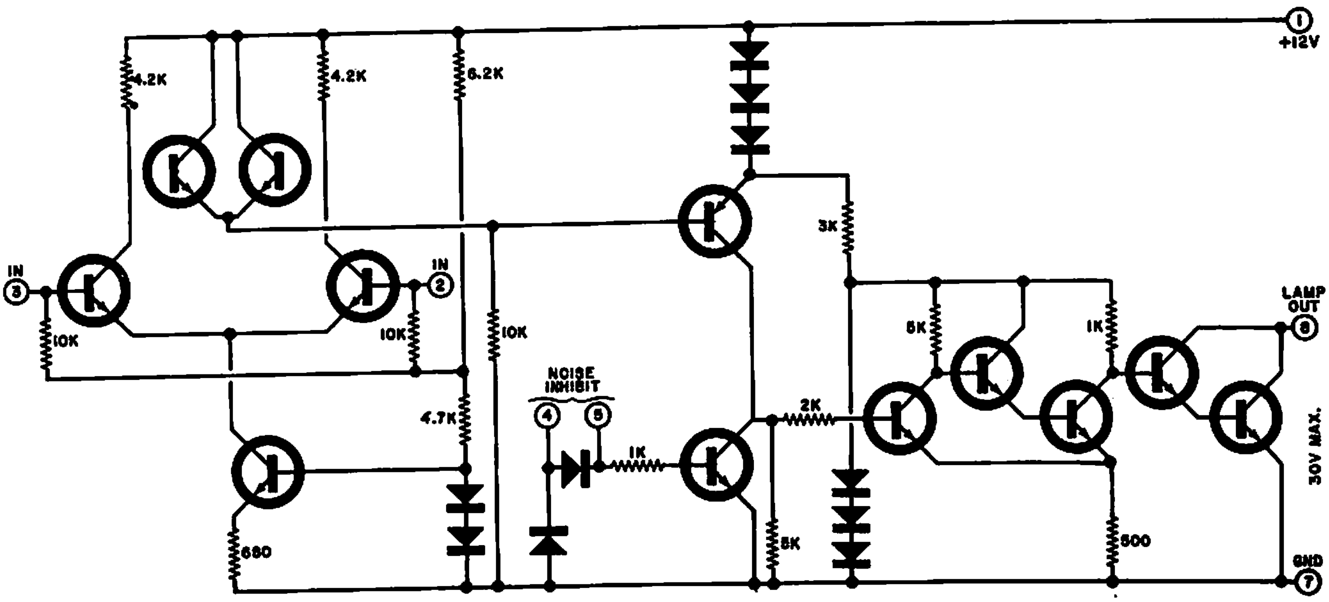
OPAMP—This popular Fairchild μA709 IC has three stages, for input, coupling and output, with choice of common-mode input resistance approaching infinity or much lower differential input resistance. Article has detailed description of IC opamp characteristics.—M. B. Leeds, Linear IC's: Part 4—Inside The Operational Amplifier, *Electronics*, Oct. 16, 1967, p 86–91.


FIXED BIAS
Q_4
Q_5
+
TO I-F FILTER
AGC SIGNAL
R_2 500
Q_2
Q_3
R-F INPUT
Q_1
C_1 10pf
R_1 50

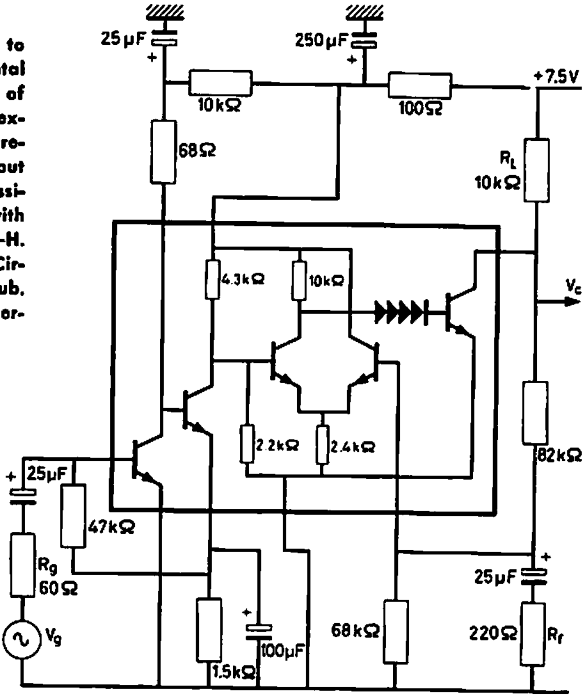
OSCILLATING MIXER—Circuit shown is portion of single 20-pin IC containing all circuits for 3-W British car radio except i-f filter and r-f tuner. Serves as self-oscillating mixer with agc, for handling peak signals well above 100 mV with 41-dB conversion gain and low distortion. Article gives complete receiver circuit on chip.—M. J. Gay, J. A. Skingley, and M. C. Sucker, Lots of Radio on Just One IC, *Electronics*, Aug. 5, 1968, p 124–129.


7
6
600Ω
21kΩ
TR3
4
1.8kΩ
9
TR1
TR2
5kΩ
TR5
TR4
2kΩ
1kΩ
3
10
2
S
8
1
5

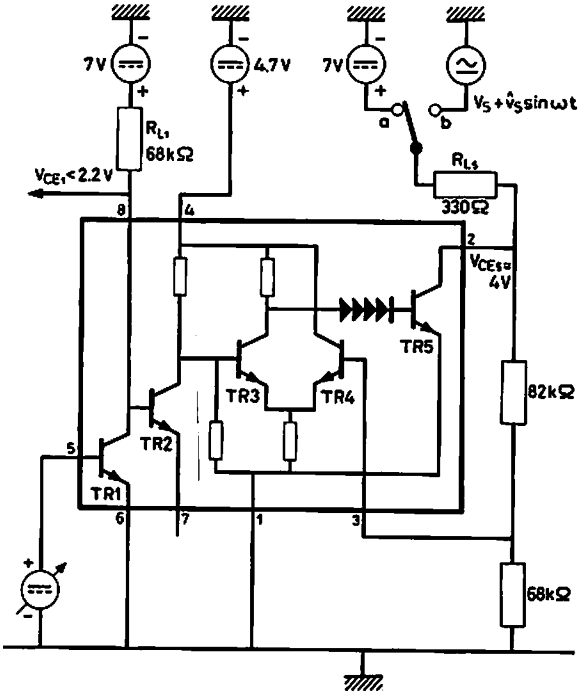
TAA435 A-F DRIVER—Philips TAA435 IC audio amplifier is intended for driving complementary output stages in medium-power audio amplifiers. TR1 and TR2 form differential amplifier permitting both a-c and d-c feedback to be applied. Input impedance is above 70K. Supply voltage can be 10 to 18 V.—Complementary Output Stages Driven by the TAA435, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 18, 1968.


4.2K
4.2K
6.2K
①
+12V
3K
IN
③
IN
②
LAMP OUT
⑧
10K
10K
10K
5K
1K
NOISE INHIBIT
④
⑤
4.7K
2K
1K
680
5K
500
30V MAX.
GND
⑦

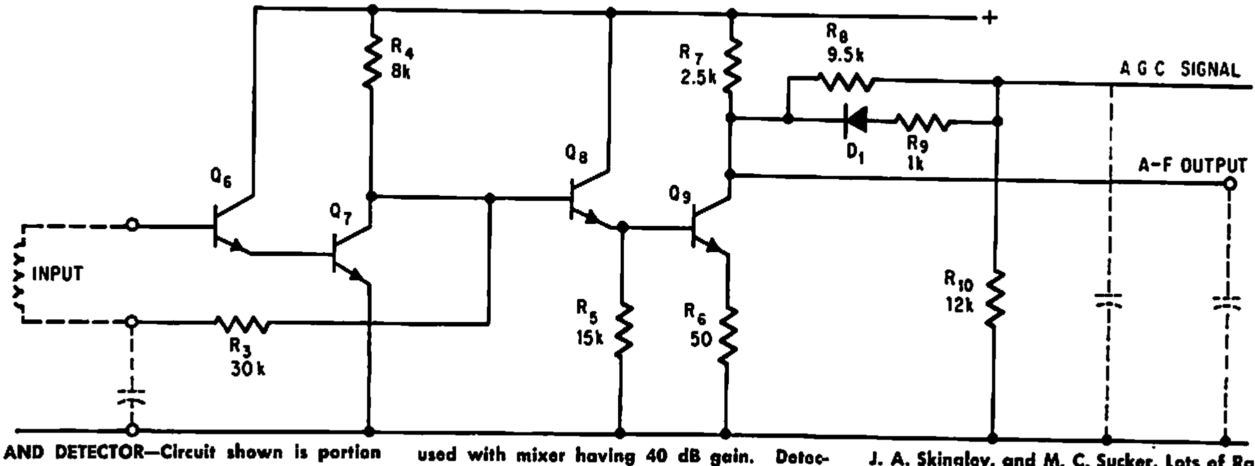
PERFECT TUNE LAMP DRIVE—Single IC chip serves as computer-type comparator circuit that turns on "Perfect Tune" lamp when set is tuned to exact center point for f-m station. Interstation noise is filtered, amplified, and rectified to turn off light between stations. IC-304 chip was made by Motorola for H. H. Scott hi-fi f-m receiver.—L. W. Fish, Jr. and K. J. Peter, New Concepts in Hi-Fi Receiver Design, *Electronics World*, Feb. 1969, p 32–34 and 69–70.


25µF
250µF
+
+
+7.5V
10kΩ
100Ω
68Ω
R_L
10kΩ
4.3kΩ
10kΩ
V_c
2.2kΩ
2.4kΩ
82kΩ
+
25µF
47kΩ
R_g
60Ω
V_g
+
100µF
1.5kΩ
68kΩ
+
25µF
220Ω
R_f

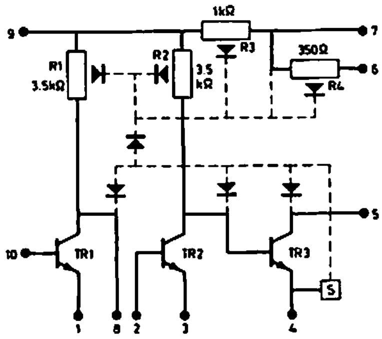
THERMAL STABILITY IN IC PREAMP—Used to determine frequency response of experimental IC preamp near lower limiting frequency of 4 Hz. Effects of thermal feedback were excluded as far as possible by making measurements with load resistance RL of output transistor increased to 10K so collector dissipation here is negligible. Article deals with methods of improving thermal stability.—H. Schmidt, Thermal Feedback in Integrated Circuits, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 1, 1968, p 29–39.


7V
4.7V
7V
-
+
R_L1
68kΩ
V_CE1<2.2V
V_S+v̂_S sinωt
a
b
R_L5
330Ω
8
4
2
V_CE5≈4V
TR5
TR3
TR4
TR2
TR1
5
6
7
1
3
82kΩ
68kΩ

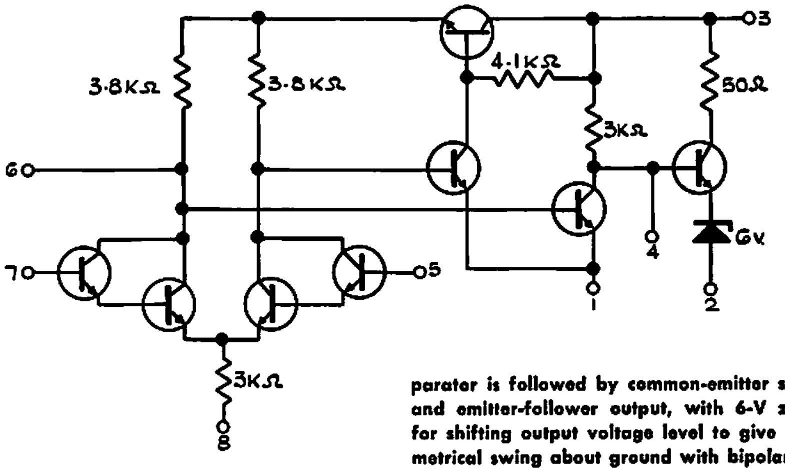
THERMAL FEEDBACK IN IC PREAMP—Experimental multistage IC preamplifier was developed to investigate transmission properties of heat path from output transistor TR5 to input transistor TR1. With switch in position a, TR5 has constant collector dissipation, for investigating thermal switching-on transient. With switch in position b, sinusoidal heat wave is generated in TR5 at frequencies ranging from 3 to 400 Hz, and propagation and phase shift of wave are analyzed. Article presents methods of improving thermal stability in integrated circuits.—H. Schmidt, Thermal Feedback in Integrated Circuits, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 1, 1968, p 29–39.


+
R_4
8k
R_7
2.5k
R_8
9.5k
A G C SIGNAL
D_1
R_9
1k
A-F OUTPUT
Q_6
Q_7
Q_8
Q_9
INPUT
R_3
30k
R_5
15k
R_6
50
R_10
12k

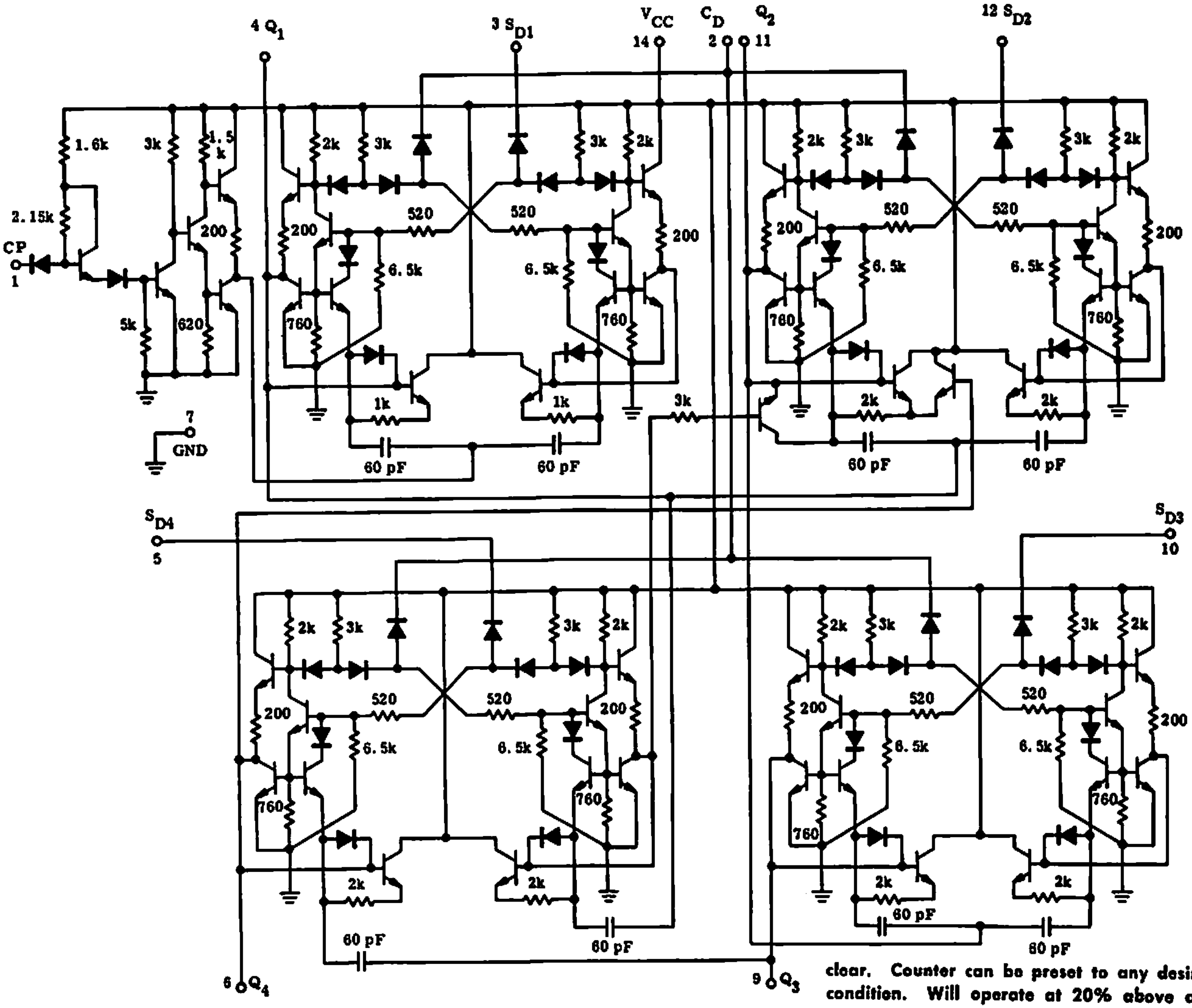
I-F AND DETECTOR—Circuit shown is portion of single 20-pin IC containing all circuits for 3-W British car radio except i-f filter and r-f tuner. Provides only 40 dB gain because used with mixer having 40 dB gain. Detector is directly coupled to final i-f. Input from mixer is about 200 mV rms. Article gives complete receiver circuit on chip.—M. J. Gay, J. A. Skingley, and M. C. Sucker, Lots of Radio on Just One IC, *Electronics*, Aug. 5, 1968, p 124–129.


1kΩ
R3
350Ω
R4
R1
3.5kΩ
R2
3.5 kΩ
TR1
TR2
TR3
S
9
7
6
5
10
1
8
2
3
4

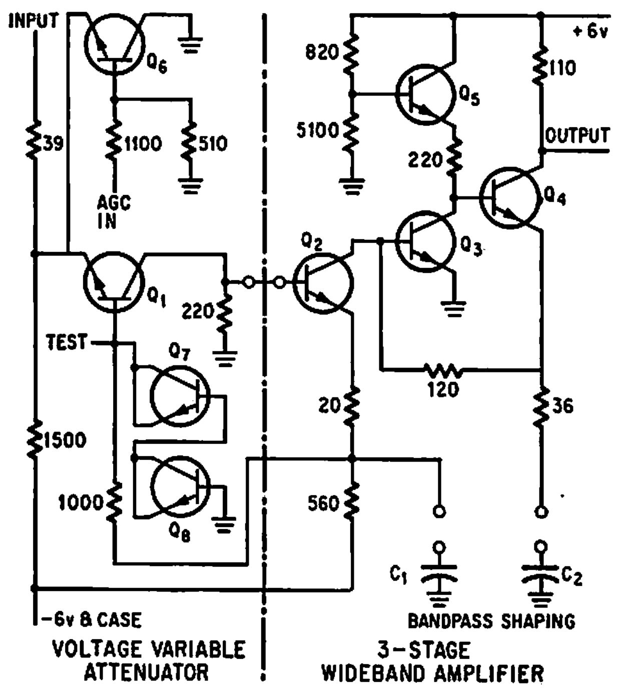
TAA293 AMPLIFIER—Contains three transistors and four resistors, which can be connected to minimum of external components for use as voltage-operated or current-operated Schmitt trigger, astable mvbr, or mono mvbr.—The TAA293 as a Schmitt Trigger and Multivibrator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 25, 1968.


3.8KΩ
3.8KΩ
4.1KΩ
3KΩ
50Ω
6V
3KΩ
6
7
5
8
4
1
2
3

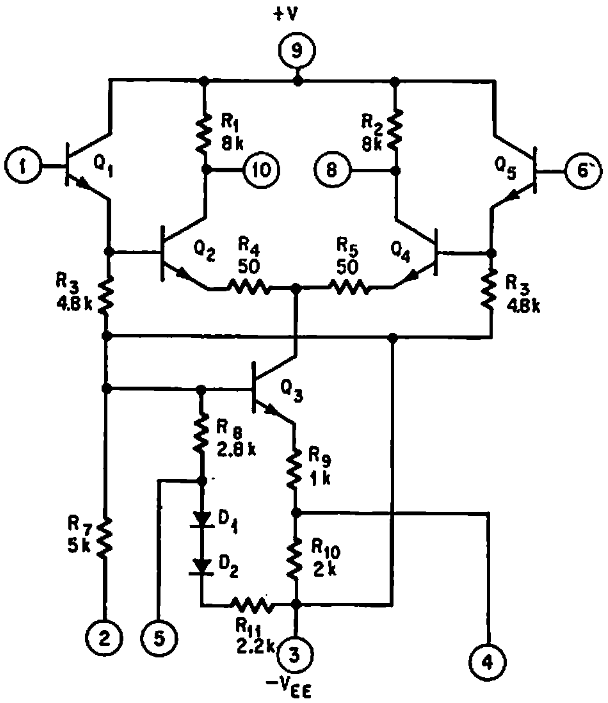
SL701 D-C AMPLIFIER—Uses precision comparator front end with Darlington compound pairs in long-tailed pair configuration. Comparator is followed by common-emitter stage and emitter-follower output, with 6-V zener for shifting output voltage level to give symmetrical swing about ground with bipolar 12-V supply.—R. C. Foss and B. J. Green, The SL700 Series and Applications, Plessey, Swindon, England, No. 7.


4 Q_1
3 S_{D1}
V_{CC}
14
C_D
2
Q_2
11
12 S_{D2}
1.6k
3k
1.5 k
2.15k
CP
1
200
5k
620
7
GND
2k
3k
520
6.5k
760
1k
60 pF
3k
S_{D4}
5
S_{D3}
10
6 Q_4
9 Q_3

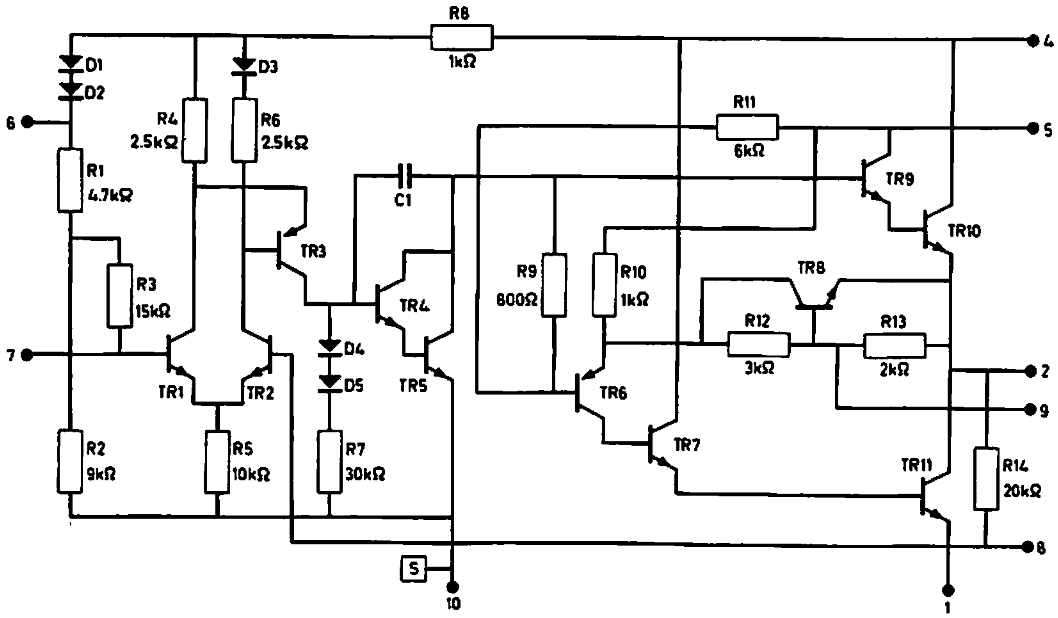
DECADE COUNTER—Motorola MC938F IC will operate at counting frequencies up to 20 MHz. Uses active pull-up devices in outputs to increase capacitive drive capabilities. Outputs correspond to standard 8-4-2-1 bcd, with individual direct sets and common direct clear. Counter can be preset to any desired condition. Will operate at 20% above and below nominal 5-V supply requirement.—MDTL Decade Counter, Motorola, Phoenix, Ariz., PS65, 1967.


INPUT
Q6
39
1100
510
AGC IN
Q1
220
TEST
Q7
1500
1000
Q8
-6v & CASE
VOLTAGE VARIABLE ATTENUATOR
820
5100
Q5
+6v
110
OUTPUT
220
Q4
Q2
Q3
120
20
36
560
C1
C2
BANDPASS SHAPING
3-STAGE WIDEBAND AMPLIFIER

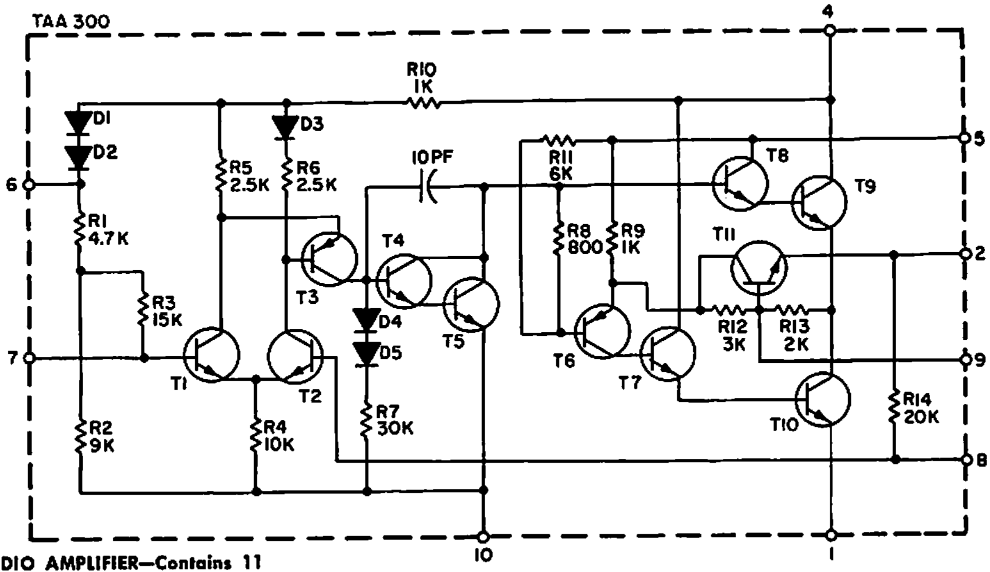
PHILCO-FORD PA7601—Uses voltage-variable attenuator for gain control to preserve frequency response, and input transistor with emitter degeneration in amplifying portion of IC to give broad bandwidth. Bandpass is 45 to 130 MHz at 3-dB points. Article gives 70-MHz i-f amplifier application.—D. W. Ford, M. M. Gutman, and W. F. Allen, Jr., It's Not How Much an IC Costs—But How Much It Can Save, *Electronics*, Oct. 30, 1967, p 66–68.


+V
9
1
Q1
R1 8k
10
8
R2 8k
Q5
6
Q2
R4 50
R5 50
Q4
R3 4.8k
R3 4.8k
Q3
R8 2.8k
R9 1k
R7 5k
D1
D2
R10 2k
R11 2.2k
2
5
3
4
-VEE

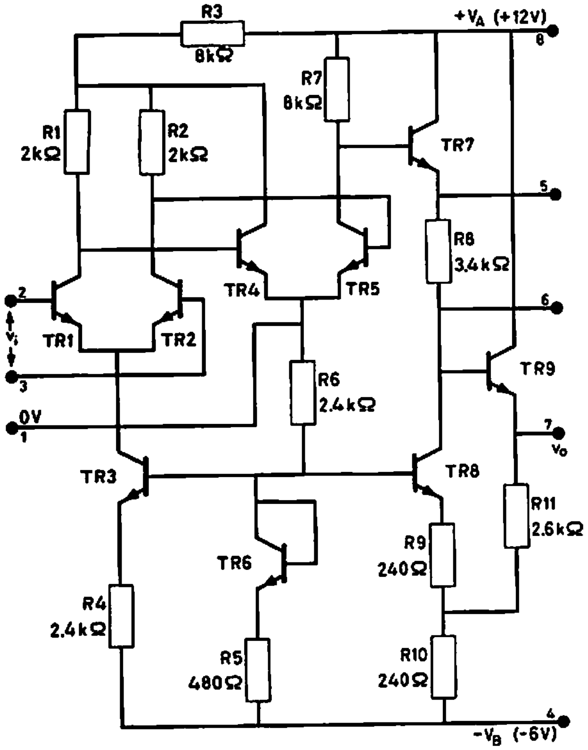
RCA CA3000 VIDEO AMP—Video-type differential amplifier has flat gain-versus-frequency response from d-c well into vhf region (around 300 MHz). Offers both single-ended or double-ended output. Presence of diffused resistors R1 and R2 in collector legs of amplifier identifies video-type IC. Article describes methods of adapting to narrow band and other applications.—J. P. Keller, Linear IC's: Part 3—Differential Amplifiers At Work, *Electronics*, Sept. 18, 1967, p 96–104.


R8
1kΩ
4
D1
D2
D3
6
R4 2.5kΩ
R6 2.5kΩ
R11 6kΩ
5
R1 4.7kΩ
C1
TR9
TR10
TR3
R3 15kΩ
R9 800Ω
R10 1kΩ
TR8
TR4
R12 3kΩ
R13 2kΩ
7
D4
D5
TR1
TR2
TR5
TR6
2
9
TR7
R2 9kΩ
R5 10kΩ
R7 30kΩ
TR11
R14 20kΩ
8
S
10
1

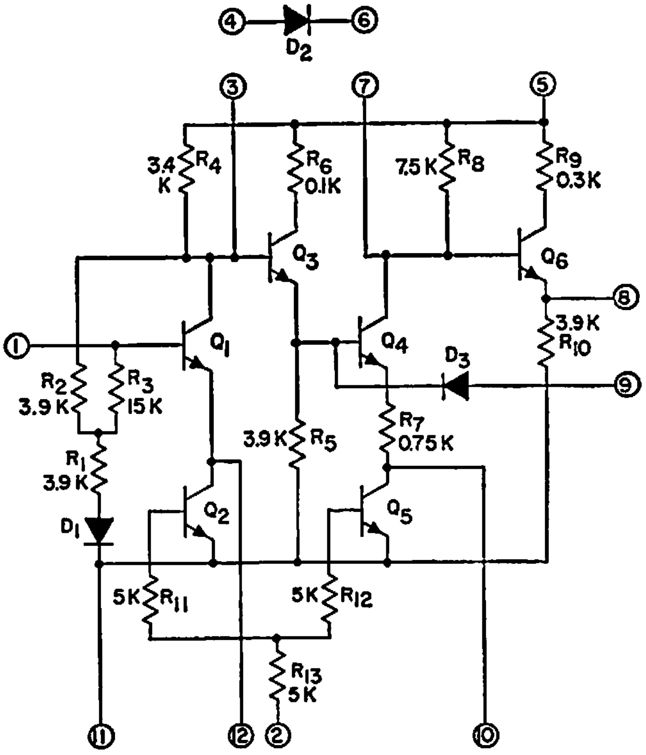
TAA300 AUDIO AMPLIFIER—Delivers 1 W audio power to 8-ohm load when operating from 9-V battery, at 10% distortion. Consists of differential-amplifier input stage TR1-TR2 having 15,000 ohms input impedance, driver stage with TR3 providing d-c coupling to TR4 and TR5 in cascade, and direct-coupled single-ended push-pull output stage using remaining transistors.—A. M. Peters, TAA300 Integrated 1 W Class B A. F. Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 136, 1969.


TAA 300
4
R10
1K
D1
D2
D3
R5
2.5K
R6
2.5K
10PF
R11
6K
T8
T9
5
6
R1
4.7K
T4
R8
800
R9
1K
T11
2
T3
R3
15K
D4
D5
T5
R12
3K
R13
2K
7
T1
T2
T6
T7
9
R7
30K
R14
20K
R2
9K
R4
10K
T10
8
10
1

TAA300 1-W AUDIO AMPLIFIER—Contains 11 transistors and 5 diodes mounted on 2-mm silicon chip with 14 resistors and 1 capacitor. —The Amperex TAA 300 Monolithic Integrated Circuits Used as a Complete Audio Amplifier, Amperex, Slatersville, R.I., S-138, 1968.

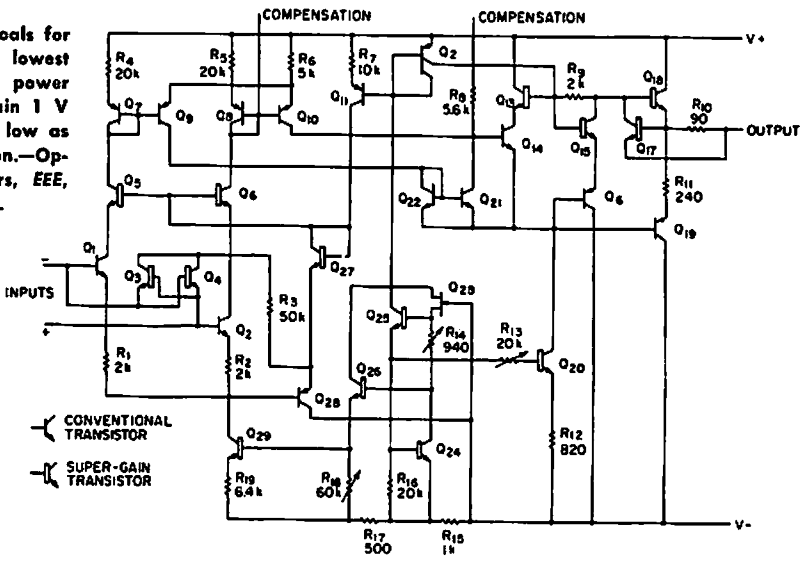

R3
8kΩ
+V_A (+12V)
8
R7
8kΩ
R1
2kΩ
R2
2kΩ
TR7
5
R8
3.4kΩ
2
TR4
TR5
TR1
TR2
v_i
3
6
TR9
R6
2.4kΩ
0V
1
7
V_o
TR3
TR8
R11
2.6kΩ
TR6
R9
240Ω
R4
2.4kΩ
R5
480Ω
R10
240Ω
4
-V_B (-6V)

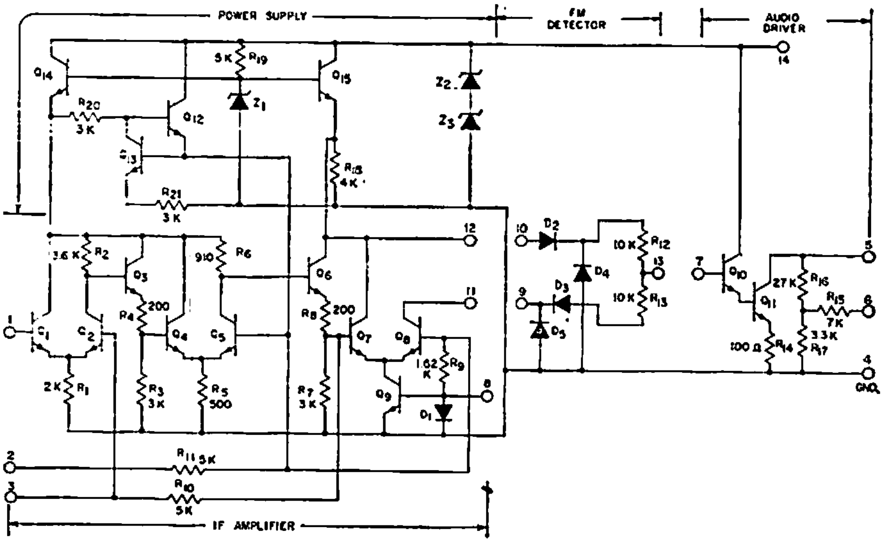
TAA241 DIFFERENCE AMPLIFIER—Input stage TR1-TR2 is difference amplifier, with TR3 in common emitter branch to insure high common-mode rejection ratio. TR7, TR8, and TR9 together form output stage, giving zero output when there is no input signal. Output impedance is about 200 ohms. Open-loop voltage gain can be as high as 6,000. —J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.


④
D2
⑥
③
⑦
⑤
3.4 K R4
R6 0.1K
7.5 K R8
R9 0.3K
Q3
Q6
⑧
①
Q1
Q4
3.9K R10
D3
⑨
R2 3.9 K
R3 15 K
3.9 K R5
R7 0.75 K
R1 3.9 K
Q2
Q5
D1
5K R11
5K R12
R13 5K
⑪
⑫
②
⑩

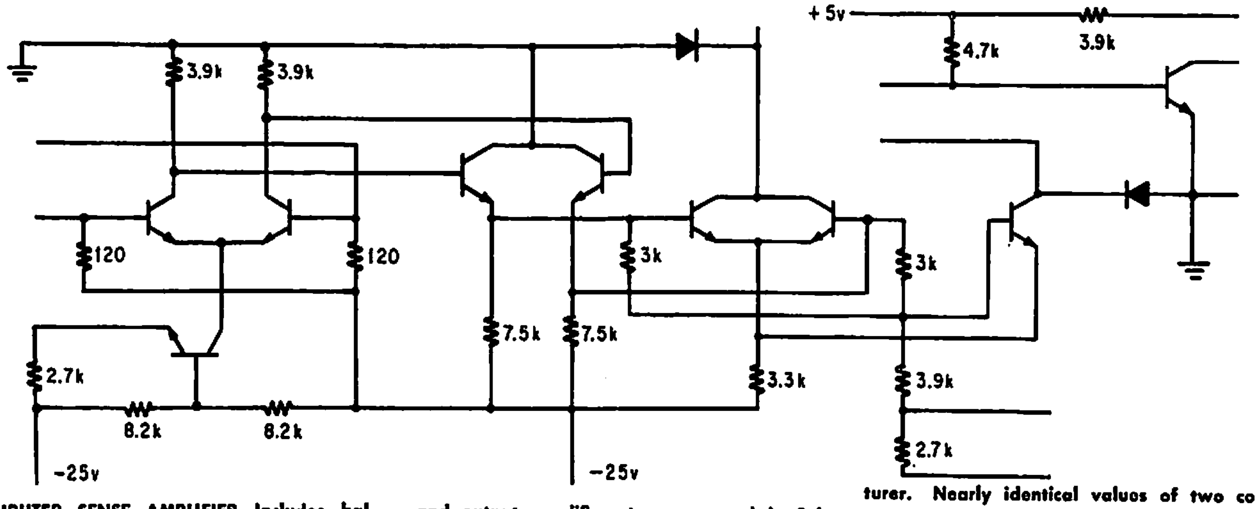
WIDEBAND AMPLIFIER—Circuit shown is that of RCA CA3023 IC, specifically designed as multistage i-f amplifier providing up to 60 dB of gain up to 10 MHz. Emitter-follower Q3 provides impedance matching and level shifting between voltage amplifiers Q1 and Q4. Emitter-follower Q6 provides low-impedance output, while Q2 and Q5 provide agc.—H. M. Kleinman, IC R.F. and I.F. Amplifiers, *Electronics World*, July 1968, p 45–48.

LM108 SUPER-BETA OPAMP—Design goals for National Semiconductor IC included lowest possible input currents and minimum power consumption. Output swings to within 1 V of supply voltages which may be as low as 2 V. Requires external compensation.—Op-Amp ICs With Super-Gain Transistors, *EEE*, Nov. 1969, p 16, 19–20, 22, and 24.

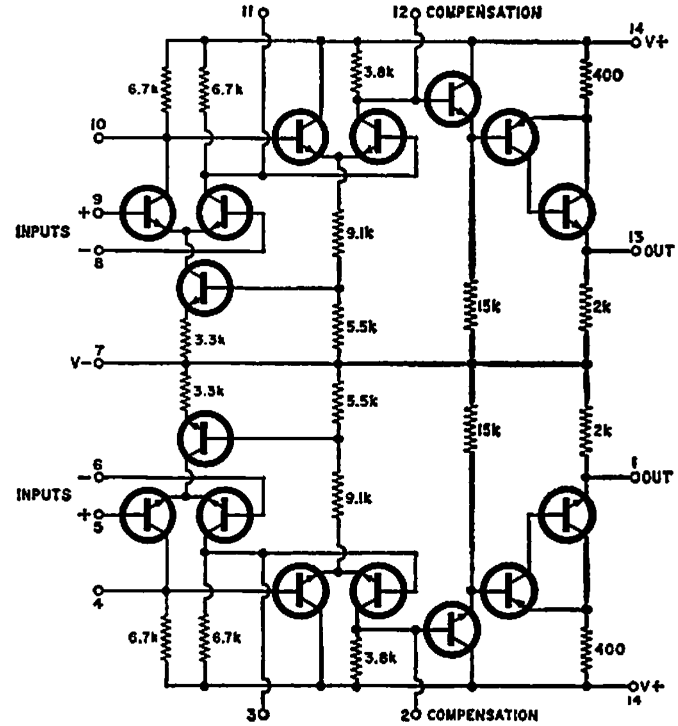

COMPENSATION
COMPENSATION
V+
V-
OUTPUT
INPUTS
-
+
R4 20k
R5 20k
R6 5k
R7 10k
R8 5.6k
R9 2k
R10 90
R11 240
R3 50k
R1 2k
R2 2k
R13 20k
R14 940
R12 820
R19 6.4k
R18 60k
R16 20k
R17 500
R15 1k
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q13
Q14
Q15
Q16
Q17
Q18
Q19
Q20
Q21
Q22
Q23
Q24
Q25
Q26
Q27
Q28
Q29
CONVENTIONAL TRANSISTOR
SUPER-GAIN TRANSISTOR


POWER SUPPLY
FM DETECTOR
AUDIO DRIVER
IF AMPLIFIER
Q14
Q15
Q12
Q13
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
5K R19
Z1
Z2
Z3
R20 3K
R21 3K
R18 4K
3.6 K R2
910 R6
R4 200
R8 200
2K R1
R3 3K
R5 500
R7 3K
1.62 K R9
D1
D2
D3
D4
D5
10 K R12
10 K R13
27 K R16
R15 7K
3.3K R17
100 Ω R14
R11 5K
R10 5K
1
2
3
4
5
6
7
8
9
10
11
12
13
14
GND

TV SOUND I-F—RCA CA3041 integrated circuit provides 70 dB gain as i-f amplifier-limiter, matched diodes for f-m detector, and audio driver, yet is priced under $2 in quantities of 11 or more.—H. M. Kleinman, IC R. F. and I.F. Amplifiers, *Electronics World*, July 1968, p 45–48.

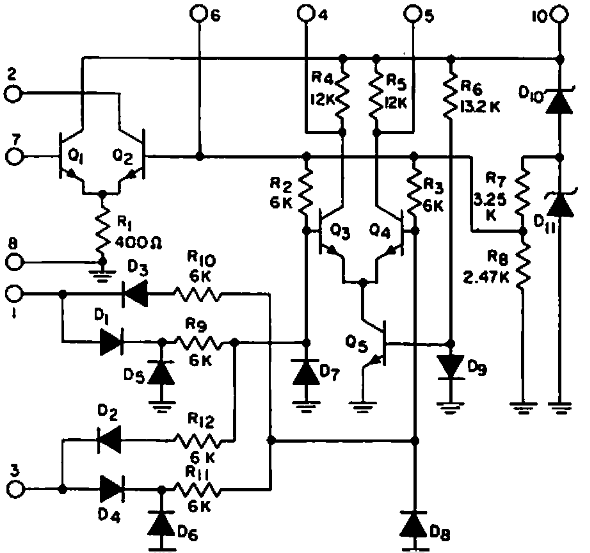

+5v
3.9k
3.9k
4.7k
3.9k
120
120
3k
3k
7.5k
7.5k
2.7k
8.2k
8.2k
3.3k
3.9k
2.7k
-25v
-25v

COMPUTER SENSE AMPLIFIER—Includes balanced differential amplifier fed by active constant-current source, pair of emitter-followers, common-emitter pair, three-resistor network, and output amplifier stage, as used in Sylvania MSP-24 IC. Author presents this as example of good IC design, that meets specs and has no unusual problems for manufacturer. Nearly identical values of two components are easier to produce than specified absolute values.—H. I. Cohen, Avoiding IC System Design Pitfalls, *Electronics*, Aug. 5, 1968, p 110–116.



11
12 COMPENSATION
14
V+
6.7k
6.7k
3.8k
400
10
INPUTS
+ 9
− 8
9.1k
13 OUT
5.5k
15k
2k
3.3k
7
V−
3.3k
5.5k
15k
2k
INPUTS
− 6
+ 5
1 OUT
9.1k
4
6.7k
6.7k
3.8k
400
V+
14
3
2 COMPENSATION

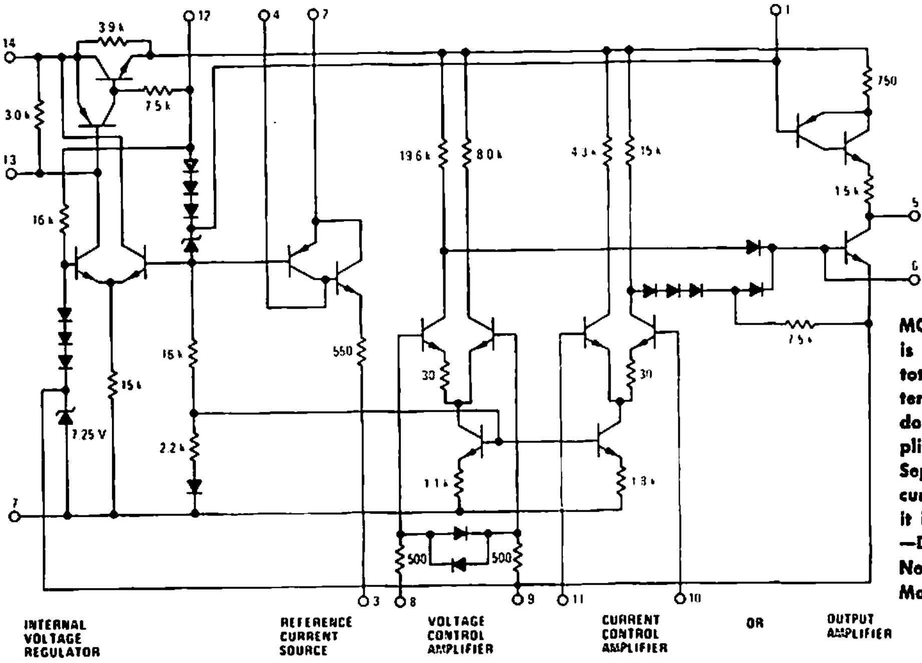
DUAL OPAMP—Used as equalized preamp section of H. H. Scott Series 2500 a-m/f-m compact stereo system. Input transistors for the two channels are connected as emitter-coupled differential amplifiers.—D. R. von Recklinghausen, IC Op-Amp Hi-Fi Preamplifier, *Electronics World*, June 1968, p 44–45.



6
4
5
10
2
7
Q1
Q2
R4 12K
R5 12K
R6 13.2 K
D10
R2 6K
R3 6K
R7 3.25 K
Q3
Q4
D11
8
R1 400Ω
D3
R10 6K
R8 2.47K
1
D1
R9 6K
Q5
D5
D7
D9
D2
R12 6 K
3
R11 6K
D4
D6
D8

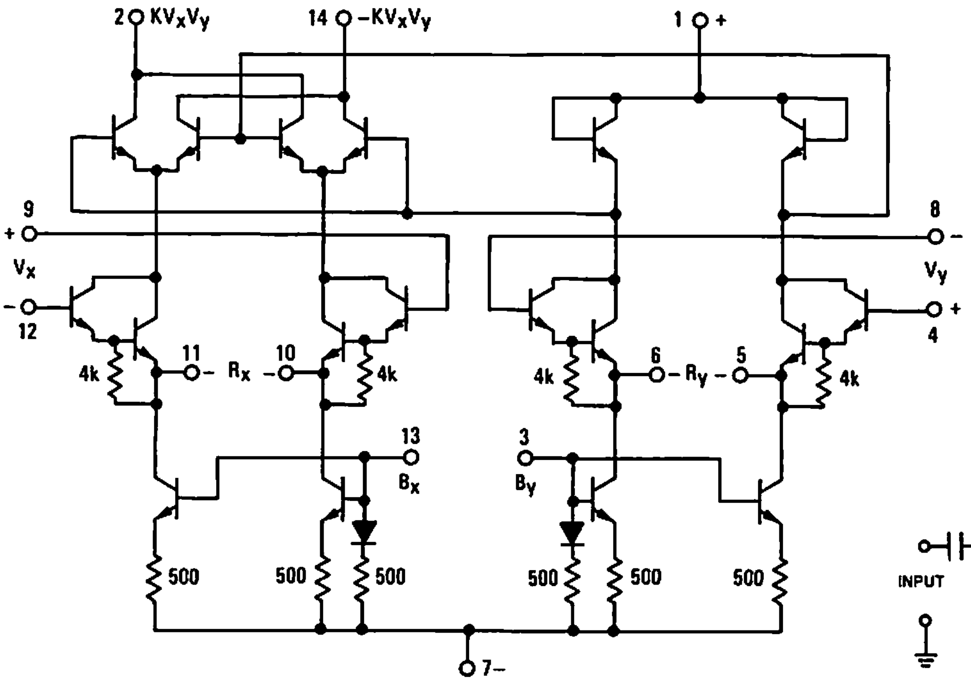
DIODES D5 AND D6 ACT AS CAPACITORS AND ARE USED TO BALANCE THE DETECTOR SUBSTRATE CAPACITANCES.

COLOR AFT—Special-function IC was developed for automatic frequency control applications in color tv. Includes zener-regulated power supply that improves performance and reduces system cost. Consists of 45-MHz limiter-amplifier Q1-Q2, four-diode matrix D1-D4 forming balanced detector that converts output of phase transformer to filtered d-c signal, constant-current driven differential amplifier Q3-Q4-Q5 providing sufficient sensitivity and power to permit use of low-cost tuning element, and zener regulator D10-D11 operating from d-c supply of 15 to 30 V.—W. M. Austin, H. M. Kleinman, and J. Sundburg, Application of the RCA-CA3044 and CA3044V1 Integrated Circuits in Automatic-Fine-Tuning Systems, RCA, Harrison, N.J., ICAN-5831, 1968.

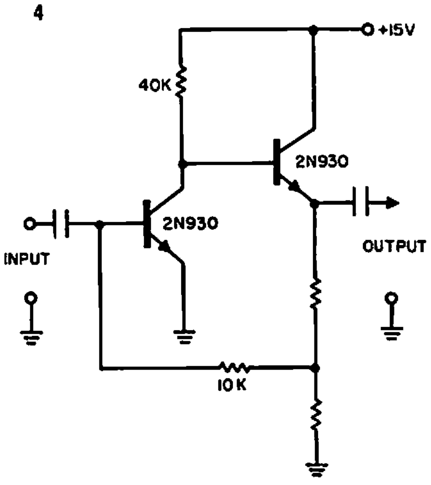


14
39k
12
4
7
1
7.5k
750
30k
13
136k
80k
43k
15k
15k
5
16k
6
16k
550
7.5k
15k
30
30
7.25 V
2.2k
11k
13k
7
500
500
3
8
9
11
10
INTERNAL VOLTAGE REGULATOR
REFERENCE CURRENT SOURCE
VOLTAGE CONTROL AMPLIFIER
CURRENT CONTROL AMPLIFIER
OR
OUTPUT AMPLIFIER

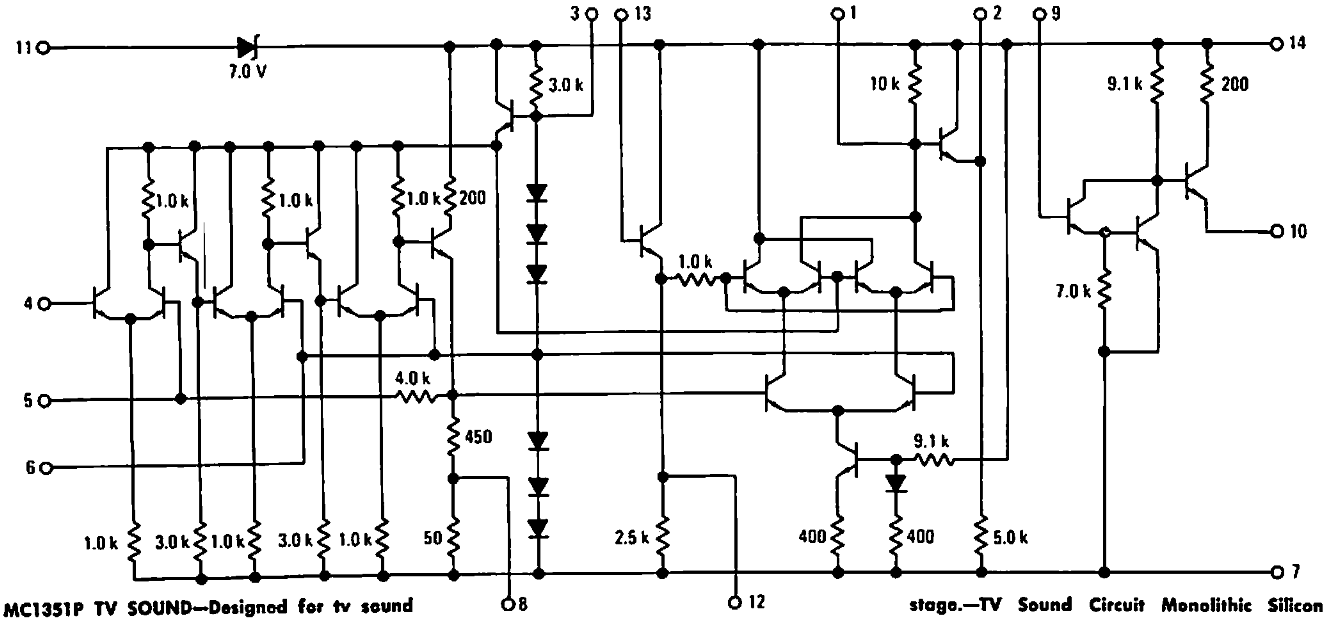
MC1566 VOLTAGE REGULATOR—Motorola IC is designed to float on output voltage, so total output voltage is limited only by external series-pass transistor voltage breakdown and safe operating area. Control amplifier samples output voltage directly. Separate differential amplifier samples output current and produces limiting so sharp that it is constant within 1% plus or minus 1 mA. —D. Kesner, Voltage Regulators—Old and New, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 14–20.


2 KVxVy
14 -KVxVy
1 +
9
+
Vx
-
12
8
-
Vy
+
4
11
Rx
10
4k
4k
4k
6
Ry
5
4k
13
Bx
3
By
500
500
500
500
500
500
7-

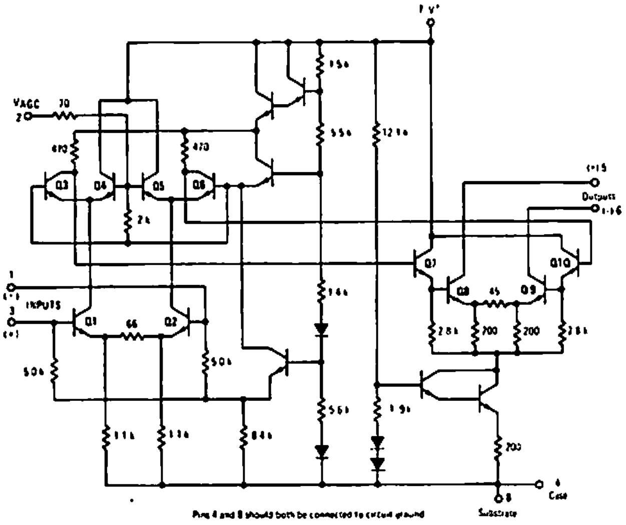
MC1595 LINEAR MULTIPLIER—Motorola IC linear four-quadrant multiplier uses dual differential amplifiers with collectors cross-coupled to produce full-wave balanced multiplication. Circuit analysis is given in Motorola Application Notes AN-489 and AN-490.—E. Renschler, The Monolithic Multiplier Breakthrough, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 27–36.


+15V
40K
2N930
2N930
INPUT
OUTPUT
10K

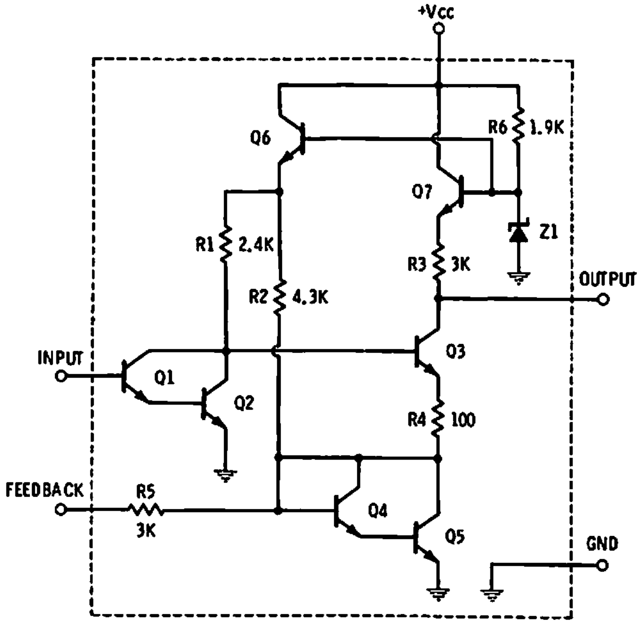
MILLER-FEEDBACK BIASING—Eliminates need for large-value emitter bypass capacitor in IC amplifier. Article also covers techniques for reducing resistor surface-area requirements in various IC circuits.—A. Tuszynski, Skirting Thin-Film Design Problems, *Electronic Design*, Aug. 30, 1965, p 38–43.


11
7.0 V
3
13
1
2
9
14
3.0 k
10 k
9.1 k
200
1.0 k
1.0 k
1.0 k
200
4
1.0 k
10
7.0 k
4.0 k
5
450
6
9.1 k
1.0 k
3.0 k
1.0 k
3.0 k
1.0 k
50
2.5 k
400
400
5.0 k
7
8
12

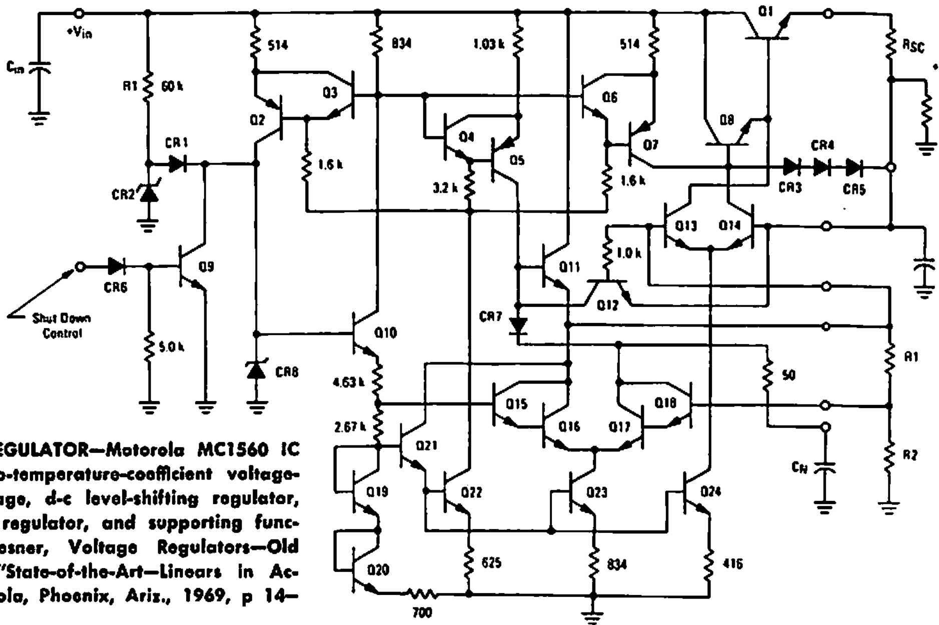
MC1351P TV SOUND—Designed for tv sound i-f limiting, detection, audio preamplifier, and driver. Output voltage swing is up to 3 V rms. I-f voltage gain is 64 dB. Will drive single external transistor serving as output stage.—TV Sound Circuit Monolithic Silicon Epitaxial Passivated MC1351P, Motorola, Phoenix, Ariz., DS9126, 1969.


+V
VAGC
2
70
470
470
Q3
Q4
Q5
Q6
2k
15k
5.5k
12k
(+)15
Outputs
(−)16
Q7
Q10
Q8
45
Q9
1
(−)
INPUTS
3
(+)
Q1
66
Q2
50k
50k
14k
2.8k
700
200
2.8k
5.6k
1.9k
11k
11k
8.4k
200
4
Case
8
Substrate
Pins 4 and 8 should both be connected to circuit ground

MC1590 I-F AMPLIFIER—Motorola IC is direct-coupled high-gain amplifier intended primarily for i-f applications up to 150 MHz. Wide-range agc characteristic makes it suitable for many video amplifier applications. May be used either single-ended or differentially coupled at input and at output.—R. Hejhall and B. Trout, Integrated Circuits for the World of High Frequency, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 21–26.


+Vcc
Q6
R6
1.9K
Q7
Z1
R1
2.4K
R3
3K
OUTPUT
R2
4.3K
INPUT
Q1
Q3
Q2
R4
100
FEEDBACK
R5
3K
Q4
Q5
GND

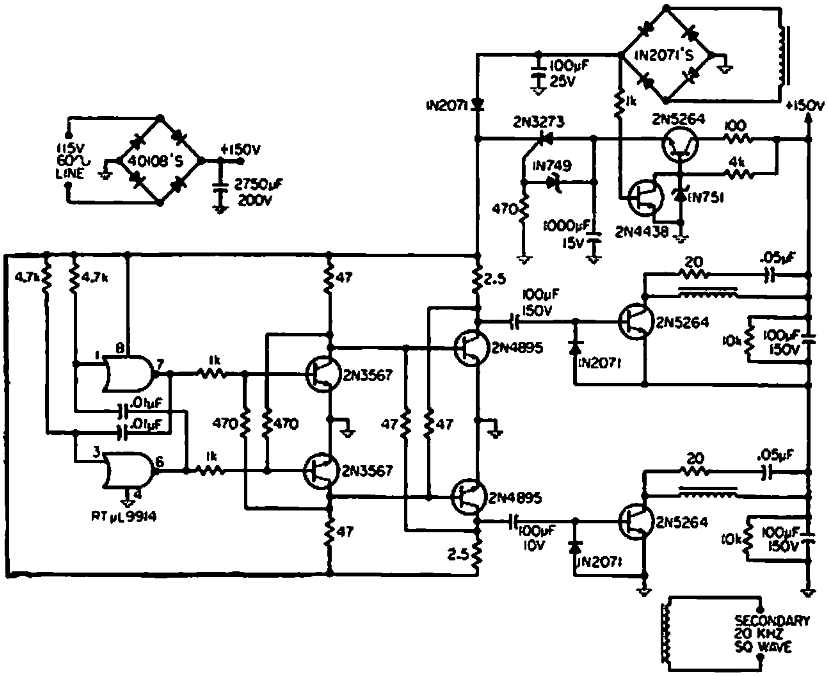
MIC0101 AUDIO-VIDEO PREAMP—Ideal for tape playback and other low-level applications where input signals are 1 mV or less. Frequency response extends well beyond radio frequencies, to about 700 kHz for 3 dB down. Consists of common-emitter Darlington directly coupled to amplifier Q3 for combined gain of about 60 dB. Series regulator circuit Q6-Q7 provides power supply filtering, while Q4 and Q5 serve as constant 1.4-V d-c bias source. Companion MIC0103 has two identical MIC0101 chips in same package for stereo applications.—M. L. Deschler, Integrated Circuit Preamplifiers, Mallory, Indianapolis, Ind., APPN-2, 1968.


+Vin
Cin
R1
60k
514
834
1.03k
514
Q1
RSC
+Vout
RL
Q3
Q6
Q2
Q4
Q5
Q7
Q8
CR1
1.6k
1.6k
CR4
CR2
3.2k
CR3
CR5
Q13
Q14
1.0k
+CL
Q9
Q11
CR6
Q12
Shut Down Control
5.0k
CR7
Q10
R1
CR8
4.63k
50
Q15
Q16
Q17
Q18
2.67k
Q21
CN
R2
Q19
Q22
Q23
Q24
Q20
625
834
416
700

VOLTAGE REGULATOR—Motorola MC1560 IC includes zero-temperature-coefficient voltage-reference stage, d-c level-shifting regulator, main series regulator, and supporting functions.—D. Kesner, Voltage Regulators—Old and New, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 14–20.

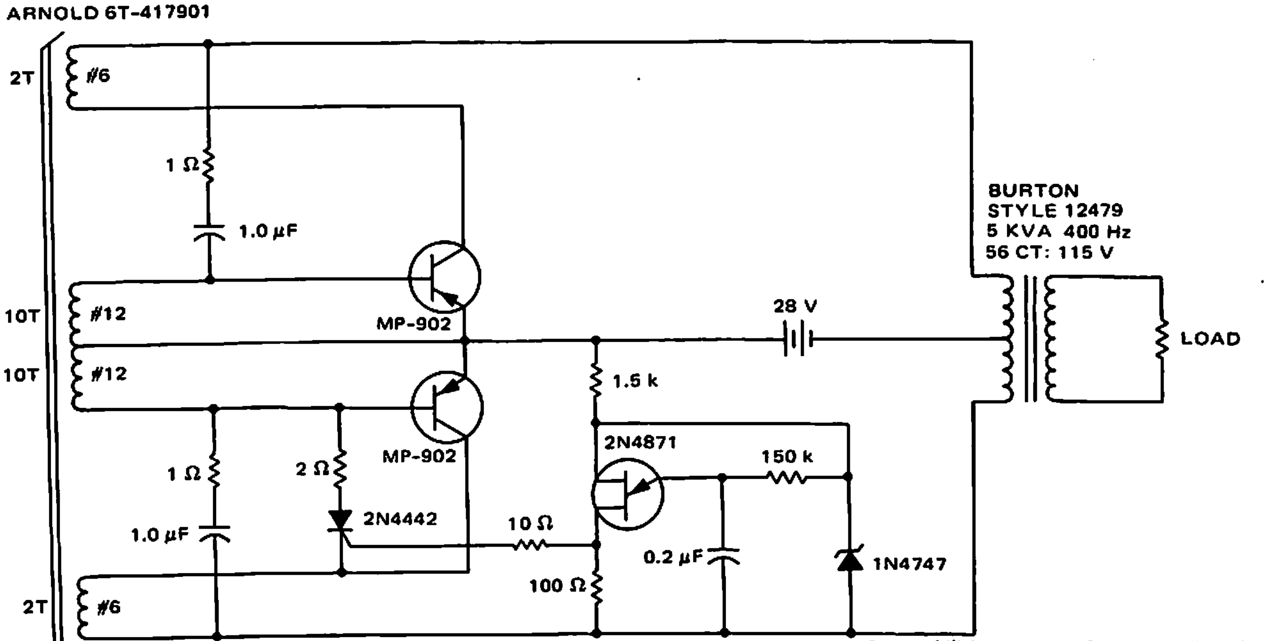
CHAPTER 42

Inverter Circuits



115V
60∿
LINE
40108'S
+150V
2750μF
200V
1N2071
100μF
25V
1N2071'S
1k
+150V
2N3273
2N5264
100
1N749
4k
470
1000μF
15V
2N4438
1N751
4.7k
4.7k
47
2.5
20
.05μF
100μF
150V
2N5264
10k
100μF
150V
1
8
7
1k
2N3567
2N4895
1N2071
.01μF
.01μF
470
470
47
47
3
6
1k
2N3567
2N4895
20
.05μF
4
RT μL9914
47
100μF
10V
2N5264
10k
100μF
150V
2.5
1N2071
SECONDARY
20 KHZ
SQ WAVE

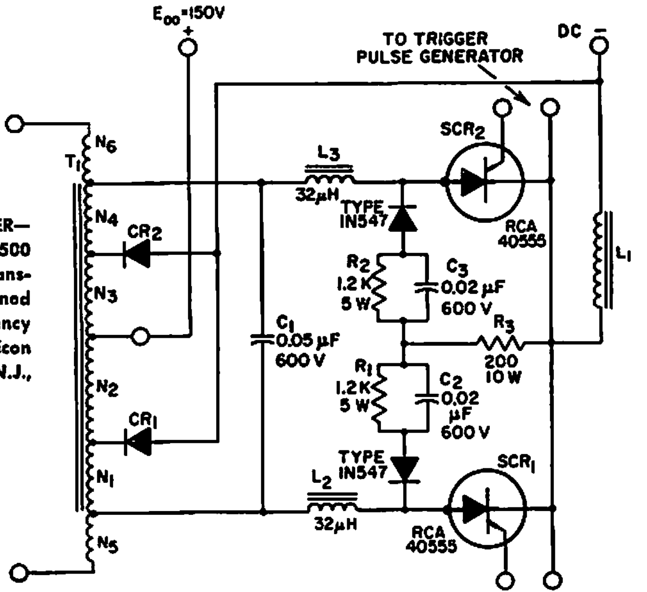
IMPROVED JENSEN—Saturable core in conventional two-transistor Jensen inverter limits switching speed, reducing efficiency at high frequencies. Improved circuit shown, using cross-coupled IC gates to form 20-kHz free-running mvbr, has 90% efficiency and good voltage regulation. Frequency is independent of load current. Maximum output is 1 kW, and power-weight ratio is better than 100 W per lb.—P. K. Edwards, New Line-Operated Inverter Offers Fast Switching and High Efficiency, *EEE*, Feb. 1969, p 115–116.



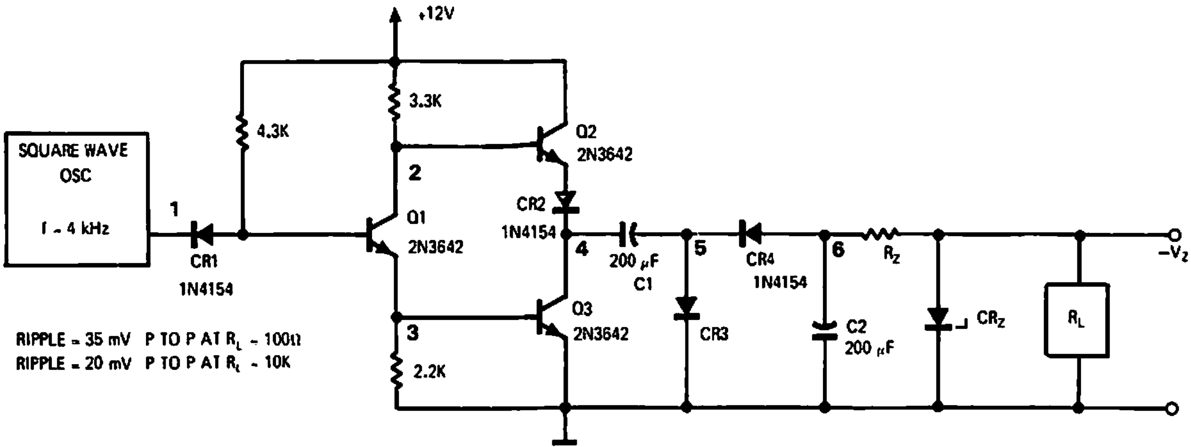
ARNOLD 6T-417901
2T
#6
1 Ω
1.0 μF
10T
#12
MP-902
10T
#12
MP-902
28 V
1.5 k
BURTON
STYLE 12479
5 KVA 400 Hz
56 CT: 115 V
LOAD
2N4871
150 k
1 Ω
2 Ω
2N4442
1.0 μF
10 Ω
0.2 μF
1N4747
100 Ω
2T
#6

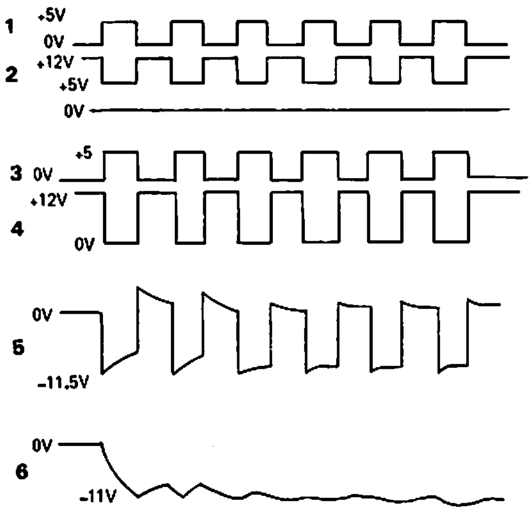
120-V A-C AT 2 KW AND 580 HZ FROM 28 V D-C—High-power inverter produces square-wave output at efficiencies of 80–90% depending on load. Circuit has no provisions for stabilizing output frequency.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–47.

10-KHZ PUSH-PULL SWITCHING INVERTER—Operates from 150-V d-c line and delivers 500 W at 10 kHz across terminals of output transformer T1. Lower frequency can be obtained by using different pulse generator frequency and different output transformer.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 196.

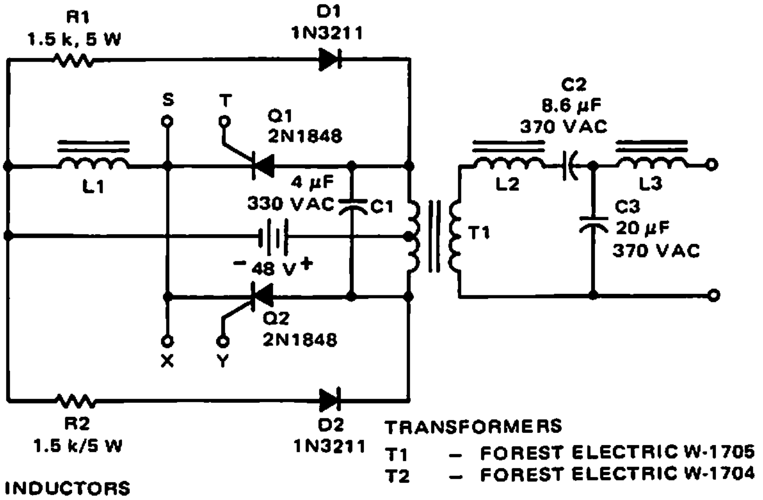

E_{00}=150V
+
TO TRIGGER PULSE GENERATOR
DC −
T_1
N_6
N_4
CR_2
N_3
N_2
CR_1
N_1
N_5
L_3
32µH
TYPE 1N547
SCR_2
RCA 40555
R_2 1.2K 5W
C_3 0.02µF 600V
R_3 200 10W
L_1
C_1 0.05µF 600V
R_1 1.2K 5W
C_2 0.02 µF 600V
TYPE 1N547
L_2
32µH
SCR_1
RCA 40555
TO TRIGGER PULSE GENERATOR

D_1, D_2 = 600-volt, 6-ampere fast-recovery diode
L_1 = Inductor, 95 turns of No. 16 magnet wire wound on Arnold Engineering Type A4-17172 (or equiv.) core
T_1 = Output transformer: N_1 = N_4 = 9 turns of No. 18 magnet wire, two strands; N_2 = N_3 = 36 turns of No. 18 magnet wire; N_5 = N_6 = 21 turns of No. 18 magnet wire; core, two sets of Siemens Type 266215-A0000-R026 (or equiv.) with 4-mil air gap

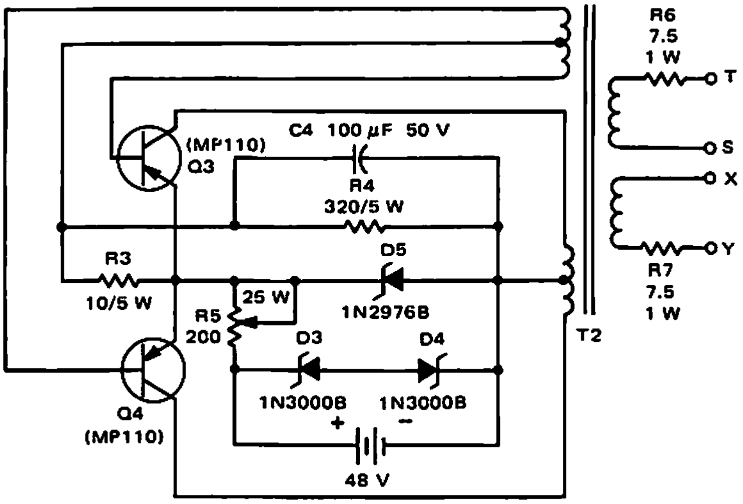

+12V
SQUARE WAVE OSC
1 - 4 kHz
1
CR1 1N4154
4.3K
3.3K
2
Q1 2N3642
Q2 2N3642
CR2 1N4154
4
200µF C1
5
CR3
CR4 1N4154
6
R_Z
C2 200µF
CR_Z
R_L
$-V_Z$
3
Q3 2N3642
2.2K
RIPPLE = 35 mV P TO P AT R_L = 100Ω
RIPPLE = 20 mV P TO P AT R_L = 10K



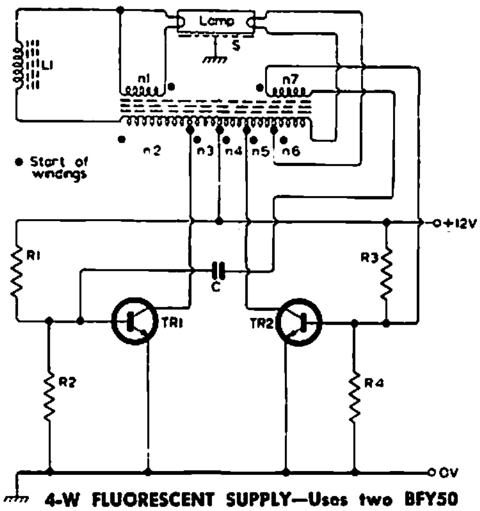
INVERTING 12 V WITHOUT TRANSFORMER—Converts single-polarity d-c source to bipolar source providing both positive and negative 12 V d-c for driving pair of IC comparators. Requires external square-wave source but oscillator frequency is not critical. Zener current-limiting resistor Rz may usually be omitted.—E. W. Locheed, Jr., Transformerless Circuit Inverts Power-Supply Voltage, *EDN*, July 15, 1970, p 63–64.


R1
1.5 k, 5 W
D1
1N3211
S
T
Q1
2N1848
C2
8.6 µF
370 VAC
L1
4 µF
330 VAC
C1
L2
L3
T1
C3
20 µF
370 VAC
- 48 V +
Q2
2N1848
X
Y
R2
1.5 k/5 W
D2
1N3211
TRANSFORMERS
T1 – FOREST ELECTRIC W-1705
T2 – FOREST ELECTRIC W-1704

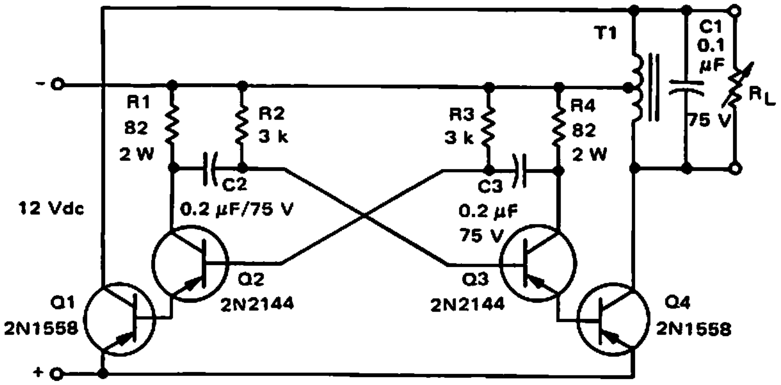
INDUCTORS
L1 – FOREST ELECTRIC W-1708
L2 – FOREST ELECTRIC W-1706
L3 – FOREST ELECTRIC W-1707


R6
7.5
1 W
T
S
X
Y
R7
7.5
1 W
(MP110)
Q3
C4 100 µF 50 V
R4
320/5 W
R3
10/5 W
D5
1N2976B
25 W
R5
200
D3
D4
1N3000B
1N3000B
+
–
48 V
Q4
(MP110)
T2

120-V A-C AT 100 W AND 60 HZ FROM 48 V D-C—Sine-wave output frequency is highly stable for both input and load voltage variations because drive circuit is frequency-controlled inverter having two secondary windings, for feeding terminals S, T, X, and Y of output inverter. Combination is commercially available as Falco Model W-1694 Inverter.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–38.

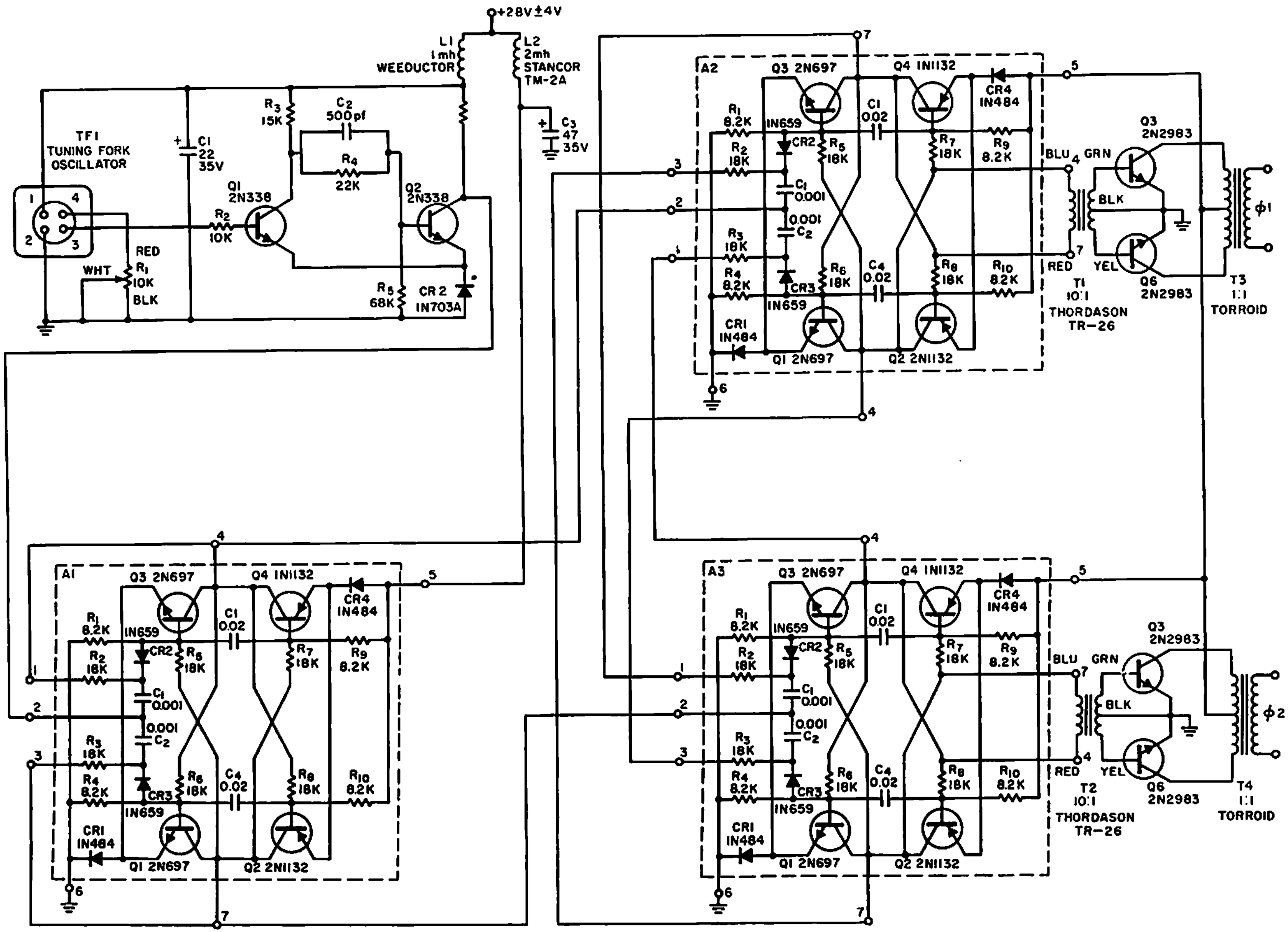

L1
Lamp
S
n1
n7
n2
n3
n4
n5
n6
• Start of windings
+12V
R1
R3
C
TR1
TR2
R2
R4
0V

4-W FLUORESCENT SUPPLY—Uses two BFY50 transistors operating as square-wave push-pull oscillator driving lamp through transformer. Operating frequency is about 20 kHz. R1 and R3 are 180, R2 and R4 are 15, and C is 1 µF. Report gives choke and transformer winding data for both 4-W and 6-W circuits.—Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.

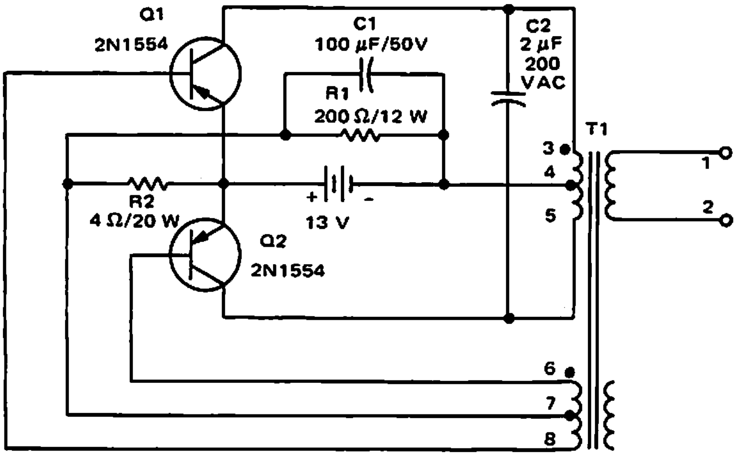

T1
C1
0.1
µF
RL
75 V
-
R1
82
2 W
R2
3 k
R3
3 k
R4
82
2 W
C2
0.2 µF/75 V
C3
0.2 µF
75 V
12 Vdc
Q2
2N2144
Q3
2N2144
Q1
2N1558
Q4
2N1558
+

T1 – Phoenix Transformer PX2677

20-V A-C AT 50 W AND 1 KHZ FROM 12 V D-C—Inverter driven by free-running mvbr provides excellent frequency regulation for variations in both load and input voltages. Output is square wave at 20 V rms. Switching of output power transistors Q1 and Q4 is done by mvbr Q2-Q3 rather than by feedback from output transformer. Useful for precision systems requiring carefully controlled frequency and waveform.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–61.


+28V±4V
L1
1mh
WEEDUCTOR
L2
2mh
STANCOR
TM-2A
C3
47
35V
TF1
TUNING FORK
OSCILLATOR
1
2
3
4
C1
22
35V
R3
15K
C2
500pf
R4
22K
Q1
2N338
Q2
2N338
R2
10K
RED
WHT
R1
10K
BLK
R5
68K
CR 2
IN703A
A1
A2
A3
Q3 2N697
Q4 IN1132
Q1 2N697
Q2 2N1132
R1
8.2K
R2
18K
R3
18K
R4
8.2K
R5
18K
R6
18K
R7
18K
R8
18K
R9
8.2K
R10
8.2K
C1
0.02
C4
0.02
C1
0.001
0.001
C2
CR1
IN484
CR2
CR3
IN659
CR4
IN484
1
2
3
4
5
6
7
BLU
GRN
BLK
YEL
RED
T1
10:1
THORDASON
TR-26
T2
10:1
THORDASON
TR-26
Q3
2N2983
Q6
2N2983
T3
1:1
TORROID
T4
1:1
TORROID
φ1
φ2

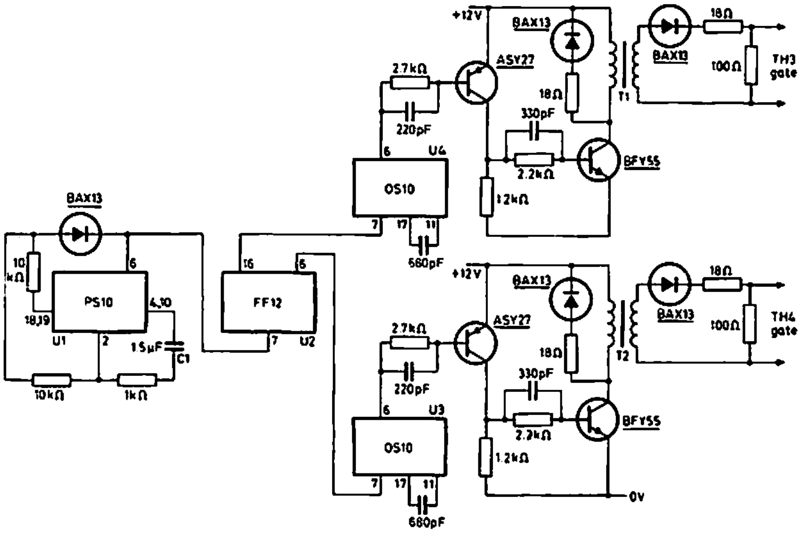
28-V D-C TO 400-HZ 2-PHASE—Use of complementary flip-flops results in high efficiency for inverter synchronized from 1,600-Hz single-phase tuning-fork oscillator. Can deliver 50 W to resistive load, and can be used to drive small synchronous motors at precise speeds. No-load standby power is less than 2 W. Reversal of one output phase leg with switch or relay will reverse motor. Article gives design details.—P. Ward, Complementary Flip-Flops Improve Bistable Performance, *Electronic Design*, May 11, 1964, p 50–55.

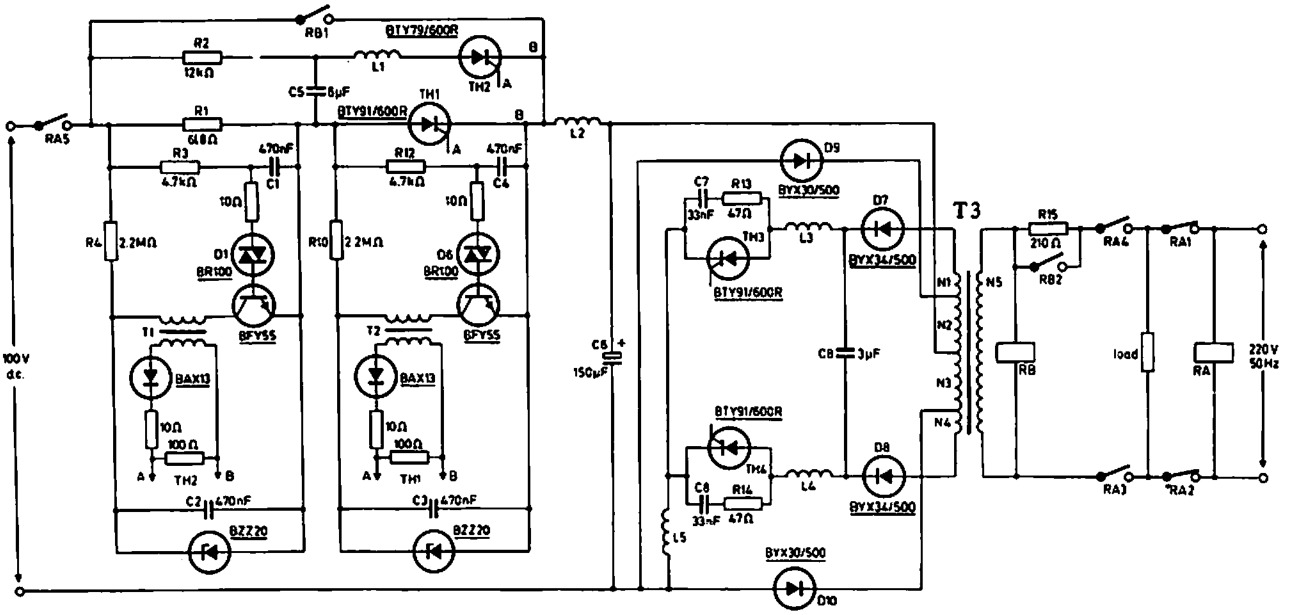

Q1
2N1554
C1
100 μF/50V
C2
2 μF
200
VAC
R1
200 Ω/12 W
T1
3
4
5
1
2
R2
4 Ω/20 W
+
-
13 V
Q2
2N1554
6
7
8

T1 — Forest Electric VJ-18

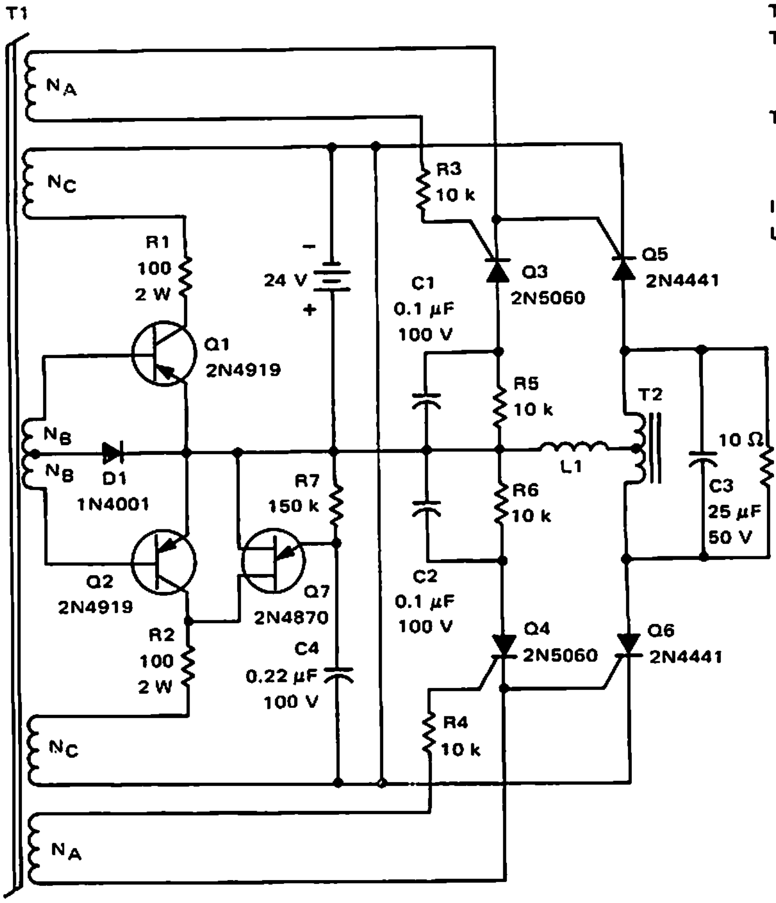
120-V A-C AT 120 W AND 60 HZ FROM 12 V D-C—Used to operate a-c equipment in automobiles. Output is square wave whose magnitude varies with load and input voltage. Regulation from no load to full load is about 30%, which means that 6-W increase in load decreases output voltage 1 V. Efficiency is 75% at full load, which is excellent for single-transformer inverter.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–52.

TRIGGER FOR 1-KW INVERTER—U1 generates 50-Hz square wave that is fed into IC flip-flop U2, whose outputs are 180 deg out of phase and feed monostable mvbr's U3 and U4 having same phase difference between their output pulses. After amplification, these pulses are fed to thyristors in stand-by inverters served by trigger. Transformers each have 150-turn primary and 75-turn secondary. Trigger can be permanently connected to its battery supply because current drain is negligible.—N. Bergstra and R. v. d. Linden, Stand-By Inverter for Emergency Mains Supply, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 96, 1970.


+12V
BAX13
ASY27
18Ω
2.7kΩ
220pF
330pF
2.2kΩ
1.2kΩ
BFY55
6
U4
OS10
7
17
11
680pF
T1
BAX13
18Ω
100Ω
TH3
gate
BAX13
10kΩ
PS10
6
4,10
18,19
U1
2
1.5μF
C1
10kΩ
1kΩ
FF12
16
6
7
U2
+12V
BAX13
ASY27
2.7kΩ
220pF
18Ω
330pF
2.2kΩ
1.2kΩ
BFY55
6
U3
OS10
7
17
11
680pF
T2
BAX13
18Ω
100Ω
TH4
gate
0V


RB1
BTY79/600R
B
R2
12kΩ
L1
C5
6μF
TH1
TH2
A
RA5
R1
68Ω
BTY91/600R
B
A
L2
R3
4.7kΩ
470nF
C1
R12
4.7kΩ
470nF
C4
10Ω
10Ω
R4
2.2MΩ
D1
BR100
R10
2.2MΩ
D6
BR100
BFY55
BFY55
T1
T2
BAX13
BAX13
10Ω
100Ω
10Ω
100Ω
A
TH2
B
A
TH1
B
C2
470nF
C3
470nF
BZZ20
BZZ20
100V
d.c.
C6
+
150μF
D9
BYX30/500
C7
33nF
R13
47Ω
TH3
L3
D7
BYX34/500
BTY91/600R
C8
3μF
BTY91/600R
TH4
D8
C8
33nF
R14
47Ω
L4
BYX34/500
L5
BYX30/500
D10
T3
N1
N2
N3
N4
N5
R15
210Ω
RA4
RA1
RB2
RB
load
RA
220V
50Hz
RA3
RA2

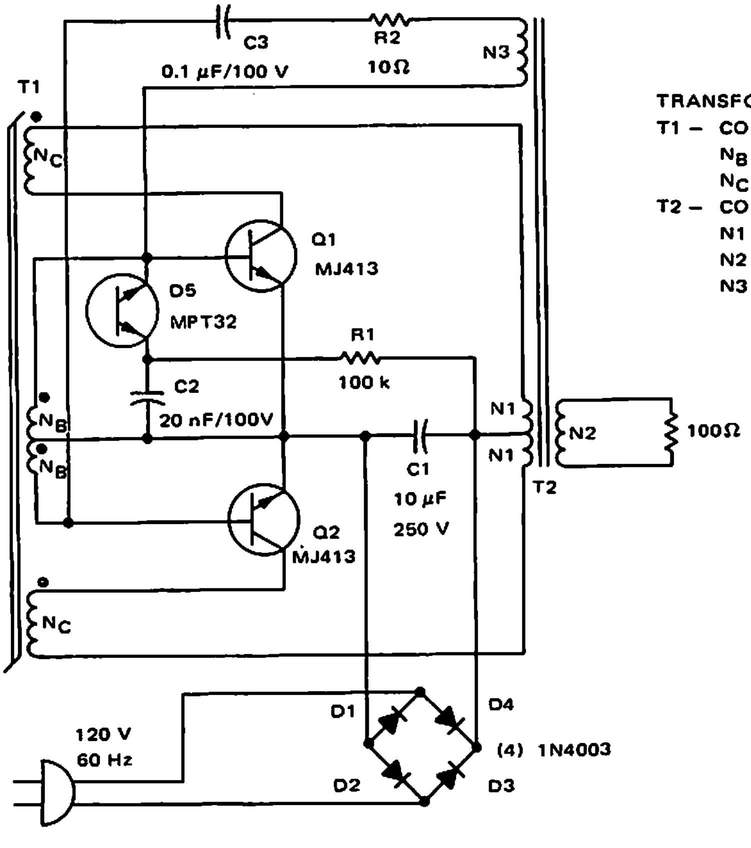
1-KW INVERTER FOR A-C LINE FAILURE—Protects critical production operation from interruption of a-c supply for more than a few cycles. McMurray Bedford inverter circuit is used to obtain good regulation, with special starting circuit to prevent short-circuit at startup if half of output transformer primary was saturated at previous shutdown. Both relays are 10 A at 220 V, 50 Hz. Gates of thyristors are fed by trigger pulses produced by separate trigger generator operating from 12-V battery.—N. Bergstra and R. v. d. Linden, Stand-By Inverter for Emergency Mains Supply, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 96, 1970.


T1
N_A
N_C
R1
100
2 W
Q1
2N4919
N_B
N_B
D1
1N4001
Q2
2N4919
R2
100
2 W
N_C
N_A
24 V
R7
150 k
Q7
2N4870
C4
0.22 µF
100 V
R3
10 k
C1
0.1 µF
100 V
Q3
2N5060
R5
10 k
R6
10 k
C2
0.1 µF
100 V
Q4
2N5060
R4
10 k
L1
Q5
2N4441
T2
10 Ω
C3
25 µF
50 V
Q6
2N4441

TRANSFORMERS
T1 – ARNOLD CORE 6T-5340-D1
$N_A + N_B$ 83 TURNS EACH #30 WIRE
N_C 8 TURNS #26 WIRE
T2 – PHOENIX TRANSFORMER PX2677
350 V, 1 kVA, 1 kHz

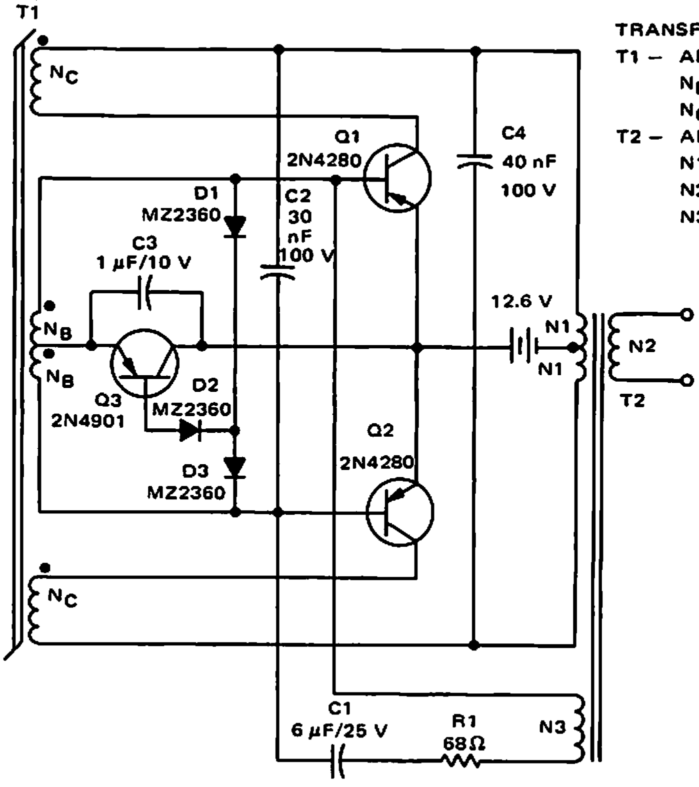
INDUCTOR
L1 – PHOENIX TRANSFORMER PX1710 2 mH, 30 A

45-V SQUARE WAVE AT 150 W WITH INVERTER-DRIVEN INVERTER—Will operate from 10–28 V d-c and deliver 45-V a-c 400 Hz which is independent of load and has high stability for input voltage variations. Efficiency is 70%. Drive circuit is current-feedback inverter Q1-Q2 with ujt Q7 in starting network. Windings on timing transformer drive pair of sensitive-gate scr's (Q3-Q4) which in turn drive main parallel-commutated inverter Q5-Q6 that supplies power to 10-ohm load across T2.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–36.


C3
0.1 µF/100 V
R2
10Ω
N3
T1
N_C
Q1
MJ413
D5
MPT32
R1
100 k
C2
20 nF/100V
N_B
N_B
N1
N1
N2
100Ω
T2
C1
10 µF
250 V
Q2
MJ413
N_C
D1
D4
(4) 1N4003
D2
D3
120 V
60 Hz

TRANSFORMERS
T1 – CORE – MAGNETICS INC. #80623-1/2D-080
N_B 15 TURNS OF AWG #26 WIRE
N_C 3 TURNS OF AWG #22 WIRE
T2 – CORE – ARNOLD GT-5800-D1
N1 100 TURNS OF 3 AWG #22 WIRES
N2 104 TURNS OF 3 AWG #19 WIRES
N3 7 TURNS OF AWG #26 WIRE

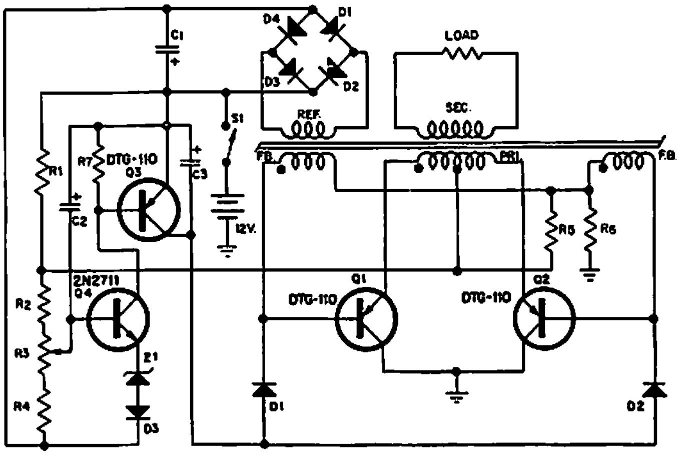
120-V AT 15 KHZ FROM 120 V A-C—Used to convert 60 Hz to higher frequency. A-c line voltage is rectified with very little filtering, for driving 15-kHz inverter that delivers square-wave output of 200 W with full-load efficiency of 88%. Provides isolation from a-c power line with minimum size and weight. Operates well on inductive loads and on small loads.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–59.

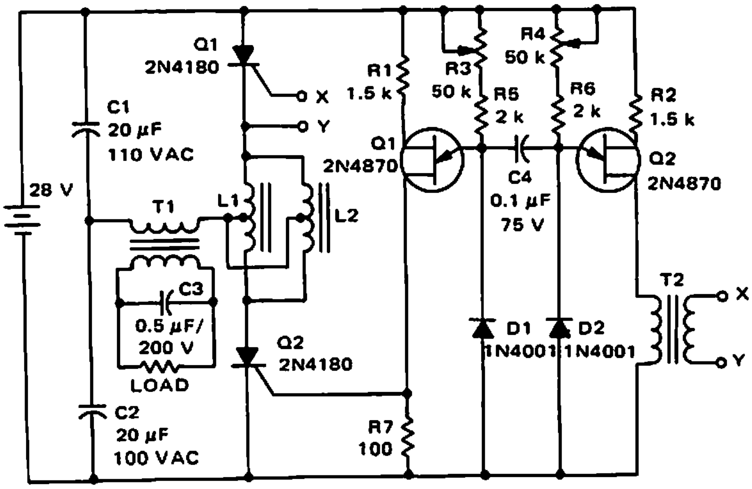

T1
NC
Q1
2N4280
C4
40 nF
100 V
D1
MZ2360
C2
30
nF
100 V
C3
1 µF/10 V
NB
NB
Q3
2N4901
D2
MZ2360
D3
MZ2360
Q2
2N4280
12.6 V
N1
N1
N2
T2
NC
C1
6 µF/25 V
R1
68Ω
N3

TRANSFORMERS
T1 – ARNOLD CORE 6T 7699D1
N_B 54 TURNS #20 WIRE
N_C 3 TURNS TWO #12 WIRES IN PARALLEL
T2 – ARNOLD CORE 3T 6464-L4
N1 12 TURNS TWO #12 WIRES IN PARALLEL
N2 120 TURNS #16 WIRE
N3 7 TURNS #20 WIRE

120-V A-C AT 400 HZ FROM 12 V D-C—Hybrid-feedback inverter gives square-wave output of 400 W at efficiency above 85% for full range of output power. Can be used with fluorescent lamps, 400-Hz 90-W motor, and other inductive as well as resistive loads. Feedback winding N3 ensures starting without load.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–57.

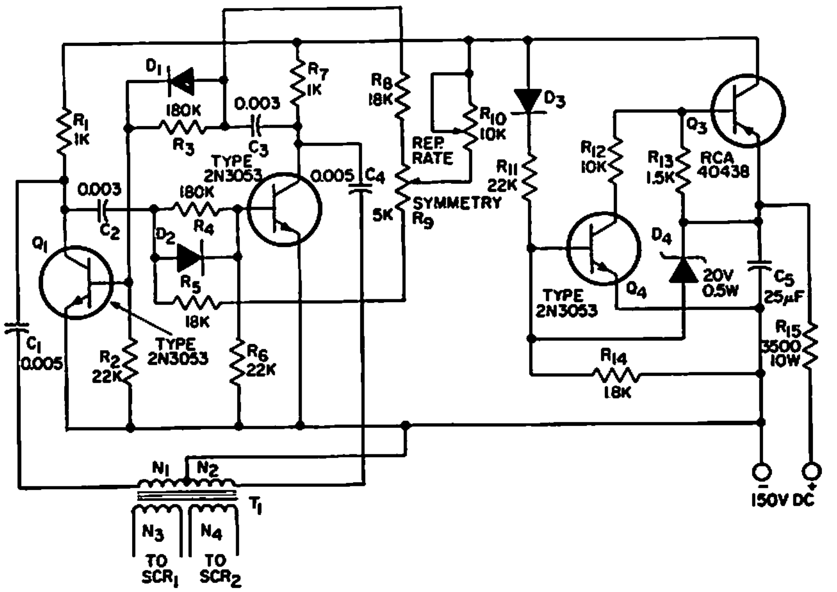
115-V A-C AT 10 W FROM 12-V BATTERY—Q1-Q2 and transformer oscillate at 400 Hz when S1 is closed, with startup assured by forward bias developed across R5-R6. Series regulator Q3-Q4 senses output of full-wave bridge, which is proportional to a-c load voltage, and controls base drive of output transistors Q1-Q2 to regulate both output voltage and frequency. Developed as low-cost regulated a-c power source for mobile applications.—Regulated Inverter, Delco Radio, Kokomo, Ind., No. 37, 1966.


C1
D4
D1
D3
D2
LOAD
REF.
SEC.
S1
R1
R7
DTG-110
Q3
C3
C2
12V.
F.B.
PRI.
F.B.
R5
R6
2N2711
Q4
R2
R3
R4
Z1
D3
Q1
DTG-110
Q2
DTG-110
D1
D2


Q1
2N4180
X
Y
C1
20 µF
110 VAC
28 V
T1
L1
L2
C3
0.5 µF/
200 V
LOAD
C2
20 µF
100 VAC
Q2
2N4180
R1
1.5 k
R3
50 k
R4
50 k
R5
2 k
R6
2 k
R2
1.5 k
Q1
2N4870
C4
0.1 µF
75 V
Q2
2N4870
T2
X
Y
D1
1N4001
D2
1N4001
R7
100

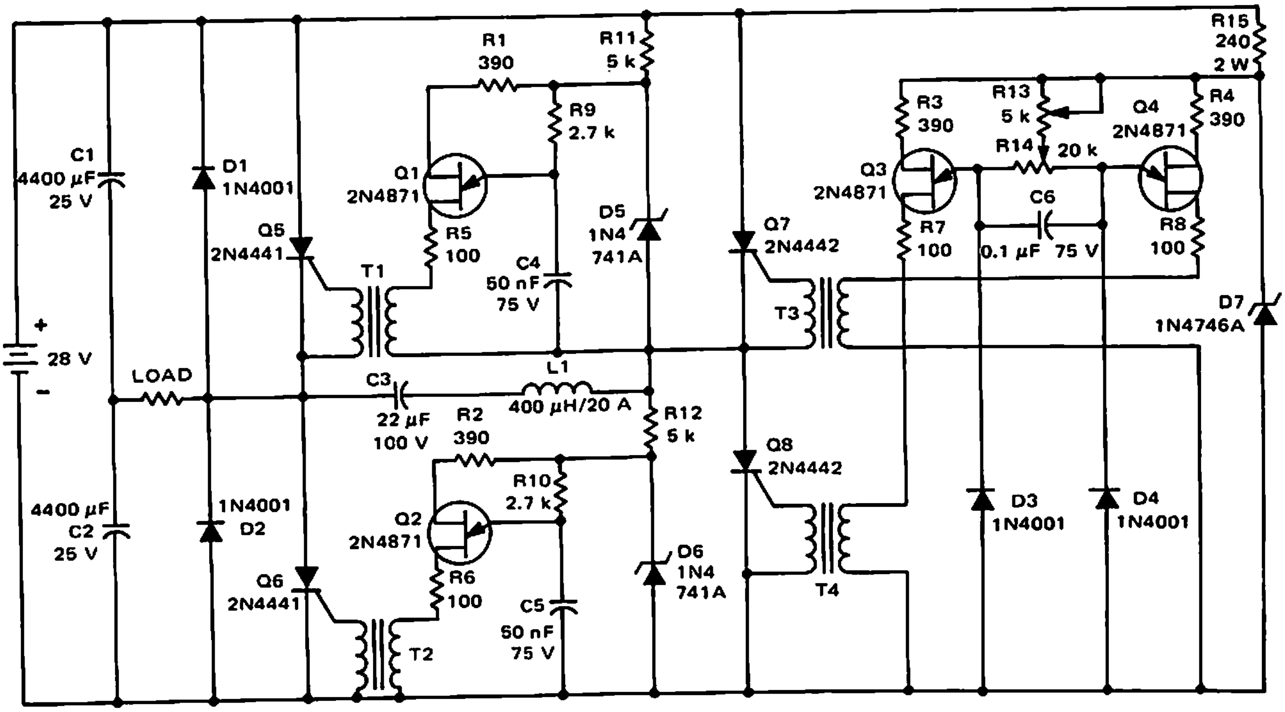
L1 and L2 – TRIAD C-49 V 32 mH CT, 5A
T1 – TRIAD F-22A 120/6.3 V 20 A
T2 – SPRAGUE 11Z13

120-V A-C AT 40 W AND 400 HZ FROM 28 V D-C—Gives pure sine-wave output with 10% voltage regulation for both input and load voltages. Can be operated indefinitely with open or shorted load. Output voltage increases from about 30 to 130 V rms as load is applied; load resistance must therefore be limited to certain range if voltage variations are undesirable. Efficiency is about 40% for 250-ohm load.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–33.


D1
180K
R3
0.003
C3
R7
1K
R8
18K
R10
10K
REP. RATE
D3
R11
22K
R12
10K
R13
1.5K
Q3
RCA 40438
R1
1K
TYPE 2N3053
0.005
C4
5K
SYMMETRY
R9
0.003
C2
180K
R4
D2
R5
18K
Q1
C1
0.005
R2
22K
TYPE 2N3053
R6
22K
TYPE 2N3053
Q4
D4
20V 0.5W
C5
25μF
R15
3500
10W
R14
18K
N1
N2
T1
N3
N4
TO SCR1
TO SCR2
−
+
150V DC

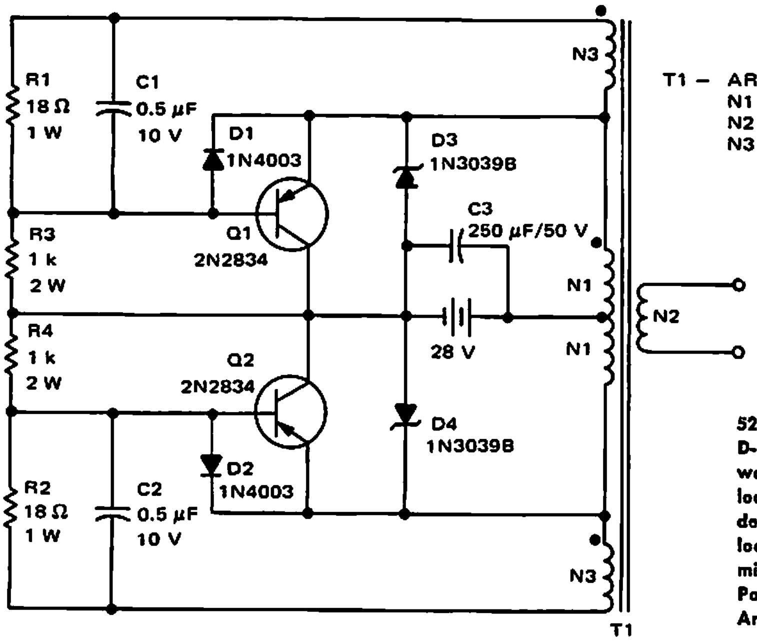
D_4 = Zener diode, 20-volt, ½-watt
T_1 = Pulse transformer; center-tapped primary: $N_1 = N_2$ = 150 turns of No. 36 wire; split secondaries: $N_3 = N_4$ = 100 turns of No. 36 wire; core material: Indiana General Type No. CF902, or equiv.

TRIGGER GENERATOR FOR INVERTER—Used for triggering pair of thyristors, SCR1 and SCR2, in 10-kHz push-pull switching inverter. Transients that might exceed maximum rating of scr's are suppressed by network consisting of R1, R2, R3, C2, C3, and two 1N547 diodes, D1 and D2.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 197.


C1
4400 μF
25 V
+
28 V
−
D1
1N4001
Q5
2N4441
R1
390
R11
5 k
R9
2.7 k
Q1
2N4871
R5
100
C4
50 nF
75 V
D5
1N4741A
T1
LOAD
C3
22 μF
100 V
L1
400 μH/20 A
R2
390
R12
5 k
R10
2.7 k
4400 μF
C2
25 V
1N4001
D2
Q2
2N4871
R6
100
C5
50 nF
75 V
D6
1N4741A
Q6
2N4441
T2
Q7
2N4442
T3
Q8
2N4442
T4
R3
390
R13
5 k
R14
20 k
Q3
2N4871
R7
100
C6
0.1 μF 75 V
Q4
2N4871
R4
390
R8
100
R15
240
2 W
D7
1N4746A
D3
1N4001
D4
1N4001

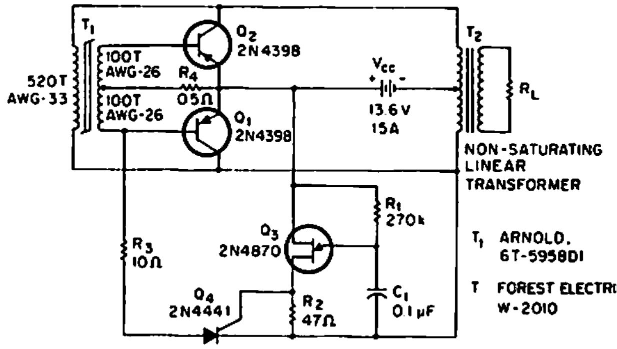
T1 – T4 – SPRAGUE 11Z12

12-V A-C AT 60 W AND 465 HZ FROM 28 V D-C—Uses impulse-commutated scr inverter to generate well-regulated square-wave output that can be used to drive 400-Hz transformer. Efficiency is about 65% at full load.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–41.

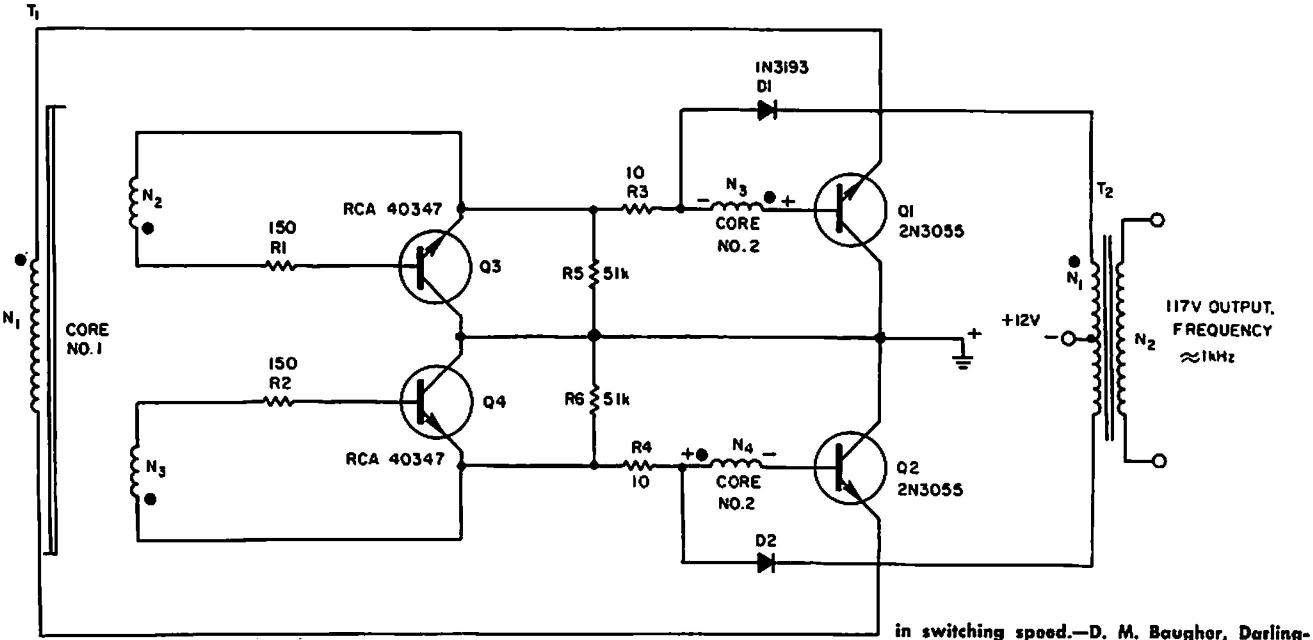

R1
18 Ω
1 W
C1
0.5 μF
10 V
D1
1N4003
D3
1N3039B
C3
250 μF/50 V
Q1
2N2834
R3
1 k
2 W
R4
1 k
2 W
Q2
2N2834
28 V
D4
1N3039B
D2
1N4003
R2
18 Ω
1 W
C2
0.5 μF
10 V
N3
N1
N1
N2
N3
T1

T1 – ARNOLD CORE GT-5502-D500
N1 26 TURNS OF AWG #14 WIRE
N2 52 TURNS OF AWG #14 WIRE
N3 3 TURNS OF AWG #22 WIRE

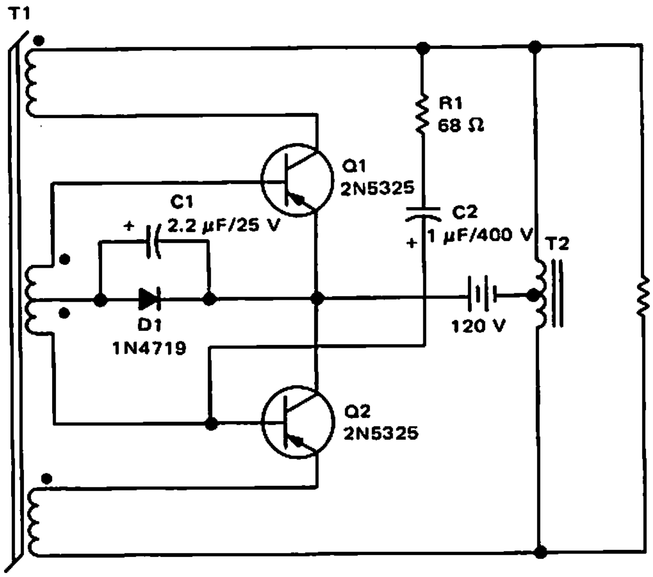
52-V A-C AT 100 W AND 15 KHZ FROM 28 V D-C—High-frequency inverter provides square-wave output with efficiency of 85% at full load. Frequency stability is excellent, being dependent only on input voltage and not load. Excellent for applications requiring minimum size and weight.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–54.


T₁
520T
AWG-33
100T
AWG-26
R₄
.05Ω
100T
AWG-26
Q₂
2N4398
Q₁
2N4398
Vcc
+ -
13.6 V
15A
T₂
R_L
NON-SATURATING
LINEAR
TRANSFORMER
R₁
270k
Q₃
2N4870
R₃
10Ω
Q₄
2N4441
R₂
47Ω
C₁
0.1 μF
T₁ ARNOLD,
6T-5958DI
T FOREST ELECTRIC,
W-2010

SELF-STARTER—Combination of low-cost plastic-encapsulated ujt and scr provides almost instantaneous saturation of Q1 in inverter circuit, for reliable startup at 400 Hz. Once inverter is operating, starting circuit stays turned off and hence consumes negligible power. Output to load is 200 W at 115 V. —R. A. Phillips, Starting Network for Transistor Inverters, *EEE*, Feb. 1969, p 114–115.


T₁
N₁
CORE
NO. 1
N₂
150
R1
RCA 40347
Q3
150
R2
Q4
N₃
RCA 40347
IN3193
D1
10
R3
N₃
CORE
NO. 2
R5 51k
R6 51k
R4
10
N₄
CORE
NO. 2
D2
Q1
2N3055
Q2
2N3055
+
+12V
T₂
N₁
N₂
117V OUTPUT,
FREQUENCY
≈1kHz

CUTTING TRANSFORMER COST—Extra windings N3 and N4 on output transformer, plus addition of D1 and D2 to Darlington inverter, reduce transformer size and cost without having excessive dissipation of conventional Darlington approach. Circuit also gives increase in switching speed.—D. M. Baugher, Darlington Inverter Features Turn-Off Drive and Low V-ce(sat), *Electronic Design*, July 5, 1969, p 86.

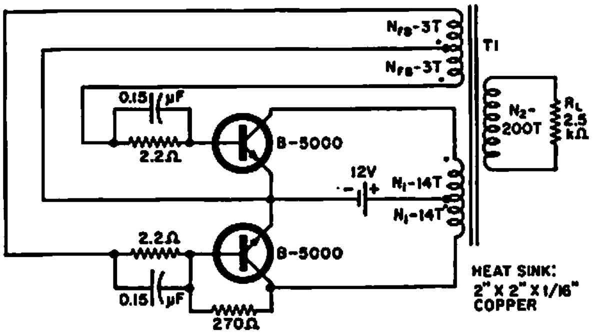


T1
R1
68 Ω
Q1
2N5325
C1
+
2.2 µF/25 V
C2
+
1 µF/400 V
T2
D1
1N4719
120 V
LOAD
Q2
2N5325

T1 – ARNOLD CORE 6T 4168S1
46T OF #23 FOR EACH BASE WINDING
5T OF 3 #18 FOR EACH COLLECTOR WINDING

T2 – PHOENIX TRANSFORMER PX-2677

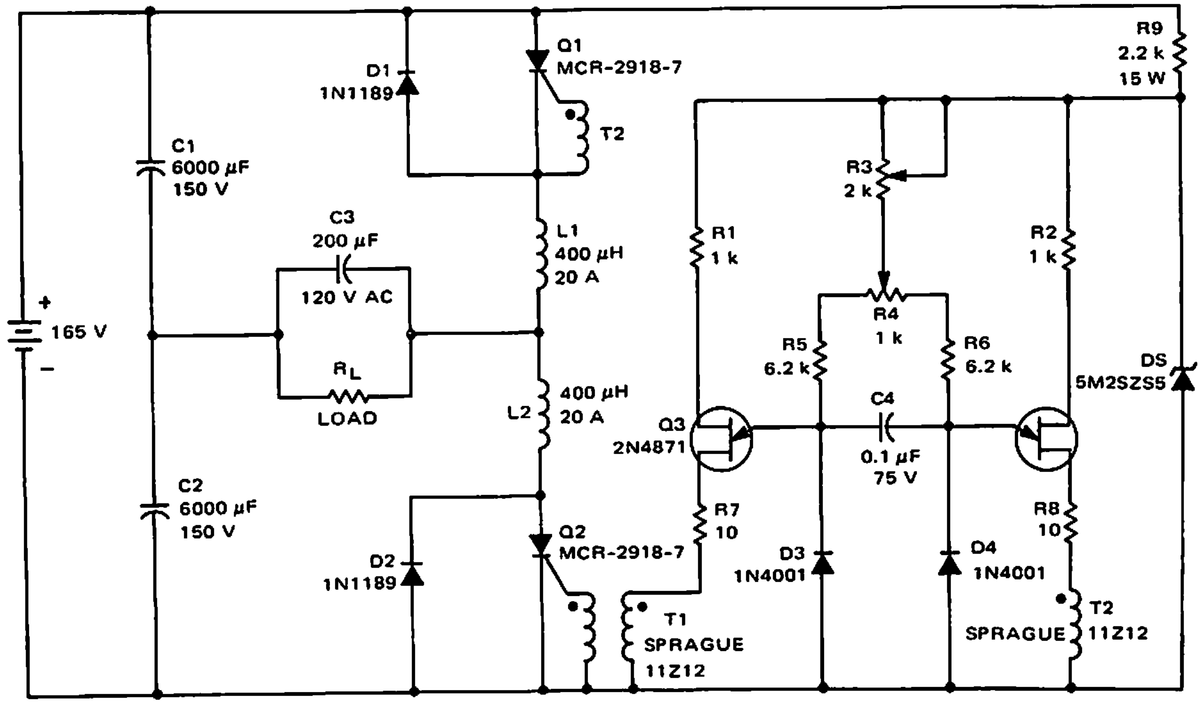
240-V A-C AT 1 KW AND 1,200 HZ FROM 120 V D-C—Square-wave output is produced at efficiency of 92% for full load, with excellent frequency stability. Will operate over input voltage range of 20 to 160 V d-c. Circuit will fail-safe if either input voltage or load is removed, even though self-excited. Has no starting limitations.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–50.



N_{FB}-3T
N_{FB}-3T
TI
0.15 µF
2.2Ω
B-5000
N_2-200T
R_L 2.5 kΩ
12V
N_1-14T
N_1-14T
2.2Ω
B-5000
0.15 µF
270Ω
HEAT SINK: 2" x 2" x 1/16" COPPER

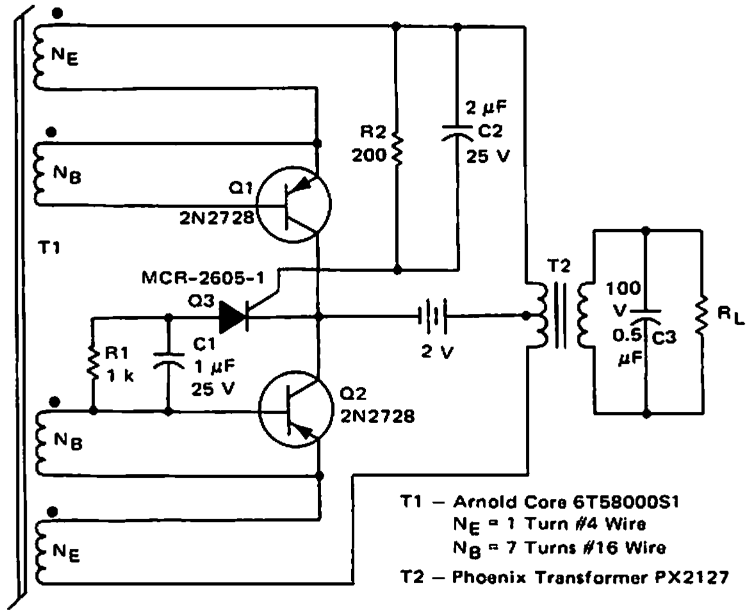
TI-WESTINGHOUSE C CORE, CATALOG #H425, WINDING #20 WIRE
(B) 22-WATT INVERTER

22-W AUTOMOTIVE—Uses inexpensive Bendix plastic-encased power transistors to convert 12-V storage-battery power to any desired higher a-c voltage determined by turns ratio of transformer, or to d-c voltage if output rectifier and filter are added.—D. E. Lancaster, Plastic Power Transistors—Advantages and Applications, *Electronics World*, Feb. 1968, p 50–52.



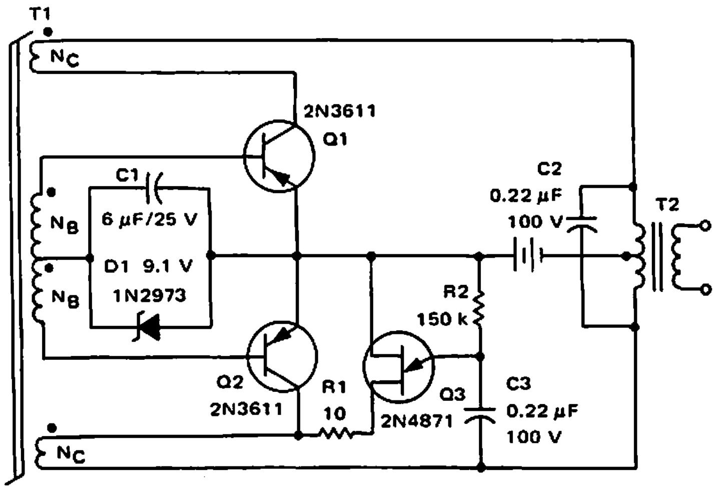
D1
1N1189
Q1
MCR-2918-7
T2
R9
2.2 k
15 W
C1
6000 µF
150 V
C3
200 µF
120 V AC
R3
2 k
L1
400 µH
20 A
R1
1 k
R2
1 k
+
165 V
–
R_L
LOAD
R4
1 k
R5
6.2 k
R6
6.2 k
DS
5M2SZS5
L2
400 µH
20 A
Q3
2N4871
C4
0.1 µF
75 V
C2
6000 µF
150 V
R7
10
R8
10
Q2
MCR-2918-7
D2
1N1189
D3
1N4001
D4
1N4001
T1
SPRAGUE
11Z12
SPRAGUE
T2
11Z12

120-V A-C AT 800 W AND 400 HZ FROM 165 V D-C—Considered to be best sine-wave inverter in use today. Output voltage is well regulated for load changes, frequency is independent of normal input and load variations, and efficiency is 60% at rated output.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–31.


NE
NB
Q1
2N2728
T1
MCR-2605-1
Q3
R1
1 k
C1
1 μF
25 V
Q2
2N2728
NB
NE
R2
200
2 μF
C2
25 V
2 V
T2
100 V
0.5 μF
C3
RL

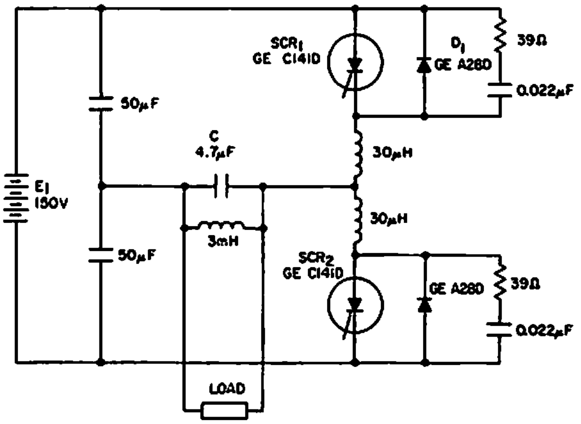
T1 – Arnold Core 6T58000S1
N_E = 1 Turn #4 Wire
N_B = 7 Turns #16 Wire
T2 – Phoenix Transformer PX2127

35-V A-C AT 80 W AND 1 KHZ FROM 2 V D-C—Current-feedback inverter provides maximum efficiency of 87% for 30-W load and 70% for full load. Input current from 2-V battery has allowable range of 10–50 A. Starting circuit for inverter consists of R1, C1, R2, C2, and Q3.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–45.

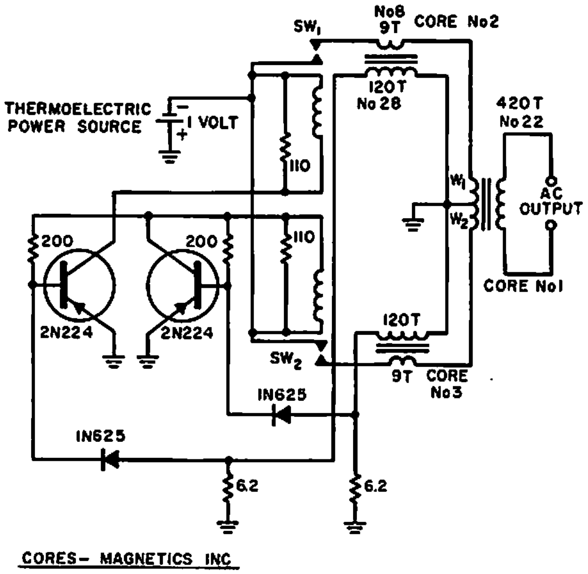

T1
NC
NB
NB
NC
C1
6 μF/25 V
D1 9.1 V
1N2973
2N3611
Q1
Q2
2N3611
R1
10
Q3
2N4871
R2
150 k
C2
0.22 μF
100 V
C3
0.22 μF
100 V
T2

T1 – ARNOLD CORE 4T – 4179 D1
N_B 200 TURNS #20 WIRE
N_C 20 TURNS THREE #16 WIRES IN PARALLEL
T2 – TRANSFORMER 110-24 VCT FELCO VJ-1
(PRODUCT OF FOREST ELECTRIC CO.)

120-V A-C AT 40 W AND 400 HZ FROM 12 V D-C—Gives frequency-stable square-wave output. Efficiency is about 80%.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 2–43.

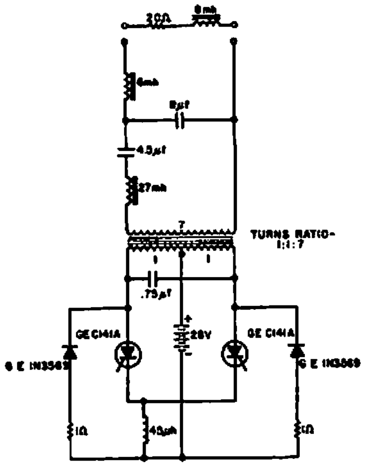

E1
150V
50μF
50μF
C
4.7μF
3mH
LOAD
SCR1
GE C141D
SCR2
GE C141D
30μH
30μH
D1
GE A280
GE A280
39Ω
0.022μF
39Ω
0.022μF

CLASS A INVERTER—Circuit is self-commutated by resonating load, for transforming d-c to a-c. Is most suitable for operation at about 1,000 Hz, because L-C resonant circuit carries full load current. Scr current is nearly sinusoidal. When SCR1 is triggered, C is charged to voltage approaching 300 V (twice supply voltage). Current then reverses and flows back to supply through D1 while C discharges. SCR2 is triggered next, with cycle repeating at about 1,000 Hz to provide 120 V a-c for load.—"SCR Manual," 4th Edition, General Electric, 1967, p 228.

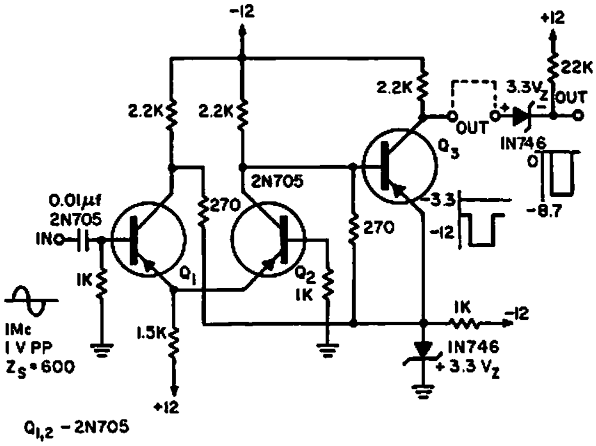

THERMOELECTRIC POWER SOURCE
1 VOLT
SW1
No8
9T
CORE No2
120T
No28
110
110
200
200
2N224
2N224
SW2
120T
9T
CORE No3
IN625
IN625
6.2
6.2
W1
W2
420T
No22
AC OUTPUT
CORE No1

CORES–	MAGNETICS INC	
No1	50026-2F	$W_1 = W_2$ = 66T No16
No2	55202–A2	
No3	55202–A2	

REED-SWITCH INVERTER—Converts 1-V d-c output of thermoelectric generator to 10 V a-c. Low-power transistor flip-flop drives reed switch coils, to eliminate contact bounce problems. Operating frequency of 100 Hz gives 1,000-hour reed switch life for 1 W delivered to load, with efficiency of 65%.—J. M. Loe, Reed Switches Reduce Power Converter Cost, *Electronic Design*, May 11, 1964, p 80–81.


20Ω
8mh
6mh
8μf
4.5μf
27mh
7
TURNS RATIO-
1:1:7
1
1
.75μf
GE C141A
GE C141A
28V
+
−
GE 1N3569
GE 1N3569
1Ω
40μh
1Ω

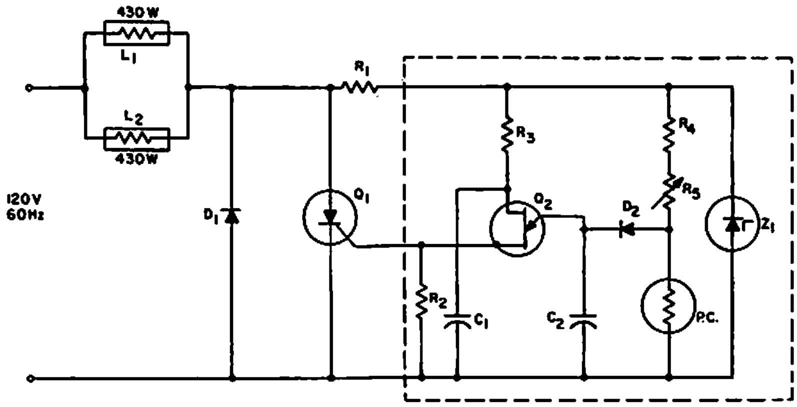
400-HZ INVERTER—Class C inverter with Ott filter converts 28 V d-c to 120 V a-c at 400 Hz with 360 W output power into 28-ohm inductive load having 20 ohms resistance. Input power is 424 W, for 85% efficiency. Article gives design equations.—"SCR Manual," 4th Edition, General Electric, 1967, p 235–237.


-12
+12
2.2K
2.2K
2.2K
22K
3.3V_Z
OUT
OUT
IN746
Q3
0
-8.7
0.01μf
2N705
IN
2N705
270
-3.3
-12
270
Q1
Q2
IK
IK
IK
-12
IMc
I V PP
Z_S = 600
1.5K
IN746
+3.3 V_Z
+12
Q1,2 - 2N705

SQUARER—Uses transient-free current-mode inverter Q1-Q2, followed by saturating inverter Q3, to convert sine waves to square waves for driving switching circuits. Thermal stability and noise immunity are excellent and sensitivity is high.—M. Neidich, Squaring Circuit Improves Symmetry and Thermal Stability, *Electronic Design*, Aug. 31, 1964, p 48.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 43
Lamp Control Circuits

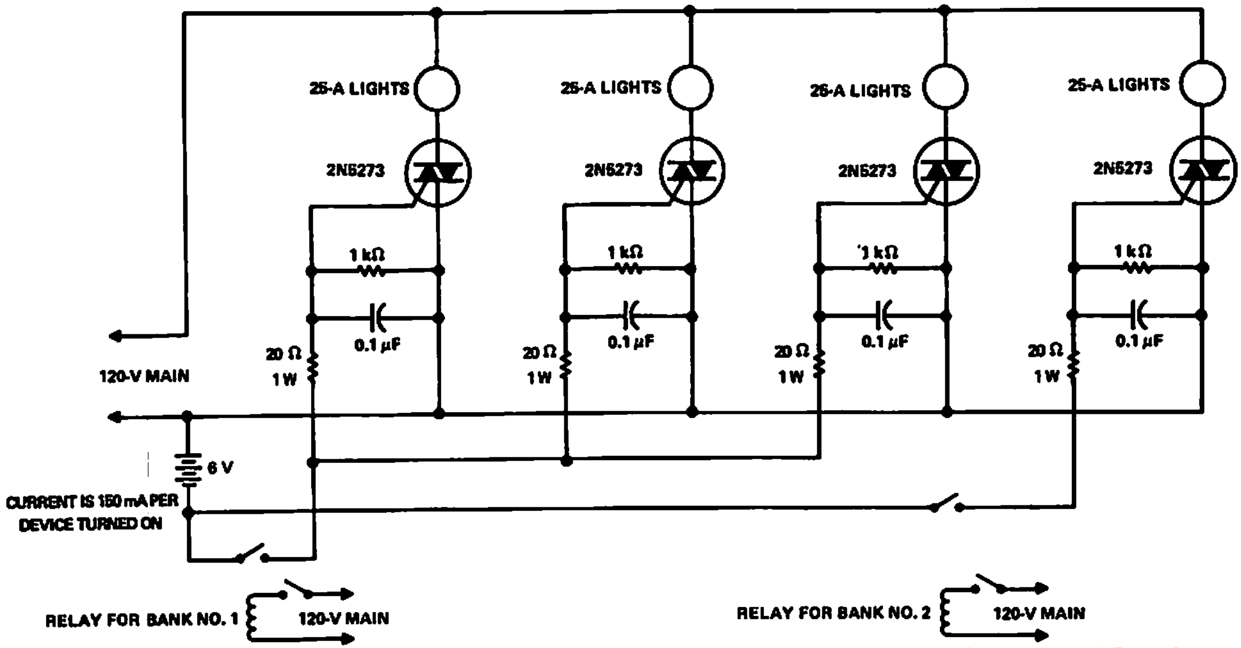

430W
L_1
L_2
430W
120V
60Hz
D_1
Q_1
R_1
R_3
Q_2
D_2
R_4
R_5
Z_1
R_2
C_1
C_2
P.C.

R_1-6.8KΩ, 2W
R_2-47Ω
R_3-1KΩ
R_4-680Ω
R_5-1KΩ, 1/2W POT
P.C.-GE A35

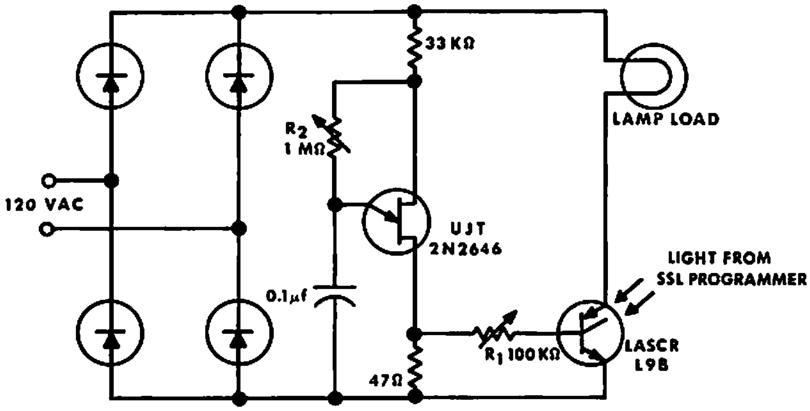
Q_1-GE C20B
Q_2-GE 2N2646
D_1-GE A41B
D_2-GE A13F
Z_1-GE Z4XL16
L_1, L_2-430W INCANDESCENT LAMP

C_1-.03µfd, 25V
C_2-.01µfd, 25V
NOTE: ALL RESISTANCES
1/2w, 10% UNLESS
OTHERWISE NOTED

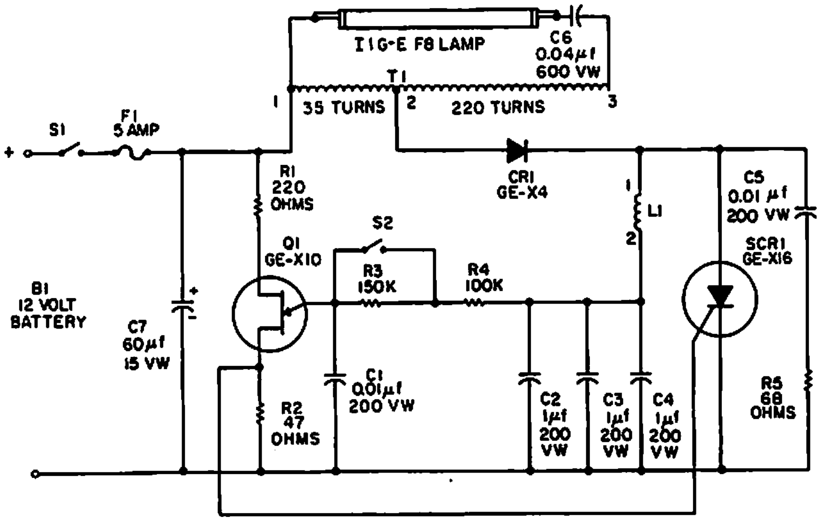
860-W LAMP CONTROL—Uses controlled-half-plus-fixed-half-wave phase control to regulate 860-W lamp from half to full power. Light output range is then 30% to 100% of maximum, regulated within 1% for 10% change in supply voltage. Not suitable for transformer-fed loads, because this method of phase control gives unsymmetrical wave having d-c components. Photocell serves as feedback element in closed loop.—"SCR Manual," 4th Edition, General Electric, 1967, p 285.


25-A LIGHTS
25-A LIGHTS
25-A LIGHTS
25-A LIGHTS
2N6273
2N6273
2N6273
2N6273
1 kΩ
1 kΩ
1 kΩ
1 kΩ
0.1 µF
0.1 µF
0.1 µF
0.1 µF
20 Ω
1 W
20 Ω
1 W
20 Ω
1 W
20 Ω
1 W
120-V MAIN
6 V
CURRENT IS 150 mA PER DEVICE TURNED ON
RELAY FOR BANK NO. 1
120-V MAIN
RELAY FOR BANK NO. 2
120-V MAIN

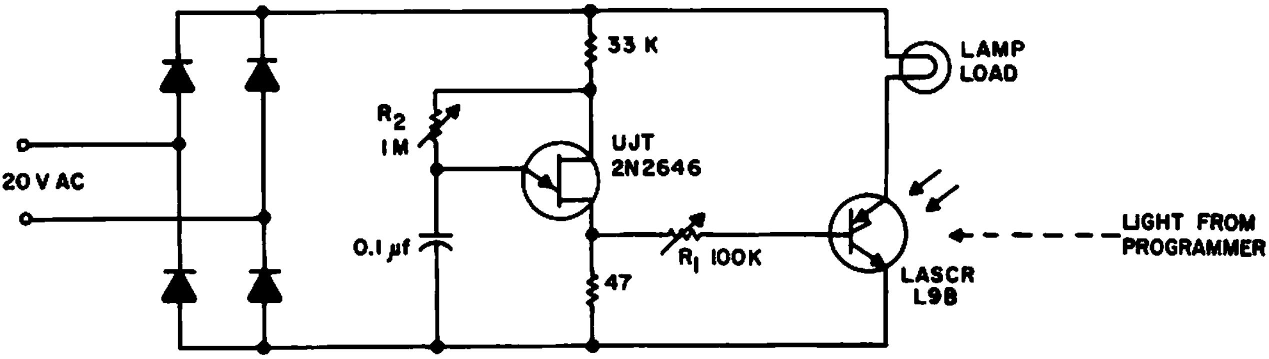
TRIAC CONTROL OF HEAVY LOADS—Low-power control arrangement turns on triacs rated at 25 A, for handling large banks of lights or other loads.—"Preferred Semiconductors and Components," Texas Instruments, Dallas, Texas, CC101, 1968, p 24608A.


33 KΩ
LAMP LOAD
R2 1 MΩ
120 VAC
UJT 2N2646
0.1μf
LIGHT FROM SSL PROGRAMMER
LASCR L9B
R1 100 KΩ
47Ω

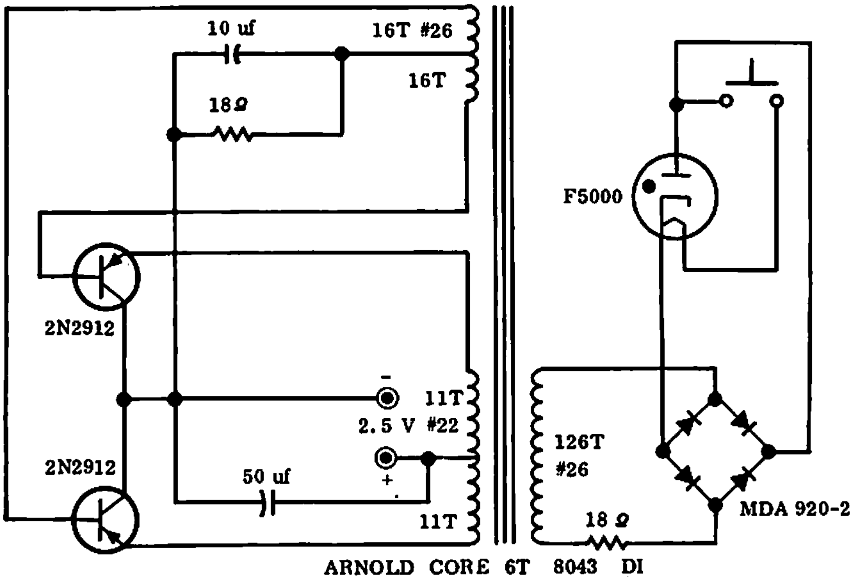
PREHEATER—Ujt provides preheating of repetitively programmed incandescent lamps by triggering lascr late in each half-cycle, with setting of R2 determining current that maintains filament temperature just below visible level. R1 adjusts sensitivity of lascr to light, to give reliable turn-on of lamp load under control of solid-state lamp in programmer.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 17.


T1G-E F8 LAMP
C6 0.04μf 600 VW
T1
1
35 TURNS
2
220 TURNS
3
S1
F1 5 AMP
+
R1 220 OHMS
CR1 GE-X4
C5 0.01 μf 200 VW
L1
1
2
S2
Q1 GE-X10
R3 150K
R4 100K
SCR1 GE-X16
B1 12 VOLT BATTERY
C7 60μf 15 VW
+
C1 0.01μf 200 VW
R2 47 OHMS
C2 1μf 200 VW
C3 1μf 200 VW
C4 1μf 200 VW
R5 68 OHMS

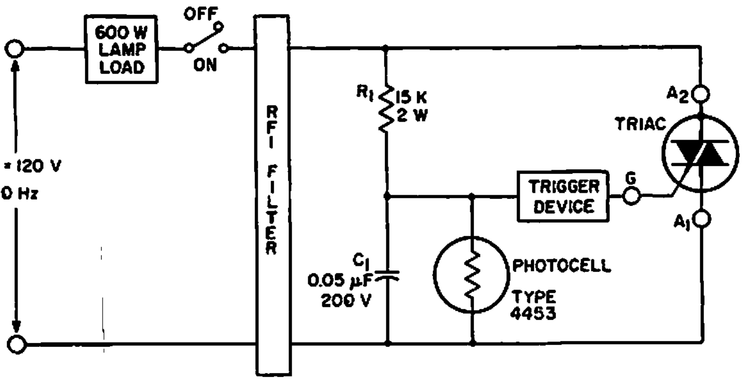
BATTERY-OPERATED FLUORESCENT—Will operate 12-inch F8 fluorescent from 12-V battery for portable use, or from 12-V auto, boat, or trailer storage battery. Remove ballast and starter from lamp fixture and replace with autotransformer for which book gives winding instructions. Inverter circuit used is high enough in frequency to give flicker-free illumination.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 138.


33 K
LAMP LOAD
R2 1M
UJT 2N2646
120 V AC
0.1 μf
R1 100K
LIGHT FROM PROGRAMMER
47
LASCR L9B

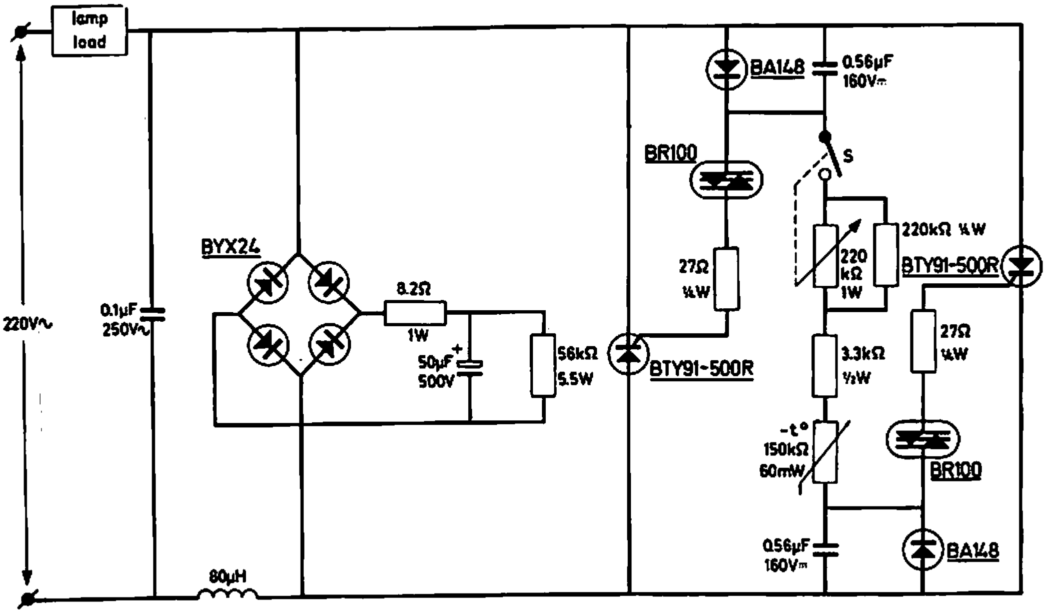
PREHEATING FOR PROGRAMMED LAMPS—Prevents thermal stresses on lamps that are optically programmed on and off for long periods of time. Ujt provides preheating by triggering lascr late in each half-cycle when programmed off. This keeps lamp current at minimum (adjusted with R2) required to maintain filament temperature just below visible level. R1 controls lascr sensitivity to light. Single ujt can serve several lascr-lamp circuits if separate gate resistor R1 is used for each lascr.—E. K. Howell, The Light Activated SCR, General Electric, Syracuse, N.Y., No. 200.34, 1965.


10 uf
16T #26
16T
18Ω
F5000
2N2912
-
11T
2.5 V #22
2N2912
50 uf
+
11T
126T
#26
18 Ω
MDA 920-2
ARNOLD CORE 6T 8043 DI

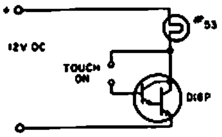
PORTABLE ULTRAVIOLET SOURCE—Converter circuit operates from 2.5-V rechargeable battery and supplies 400 mA at 26 V d-c for F5000 ultraviolet lamp. Frequency of inverter is 8 kHz.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 7–1–7.


600 W LAMP LOAD
OFF
ON
V_I = 120 V
60 Hz
RFI FILTER
R_1 15 K 2 W
C_1 0.05 μF 200 V
TRIGGER DEVICE
G
A_2
TRIAC
A_1
PHOTOCELL
TYPE 4453

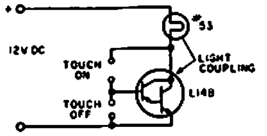
LAMPS ON AT NIGHT—Lamp load is turned on by triac when drop in illumination on photocell increases its impedance enough to make trigger diode turn on. Can be used for outdoor lighting controls.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 259.


lamp load
220V∿
0.1μF 250V∿
BYX24
8.2Ω 1W
50μF 500V
56kΩ 5.5W
BTY91-500R
BA148
0.56μF 160V⎓
BR100
27Ω ¼W
S
220 kΩ 1W
220kΩ ¼W
BTY91-500R
3.3kΩ ½W
27Ω ¼W
-t° 150kΩ 60mW
BR100
0.56μF 160V⎓
BA148
80μH

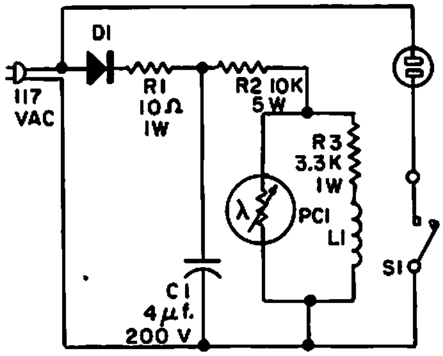
3-KW ANTIPARALLEL-THYRISTOR CONTROL—Will handle starting surges for lamp loads up to 3 kW, and up to 7 kW if there are no starting surges. Thermistor in R-C network limits amplitude and duration of initial current surge for incandescent lamps. Steepness of current transients is limited by 80-μH choke consisting of 50 turns wound on Ferroxcube 50-mm rod 10 mm in diameter.—Lamp Dimmer, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 2, 1967.


+
12V DC
TOUCH ON
#53
D16P

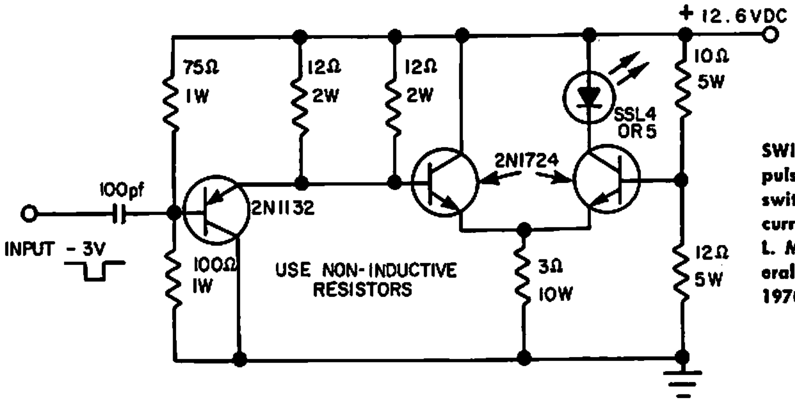
DARLINGTON TOUCH SWITCH—Lamp is turned on only while finger is touching both collector and base terminals of D16P Darlington transistor. Works well with slightly moist skin, but may not work for dry-skin touch.—E. K. Howell, Small Scale Integration in Low Cost Control Circuits, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 19.


+
12V DC
TOUCH ON
TOUCH OFF
#53
LIGHT COUPLING
L14B

LATCHING TOUCH SWITCH—Touching finger to both collector and base of L14B Darlington transistor turns on lamp, and light coupling between lamp and L14B latches lamp on. Lamp is turned off by touching base and emitter terminals, bypassing light-generated internal base current. Works well with slightly moist skin, but may not work for dry-skin touch.—E. K. Howell, Small Scale Integration in Low Cost Control Circuits, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 19.

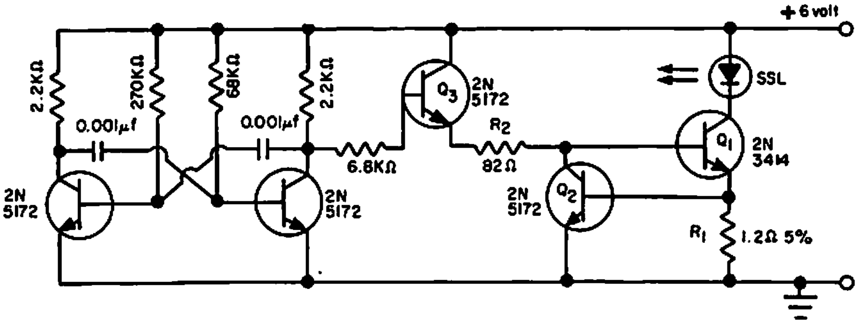

D1
117 VAC
R1 10Ω 1W
R2 10K 5W
R3 3.3K 1W
λ
PC1
L1
S1
C1 4µf. 200 V

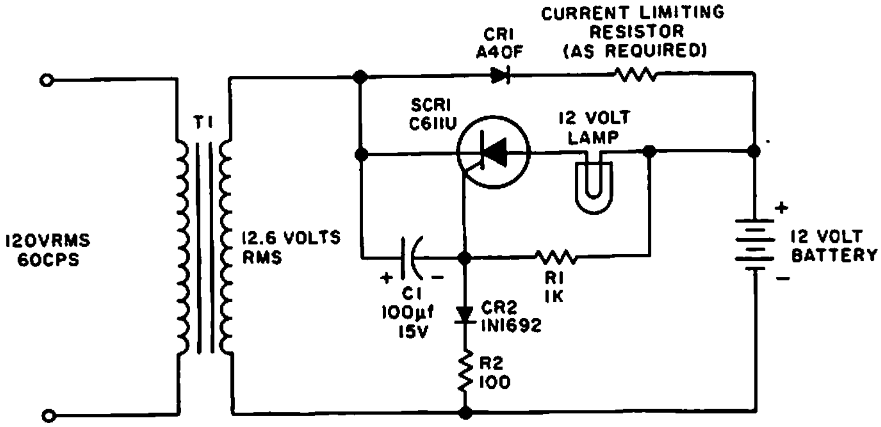
NIGHT LIGHT—Automatically turns 15-W light on at sunset and turns it off at sunrise. Uses GE-X7 magnetic reed switch for S1. Lamp plugs into outlet in series with switch. Diode D1 is GE-504. PC1 is GE-X6 or equivalent photocell.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 120.


+ 12.6VDC
75Ω 1W
12Ω 2W
12Ω 2W
SSL4 OR5
10Ω 5W
2N1724
100pf
INPUT - 3V
2N1132
100Ω 1W
USE NON-INDUCTIVE RESISTORS
3Ω 10W
12Ω 5W

SWITCH FOR SOLID-STATE LAMP—Used in pulsed-light communication, with current-mode switch driving solid-state lamp with peak currents of 2 A at 50-ns rise and fall times.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 21.

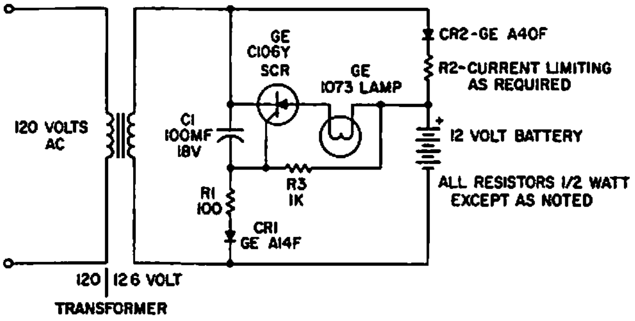
SOLID-STATE LAMP PULSER—Pulsing of ssl at 500 mA for 20% duty cycle increases light output up to five times. Asymmetrical flip-flop produces current drive for Q3 for 20% of period, which acts as low-current switch for constant-current source Q1-Q2 that pulses solid-state lamp. Period of flip-flop is about 350 µs.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 26.

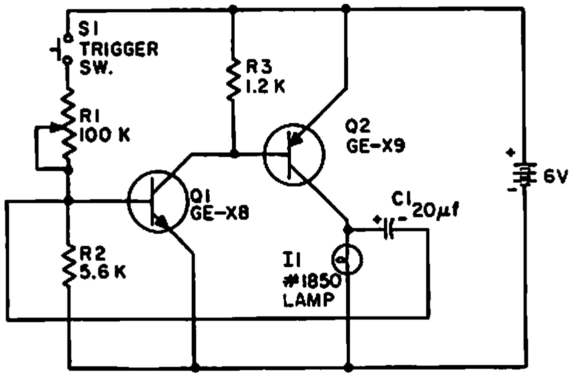

+6 volt
2.2KΩ
270KΩ
68KΩ
2.2KΩ
0.001µf
0.001µf
2N 5172
2N 5172
6.8KΩ
Q3
2N 5172
R2
82Ω
2N 5172
Q2
SSL
Q1
2N 3414
R1
1.2Ω 5%


CURRENT LIMITING RESISTOR (AS REQUIRED)
CR1 A40F
SCR1 C6IIU
12 VOLT LAMP
T1
120VRMS 60CPS
12.6 VOLTS RMS
C1 100µf 15V
R1 1K
CR2 1N1692
R2 100
12 VOLT BATTERY

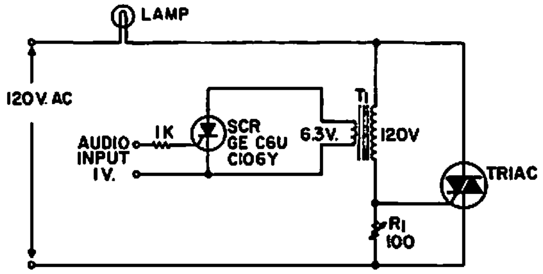
EMERGENCY-LIGHTING SWITCH—Provides battery-operated emergency lighting instantaneously and automatically when 120-V a-c line power fails. When a-c power is restored, emergency lamp is turned off and battery recharged. Suitable for restaurants, shops, corridors, elevators, and other places where loss of illumination is undesirable or intolerable.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 33.

EMERGENCY LIGHT—Turns on battery-powered lamp instantly when a-c power service fails. Emergency light turns off when line power is restored, and battery then recharges from a-c line. Requires no maintenance.—"Silicon Controlled Rectifier," General Electric, Syracuse, N.Y., No. 150.9, 1969.


120 VOLTS AC
C1 100MF 18V
GE C106Y SCR
GE 1073 LAMP
R1 100
R3 1K
CR1 GE A14F
CR2-GE A40F
R2-CURRENT LIMITING AS REQUIRED
12 VOLT BATTERY
ALL RESISTORS 1/2 WATT EXCEPT AS NOTED
120 | 12.6 VOLT TRANSFORMER

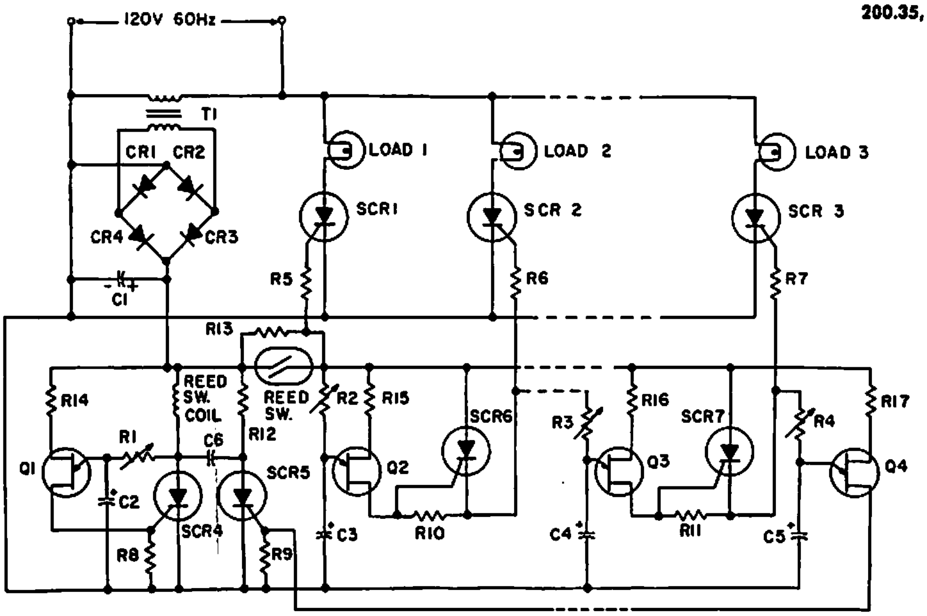

S1 TRIGGER SW.
R1 100 K
R2 5.6 K
R3 1.2 K
Q1 GE-X8
Q2 GE-X9
C1 20μf
I1 #1850 LAMP
6V

TRIGGERED LIGHT SOURCE—Can be used with appropriate focusing lens in light-source gun, for shooting alleys where target rifles are not permissible. Intended for use with photoelectric target that flashes when hit by light beam.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 79.


LAMP
120V AC
AUDIO INPUT 1V.
1K
SCR GE C6U C106Y
6.3V.
T1
120V
TRIAC
R1 100

NOTE: T_1 IS A 6.3V., 1A. "FILAMENT" TRANSFORMER. ADJUST R_1 FOR MAXIMUM RESISTANCE THAT WILL NOT TURN ON LAMP WITH ZERO INPUT.

AUDIO-CONTROLLED LAMP—Low audio input voltage (1 V) provides on-off control of 120-V 500-W lamp. Switching action of scr-triac combination is very rapid compared to response times of lamp and human eye, so effect produced with audio input is similar to proportional control circuit. If input to scr consists of phase-controlled pulses, full-wave control of lamp load is obtained.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 14.


120V 60Hz
T1
CR1 CR2
CR4 CR3
C1
LOAD 1
LOAD 2
LOAD 3
SCR1
SCR 2
SCR 3
R5
R6
R7
R13
R14
REED SW. COIL
REED SW.
R12
R2
R15
SCR6
R3
R16
SCR7
R4
R17
Q1
R1
C6
C2
SCR4
SCR5
Q2
Q3
Q4
R8
R9
C3
R10
C4
R11
C5

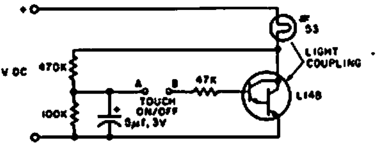
HALF-WAVE CHASER—Used for turning on string of lights sequentially to give effect of moving sign. Each stage has individual timing adjustment. When power is applied, all scr's are off; Q1 starts timing and, after delay set by R1, fires SCR4 which energizes reed switch. This turns SCR1 and first lamp on, and initiates timing of Q2 for delayed firing of SCR6 and SCR2. Process continues until Q4 fires, turning on SCR5 and turning off SCR4. Reed switch then drops out, turning off all scr's except SCR5 and resetting circuit for next sequential flashing cycle.—A. A. Adem, Flashers, Ring Counters and Chasers, General Electric, Syracuse, N.Y., No. 200.48, 1966, p 7.

R1, R2, R3, R4 : 500K POTS
R5, R6, R7, : 750Ω 1/2W
R8, R9 : 1K 1/2 W
R10, R11 : 33Ω 1/2W
R12 470Ω 1/2W
R13 : 1MEG 1/2W
R14, R15, R16, R17: 330Ω 1/2W

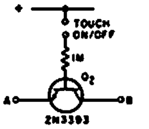
C1 : 500μF 25 V
C2, C3, C4, C5: 2μF, 10V
C6: .22μF 100V
T1: 120:12.6 STEPDOWN
REED SW: GE 2DR15 (1AMP)
GE 2DR30 (3AMP)
REED SW COIL: 10,000T #39 WIRE 825Ω
CR1-CR4: (4) GE A13A

Q1-Q4: (4) GE 2N2646 UJT
SCR1-SCR3 (3) GE C20B
SCR4-SCR7 (4) GE C106Y
LOADS: 550 WATTS EACH

ADDITIONAL STAGES MAY BE ADDED BETWEEN DASHED LINES.

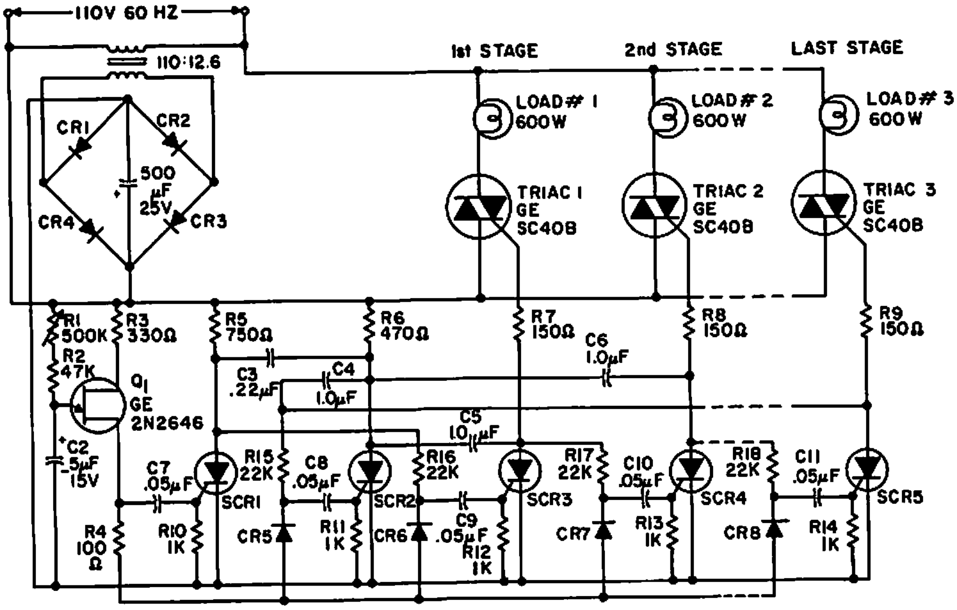

+
12V DC
470K
100K
A
B
47K
TOUCH ON/OFF
+ 5µf, 3V
#53
LIGHT COUPLING
L14B

LATCHING, SINGLE BUTTON, ALTERNATING, FLASHES IF HELD.


+
TOUCH ON/OFF
1M
Q2
A
B
2N3393

HIGH SENSITIVITY MODIFICATION

SINGLE-BUTTON ON-OFF TOUCH SWITCH—Touching single pair of contacts alternately turns lamp on and off. Lamp flashes if finger is held on button. Latching is provided by light coupling between lamp and L14B Darlington transistor. Works well with slightly moist skin, but may not work for dry-skin touch. High-sensitivity modification ensures dry-skin operation.—E. K. Howell, Small Scale Integration in Low Cost Control Circuits, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 19.


110V 60 HZ
110:12.6
CR1
CR2
CR3
CR4
500 µF 25V
1st STAGE
2nd STAGE
LAST STAGE
LOAD # 1 600W
LOAD # 2 600W
LOAD # 3 600W
TRIAC 1 GE SC40B
TRIAC 2 GE SC40B
TRIAC 3 GE SC40B
R1 500K
R2 47K
R3 330Ω
R4 100 Ω
R5 750Ω
R6 470Ω
R7 150Ω
R8 150Ω
R9 150Ω
Q1 GE 2N2646
C2 .5µF 15V
C3 .22µF
C4 1.0µF
C5 1.0µF
C6 1.0µF
C7 .05µF
C8 .05µF
C9 .05µF
C10 .05µF
C11 .05µF
R10 1K
R11 1K
R12 1K
R13 1K
R14 1K
R15 22K
R16 22K
R17 22K
R18 22K
SCR1
SCR2
SCR3
SCR4
SCR5
CR5
CR6
CR7
CR8

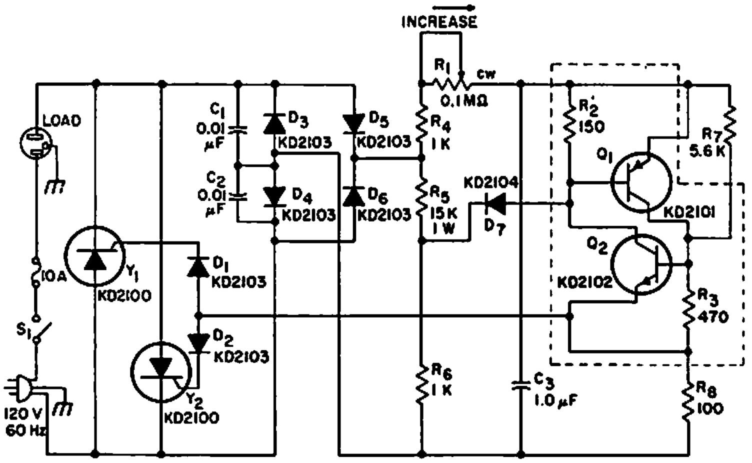
ALL SCR'S GE C106Y ALL RESISTORS 1/2 W
ALL DIODES GE A13 F
FOR 1000 WATT LOAD USE
GE SC45B TRIACS.
ADDITIONAL STAGES MAY BE ADDED BETWEEN DOTTED LINES.

A-C CHASER—Modification of ring counter is used for turning on string of lights sequentially to give effect of moving sign. When power is first turned on, all scr's are off and ujt oscillator is energized by bridge rectifier. At end of delay determined by setting of R1, ujt fires and turns on SCR1. Next firing of ujt turns on SCR3 and fires triac 1. Next two pulses turn on SCR4 and SCR5 in turn and fire triacs 2 and 3 in turn. Following pulse fires SCR2 which commutates other four scr's off. Next pulse starts cycle over again by turning SCR1 on and SCR2 off. OFF time thus takes two pulses and ON time one pulse, which makes performance more appealing to the eye. If ujt frequency is 1 Hz, each lamp is on 1 s and off 2 s.—A. A. Adem, Flashers, Ring Counters and Chasers, General Electric, Syracuse, N.Y., No. 200.48, 1966, p 6.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

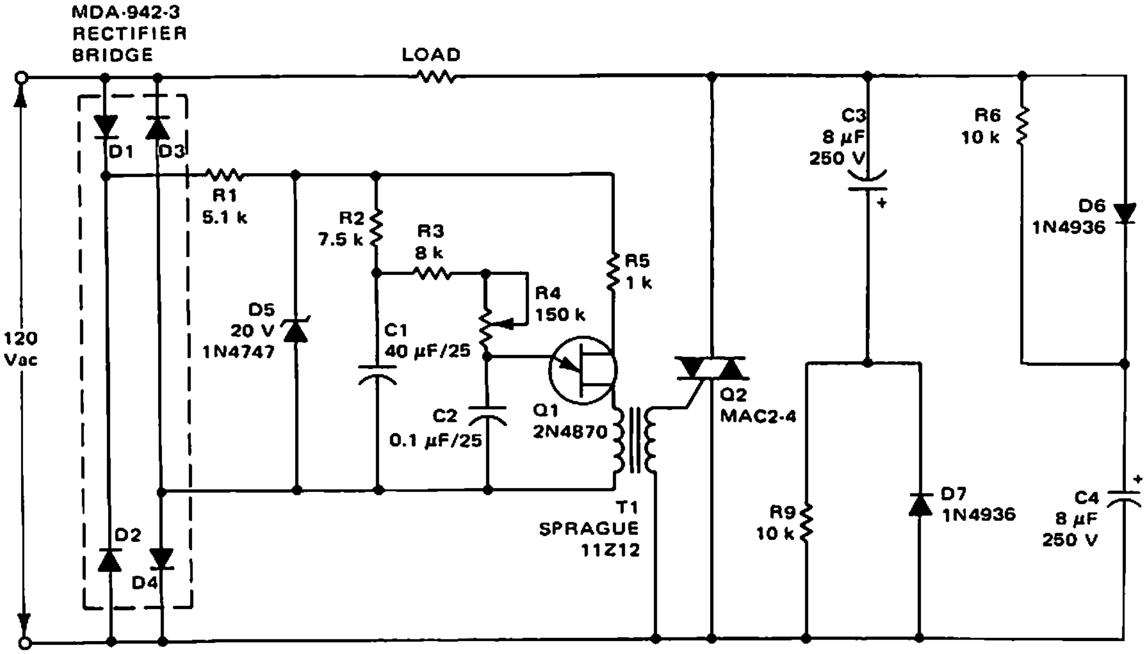
CHAPTER 44

Lamp Dimmer Circuits



INCREASE
R1
CW
0.1MΩ
R4 1K
LOAD
C1 0.01 µF
D3 KD2103
D5 KD2103
C2 0.01 µF
D4 KD2103
D6 KD2103
R5 15K 1W
KD2104
D7
R2 150
Q1
R7 5.6K
KD2101
Q2
KD2102
R3 470
10A
Y1 KD2100
D1 KD2103
S1
D2 KD2103
Y2 KD2100
120 V 60 Hz
R6 1K
C3 1.0µF
R8 100

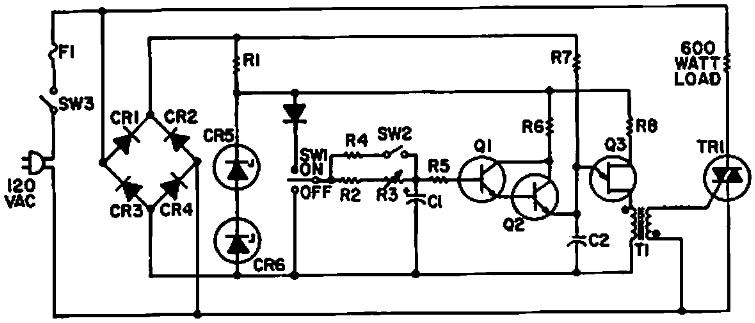
DUAL-SCR DIMMER—Can handle 500-W incandescent-lamp load, heater, or universal motor, providing full range of control and high reliability.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 49.



MDA-942-3 RECTIFIER BRIDGE
LOAD
D1
D3
R1 5.1 k
R2 7.5 k
R3 8 k
R4 150 k
R5 1 k
D5 20 V 1N4747
C1 40 µF/25
C2 0.1 µF/25
Q1 2N4870
T1 SPRAGUE 11Z12
Q2 MAC2-4
C3 8 µF 250 V
+
R6 10 k
D6 1N4936
D7 1N4936
R9 10 k
C4 8 µF 250 V
+
120 Vac
D2
D4

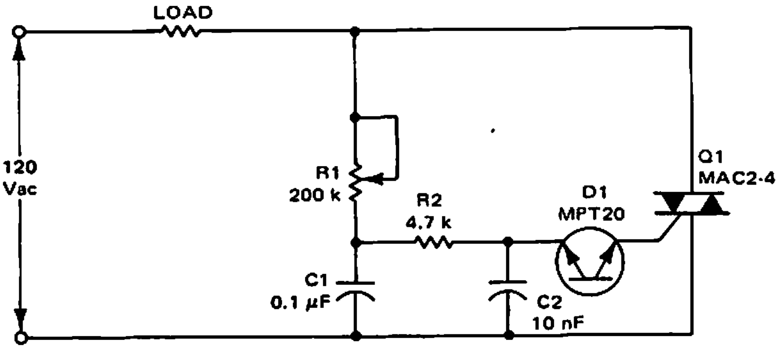
800-W SOFT-START DIMMER—Combining soft-start feature with dimmer control R4 prevents high inrush currents to cold filaments of incandescent lamps, thereby extending lamp life. Accidental turnon is prevented by special dv/dt network including capacitors C3 and C4.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–14.

20-MINUTE DIMMER—Time-dependent incandescent-lamp dimmer handles up to 600-W load with triac specified. High input impedance of Darlington Q1-Q2 permits very long charging and discharging times for C1, to give very slow turn-on or turn-off of lamp load, depending on setting of SW1. At maximum-resistance setting of R3, about 20 minutes is required for lights to dim automatically from full-on to full-off. Also called bachelor light.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 14.


F1
SW3
120 VAC
CR1
CR2
CR3
CR4
CR5
CR6
R1
R7
600 WATT LOAD
SW1 ON
OFF
R4
SW2
R2
R3
R5
C1
Q1
Q2
R6
R8
Q3
C2
T1
TR1

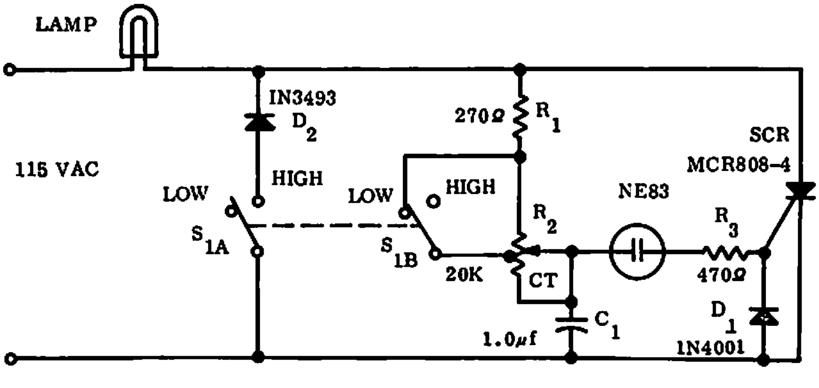
CR1 THRU CR4 : G-E IN1693 RECTIFIER DIODE
CR5, CR6 : G-E Z4XL7.5 ZENER DIODE
CR7 : G-E IN1692 RECTIFIER DIODE
C1 : 100 μf, 15 WVDC ELECTROLYTIC CAPACITOR (G-E QT1-22)
C2 : 0.1 μf, 15 WVDC CAPACITOR
Q1, Q2 : G-E 2N2712 n-p-n TRANSISTOR
Q3 : G-E 2N2647 UNIJUNCTION TRANSISTOR
TR1 : TRIAC SC41B
F1 : 3 AMPERE FUSE

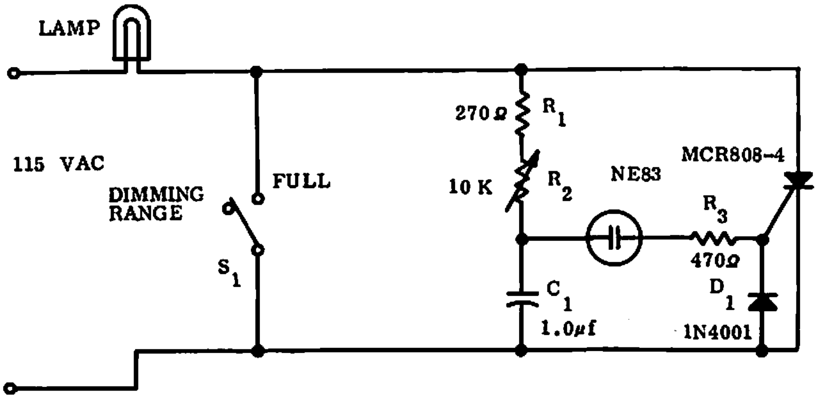
R1 : 3.3K OHM, 2 WATT RESISTOR
R2, R4 : 4.7K OHM, 1/2 WATT RESISTOR
R3 : 5 MEGOHM, 1 WATT POTENTIOMETER
R5, R7 : 1 MEGOHM, 1/2 WATT RESISTOR
R6 : 2.2K OHM, 1/2 WATT RESISTOR
R8 : 470 OHM, 1/2 WATT RESISTOR
SW1 : SPDT SWITCH
SW2 : SPST SWITCH
T1 : SPRAGUE 35ZM923 PULSE TRANSFORMER


LOAD
120 Vac
R1 200 k
R2 4.7 k
C1 0.1 μF
C2 10 nF
D1 MPT20
Q1 MAC2-4

800-W TRIAC DIMMER—Simple control circuit controls conduction angle of triac from zero to about 170 degrees, providing better than 97% of full-power control. One possible problem is high starting current in lamps with cold filaments.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–16.

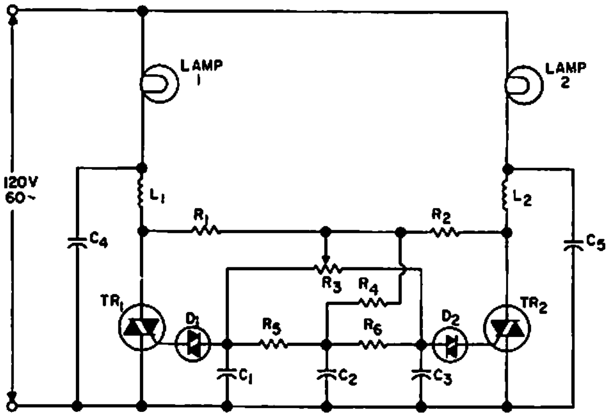
FULL-RANGE DIMMER—Provides control from full brilliance to zero by switching out rectifier and half of potentiometer resistance at midpoint of dimming range.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 10–2–2.


LAMP
115 VAC
IN3493 D2
LOW
HIGH
S1A
270Ω R1
LOW
HIGH
S1B
R2
20K
CT
NE83
C1
1.0μf
R3
470Ω
SCR MCR808-4
D1 1N4001


LAMP
115 VAC
DIMMING RANGE
FULL
S1
270Ω R1
10 K R2
NE83
MCR808-4
R3
470Ω
C1
1.0μf
D1
1N4001

HALF-WAVE DIMMER—Provides from 70% of maximum brilliance down to zero. Switch bypasses control when full brilliance is desired. Rating of scr determines wattage of lamp.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 10–2–1.

CROSSFADER FOR SLIDE PROJECTORS—Tandem dimmer circuit can be used for such applications as fading between two slide projectors, two movie projectors, or two illuminated signs. Moving R3 to either side of center fires one triac earlier in each half-cycle and the other later, with total light output for both lamps staying about constant for all control positions. Choice of triac depends on lamp wattage.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 17.



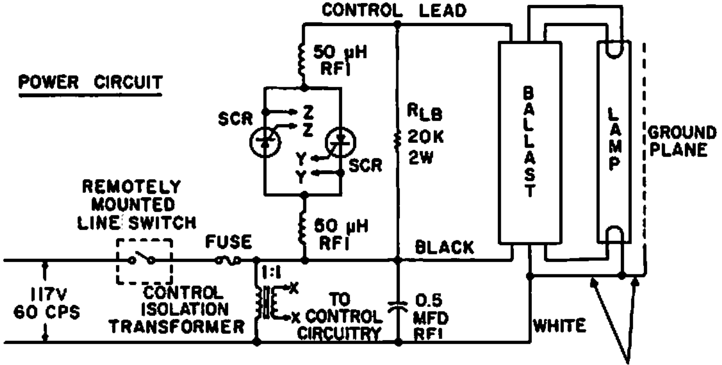
LAMP 1
LAMP 2
120V 60~
L1
L2
R1
R2
C4
C5
R3
R4
TR1
TR2
D1
D2
R5
R6
C1
C2
C3

$R_1 = R_2 = 6800\Omega$, 1 WATT
$R_3 = 150K\ \Omega$ LINEAR POT. 1W
$R_5 = R_6 = 22K\Omega$, 1/2W.
$R_4 = 15K\Omega$, 1/2W.
$TR_1 = TR_2 =$ TRIAC
$D_1 = D_2 =$ GE ST-2 DIAC

$L_1 = L_2 = 60\mu hy$ (FERRITE CORE)
$C_1 = C_2 = C_3 = 0.1\mu f$ 50V
$C_4 = C_5 = 0.1\mu f$ 200 VOLTS

NOTE: TOTAL LIGHT LEVEL (SUM OF LAMPS 1+2) CONSTANT WITHIN 15%.

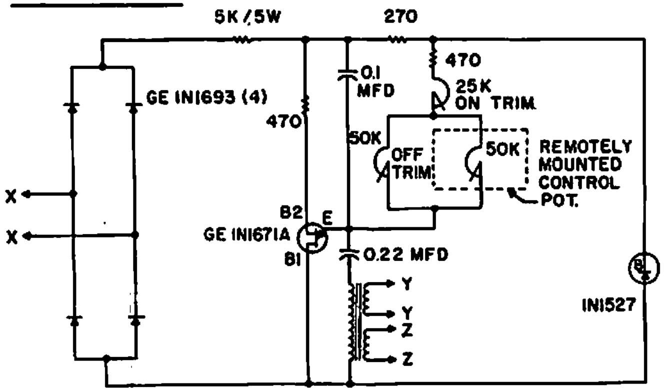
POWER CIRCUIT



CONTROL LEAD
50 μH RFI
SCR
Z
Z
Y
Y
SCR
RLB 20K 2W
50 μH RFI
BLACK
B A L L A S T
L A M P
GROUND PLANE
REMOTELY MOUNTED LINE SWITCH
FUSE
1:1
X
X
117V 60 CPS
CONTROL ISOLATION TRANSFORMER
TO CONTROL CIRCUITRY
0.5 MFD RFI
WHITE

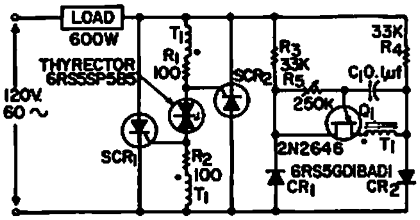
NUMBER OF BALLAST/LAMP COMBINATIONS IN PARALLEL DETERMINED BY CURRENT CAPABILITY OF DIMMER.

CONTROL CIRCUIT



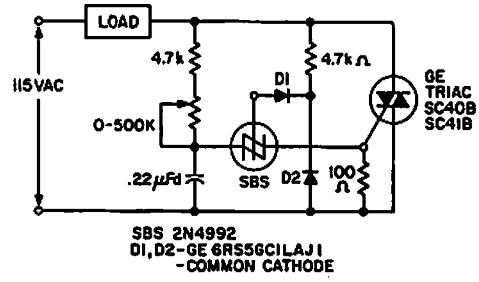
5K/5W
270
GE IN1693 (4)
470
0.1 MFD
470
25K ON TRIM
50K
OFF TRIM
50K
REMOTELY MOUNTED CONTROL POT.
X
X
B2
E
GE IN1671A
B1
0.22 MFD
Y
Y
Z
Z
IN1527

FLUORESCENT DIMMER—Uses scr's connected in inverse parallel with special G-E 89G718 dimming ballast for one F40T12 rapid-start fluorescent lamp. Includes rfi suppression. Excellent basic reference article on design requirements for fluorescent dimmers. Choice of scr depends on average value of current waveform; C11 and C15 types are adequate for all but largest installations. Ground plane, consisting of metal strip 1" from lamp and connected to common or white side of line, is necessary as starting aid for lowest setting of control.—E. E. Von Zastrow, Fluorescent Lamp Dimming with SCR's and Associated Semiconductors, General Electric, Syracuse, N.Y., No. 200.18, 1962.



LOAD 600W
THYRECTOR 6RS5SP5B5
120V 60 ~
T1
R1 100
SCR1
R2 100
T1
SCR2
R3 33K
R5 250K
33K R4
C1 0.1μf
Q1
2N2646
T1
6RS5GD1BAD1
CR1
CR2

FULL-WAVE 600-W SCR CONTROL—Provides manual dimming of lamp load with R5, but over limited range. Can also be used for heater and fan control.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 15.



LOAD
115VAC
4.7k
4.7kΩ
0-500K
D1
GE TRIAC SC40B SC41B
.22μFd
SBS
D2
100 Ω

SBS 2N4992
D1, D2-GE 6RS5GC1LAJ1 -COMMON CATHODE

LAMP DIMMER—Silicon bilateral switch and triac give hysteresis-free phase control for lamp dimming and similar applications. 8-V switching voltage of sbs is stable over wide temperature range.—Silicon Economy Bilateral Switch 2N4992, General Electric, Syracuse, N.Y., No. 65.32, 1967.

$C_1 C_2$ = 0.068 microfarad, 200 volts, 10%

F_1 = fuse, size suitable to load

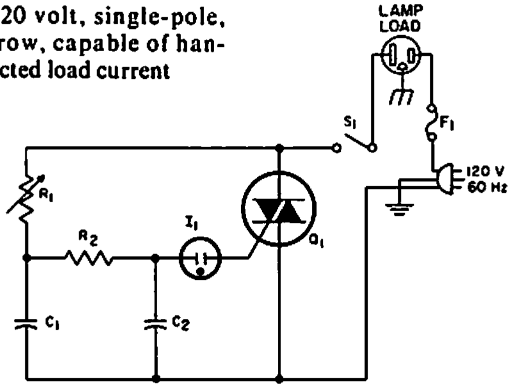
I_1 = lamp, neon type NE-83

Q_1 = triac, RCA 40502 or RCA 40429 (the RCA 40429 may be used with the Wakefield No. NC401K or equivalent heat sink.)

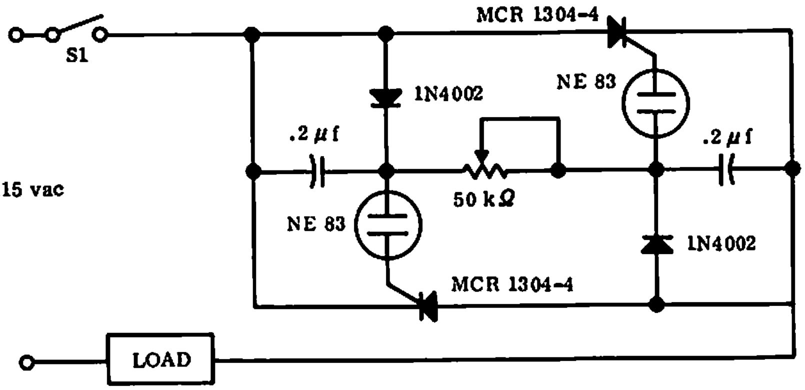
R_1 = potentiometer, 50,000 ohms, 2 watts, linear taper

R_2 = 15,000 ohms, 1/2 watt, 10%, carbon

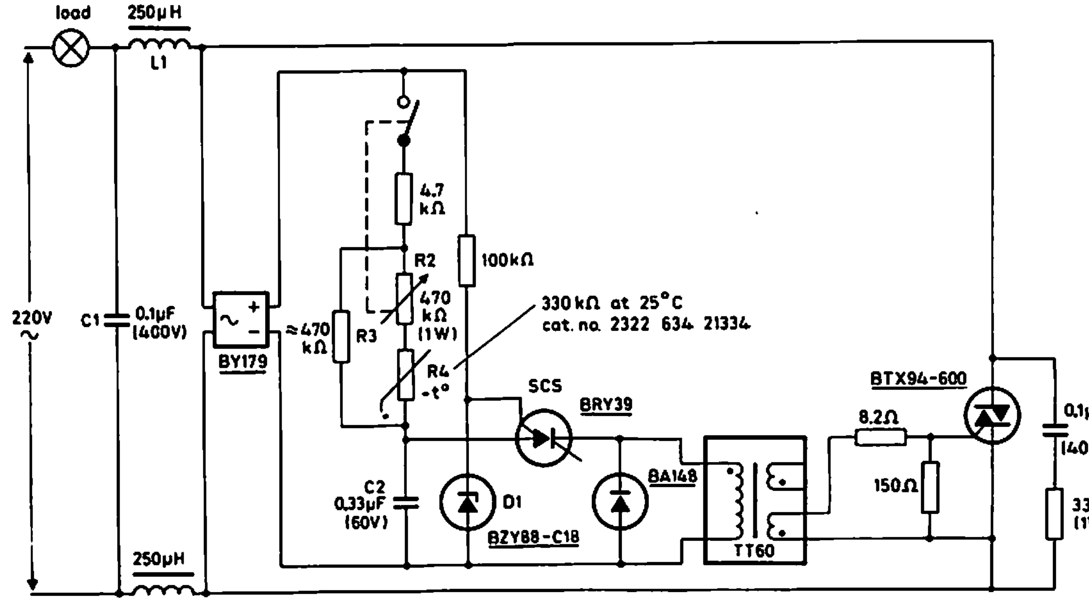
S_1 = switch, 120 volt, single-pole, single-throw, capable of handling expected load current


LAMP LOAD
S1
F1
120 V 60 Hz
R1
R2
I1
Q1
C1
C2

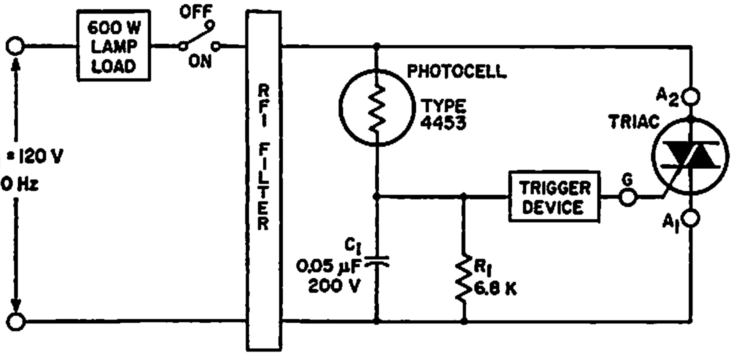
700-W DIMMER—Triac provides full-wave control from maximum brilliance down to zero illumination for incandescent lamp loads. Heat sink must be used with triac for loads above 300 W.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 81.


S1
115 vac
MCR 1304-4
1N4002
NE 83
.2 µf
50 kΩ
.2 µf
NE 83
1N4002
MCR 1304-4
LOAD

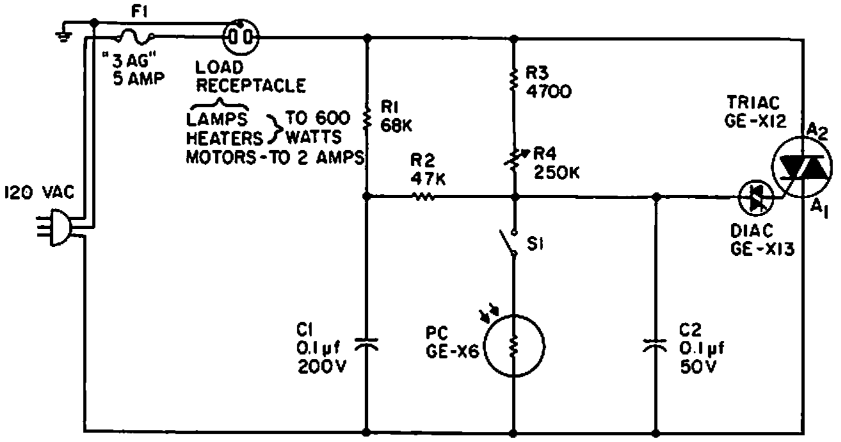
TWO-SCR DIMMER—Handles 300-W lamp and provides full range of brilliance control, using minimum number of low-cost components.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 10–2–3.


load
250µH
L1
220V ~
C1
0.1µF (400V)
BY179
≈470 kΩ
R3
4.7 kΩ
R2
470 kΩ (1W)
100kΩ
330kΩ at 25°C cat. no. 2322 634 21334
R4 -t°
SCS
BRY39
C2 0.33µF (60V)
D1
BZY88-C18
BA148
TT60
BTX94-600
8.2Ω
150Ω
0.1µF (400V)
33Ω (1W)
250µH
L2

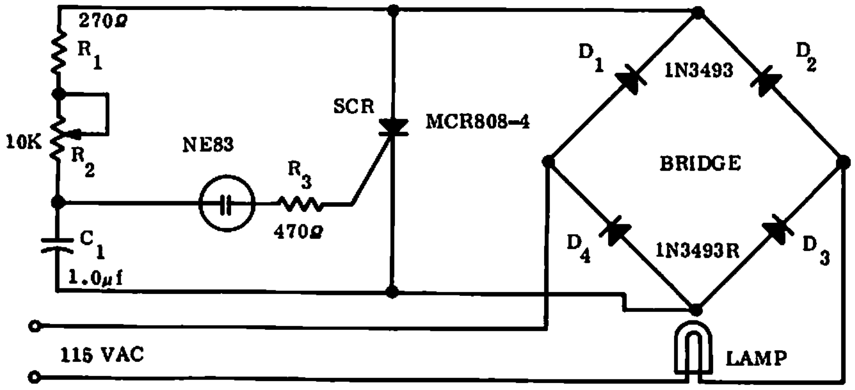
3,000-W LAMP DIMMER—Triac controlled by scs handles starting surges and gives smooth power control of incandescent lamp load up to 3 kW.—G. J. Derksen and G. J. Tobisch, Lamp Dimmer, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 82, 1970.


600 W LAMP LOAD
OFF
ON
V₁ = 120 V
60 Hz
RFI FILTER
PHOTOCELL
TYPE 4453
TRIAC
A2
A1
G
TRIGGER DEVICE
C1
0.05 µF
200 V
R1
6.8 K

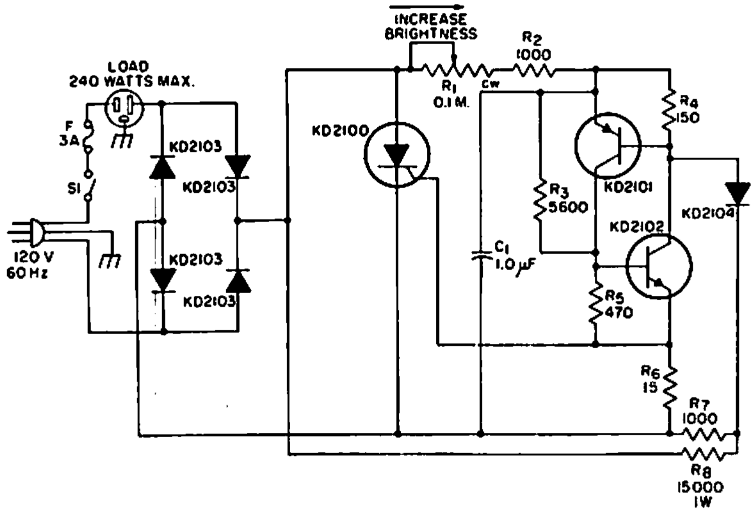
LIGHT TURNS ON LAMP GRADUALLY—Increase in light on photocell causes proportional reduction in cell resistance, to make trigger-triac increase lamp load voltage proportionally.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 259.


F1
"3 AG"
5 AMP
LOAD RECEPTACLE
LAMPS
HEATERS
TO 600 WATTS
MOTORS-TO 2 AMPS
120 VAC
R1
68K
R2
47K
R3
4700
R4
250K
S1
TRIAC
GE-X12
A2
A1
DIAC
GE-X13
C1
0.1 µf
200V
PC
GE-X6
C2
0.1 µf
50V

FULL-WAVE DIMMER AND MOTOR CONTROL—Gives full symmetrical control from zero to 100% of line voltage for lamp or motor plugged into load receptacle. Also includes cadmium sulfide photocell for turning lamp on automatically in home at dusk. With shaded-pole fan or blower motor, range of speed control is about 4 to 1. With motors, performance is improved by placing 100-ohm 1-W resistor in series with 0.1-µF capacitor across triac.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 147.

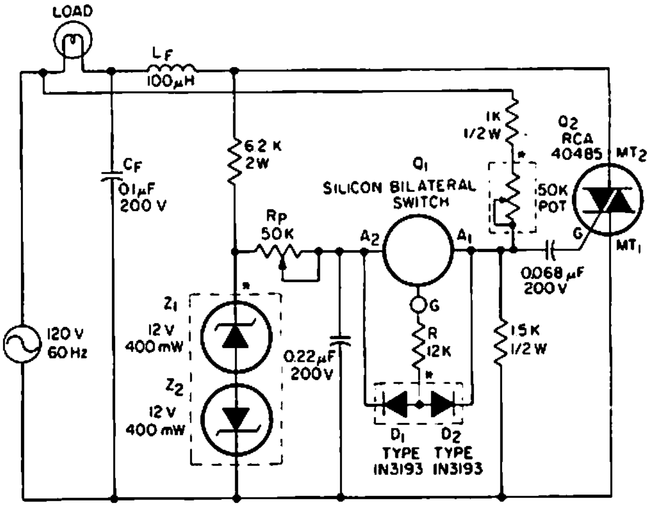

270Ω
R1
10K
R2
C1
1.0µf
NE83
R3
470Ω
SCR
MCR808-4
D1
D2
D3
D4
1N3493
BRIDGE
1N3493R
115 VAC
LAMP

FULL-WAVE BRIDGE DIMMER—Gives full range of control from maximum brilliance to zero continuously with single scr that is phase-controlled over both halves of cycle.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 10-2-2.

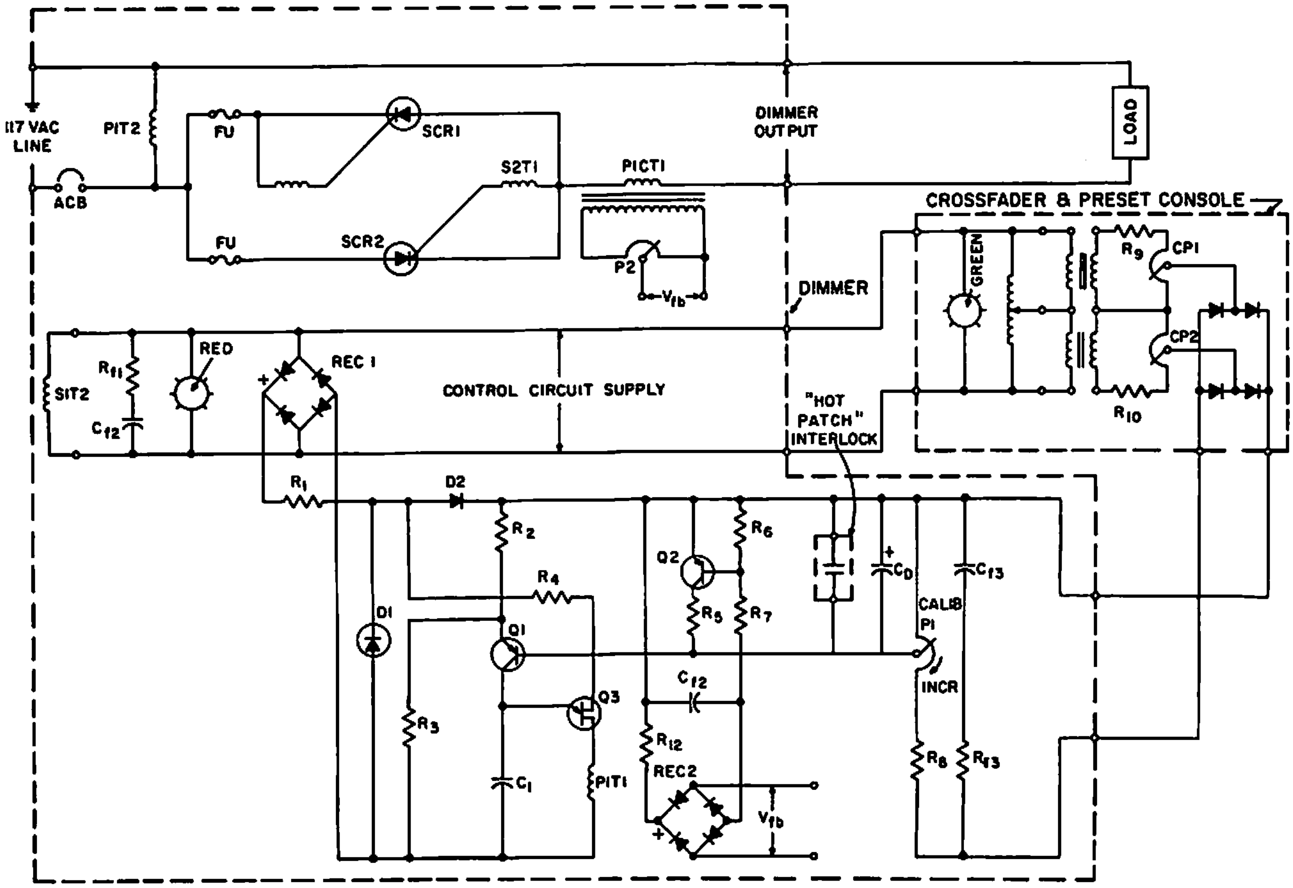

LOAD
240 WATTS MAX.
F
3A
S1
120 V
60 Hz
KD2103
KD2103
KD2103
KD2103
KD2100
INCREASE BRIGHTNESS
R1
0.1 M.
CW
R2
1000
R3
5600
C1
1.0 µF
KD2101
R4
150
KD2102
KD2104
R5
470
R6
15
R7
1000
R8
15000
1W

240-W DIMMER—R1 adjusts point in each half-cycle of a-c line at which scr is triggered for passing current through lamp load. Provides full range of brightness control. Produces some rfi, which can be reduced with L-filter consisting of 0.05-µF paper capacitor on which is wound 18 ft of No. 18E wire, with choke in series with load. Capacitor is connected between lamp-coil junction and other side of line.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 45.

DIMMER WITH CLAMPING—Steering diodes D1 and D2 act with R to permit larger conduction angles and prevent circuit from misfiring at low light levels when subjected to dips in line voltage. Circuit also extends lamp life by holding line voltage rises to within 3% of 120 V.—G. J. Granieri, AC Voltage Regulators Using Thyristors, RCA, Harrison, N.J., AN-3886, 1969.

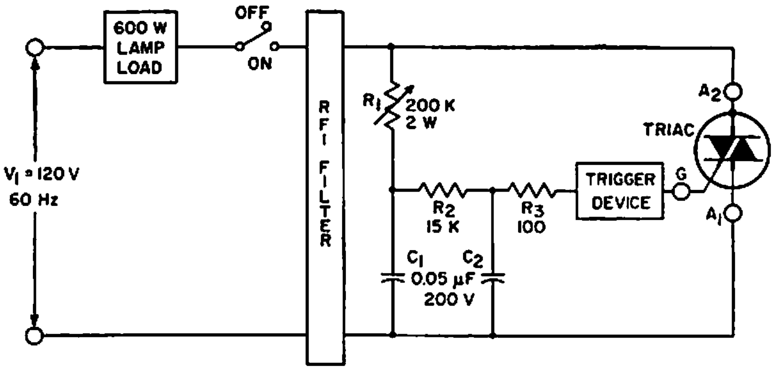

LOAD
L_F 100μH
C_F .01μF 200 V
120 V 60 Hz
62 K 2W
Rp 50K
*
Z_1 12 V 400 mW
Z_2 12 V 400 mW
0.22μF 200V
Q_1 SILICON BILATERAL SWITCH
A_2
A_1
G
R 12K
*
D_1 D_2 TYPE TYPE 1N3193 1N3193
1K 1/2W
*
50K POT
Q2 RCA 40485
MT2
G
MT1
0.068μF 200V
15K 1/2W

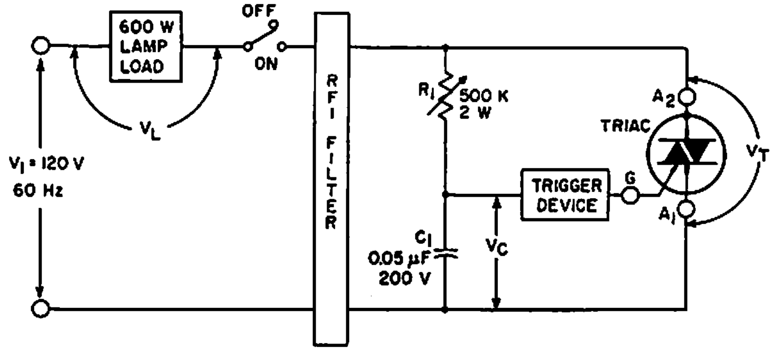
*DASHED LINES INDICATE MAJOR, ADDITIONAL COMPONENTS REQUIRED TO ACHIEVE VOLTAGE CLAMP


117 VAC LINE
ACB
PIT2
FU
SCR1
FU
SCR2
S2T1
PICT1
P2
V_{fb}
DIMMER OUTPUT
LOAD
CROSSFADER & PRESET CONSOLE
GREEN
R_9
CP1
CP2
R_{10}
DIMMER
"HOT PATCH" INTERLOCK
RED
REC 1
SIT2
R_{f1}
C_{f2}
CONTROL CIRCUIT SUPPLY
R_1
D2
R_2
R_4
Q1
D1
R_3
Q3
C_1
PIT1
Q2
R_6
R_5
R_7
C_{f2}
R_{12}
REC2
V_{fb}
C_D
C_{f3}
CALIB P1
INCR
R_8
R_{f3}

DIMMER WITH PRESET AND CROSSFADER—Solid-state incandescent-lamp dimmer may have any number of presets, although circuit shows only one load with two-scene preset for theatrical applications. When crossfader control is moved and voltage is taken away from one circuit of preset and applied to another, takeover circuit applies the larger of the two voltages acting on it to dimmer as input reference. Values are: P1 1K; R1 3K; R2 470; R3 22K; R4 220; R5 47; R6 330; R7 22K; R8-10 3.3K; C1 0.2 μF; CD 200 μF; REC-1-2 4 G-E 1N1695; D1 1N1527; Q1-2 2N525; Q3 2N1671A; D2 1N536; T1 UTC H51.—E. E. Von Zastrow, The Silicon Controlled Rectifier in Lamp Dimming and Heating Control Service, General Electric, Syracuse, N.Y., No. 200.14, 1965.

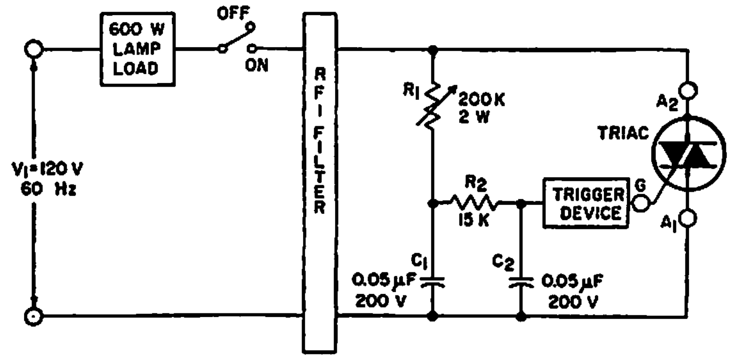
600-W DIMMER WITH SERIES GATE RESISTOR—Resistor R3, in series with trigger device (usually avalanche diode) limits discharge current from C2, to reduce instantaneous voltage drop across C2 and minimize both hysteresis and quick-turn-on effect.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 258.

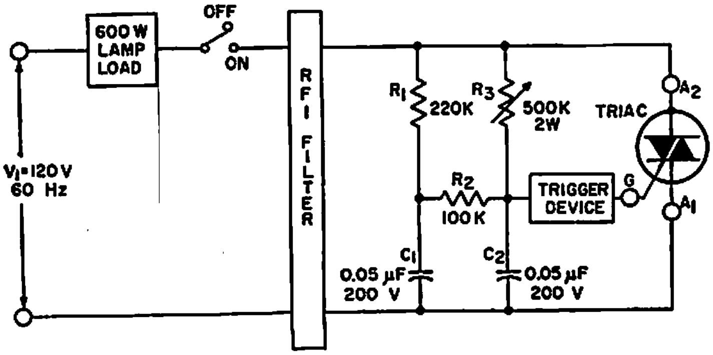

600 W LAMP LOAD
OFF
ON
V_I = 120 V
60 Hz
RFI FILTER
R_1 200 K 2 W
R_2 15 K
R_3 100
C_1 C_2 0.05 µF 200 V
TRIGGER DEVICE
G
TRIAC
A_2
A_1


600 W LAMP LOAD
OFF
ON
V_L
V_I = 120 V
60 Hz
RFI FILTER
R_1 500 K 2 W
C_1 0.05 µF 200 V
V_C
TRIGGER DEVICE
G
TRIAC
A_2
A_1
V_T

SINGLE-TIME-CONSTANT 600-W PHASE CONTROL—Used as dimmer. Has some hysteresis effect. Will turn on incandescent lamp with appreciable initial brilliance, for reasons explained in book.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 256.

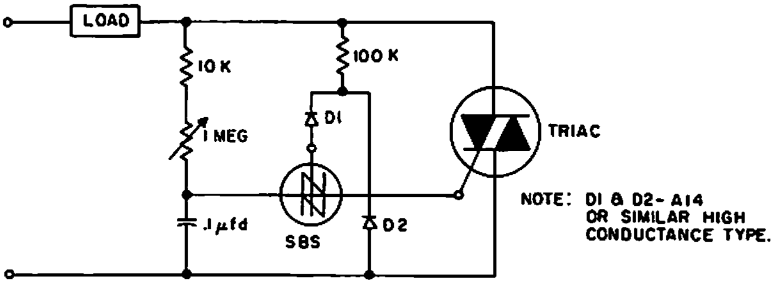
DOUBLE-TIME-CONSTANT 600-W DIMMER—Gives lower initial load voltage and lower initial lamp brightness, along with less hysteresis, than phase control circuit having single time constant.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 257.


600 W LAMP LOAD
OFF
ON
V_I = 120 V
60 Hz
RFI FILTER
R_1 200K 2 W
R_2 15 K
C_1 0.05 µF 200 V
C_2 0.05 µF 200 V
TRIGGER DEVICE
G
TRIAC
A_2
A_1

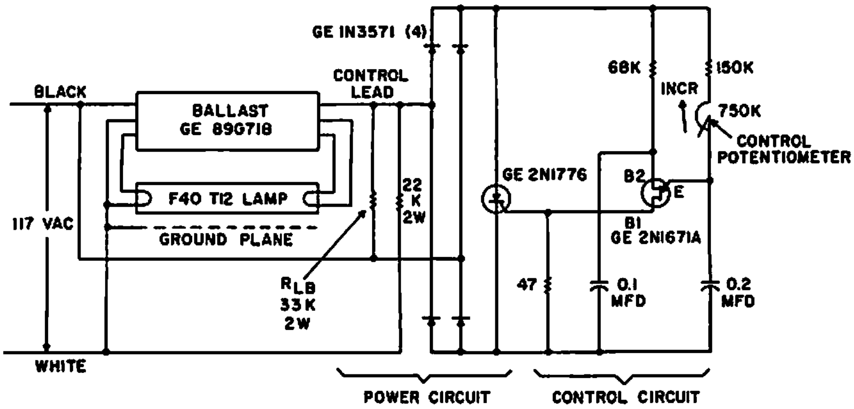

600 W LAMP LOAD
OFF
ON
V_I = 120 V
60 Hz
RFI FILTER
R_1 220K
R_3 500K 2W
R_2 100 K
C_1 0.05 µF 200 V
C_2 0.05 µF 200 V
TRIGGER DEVICE
G
TRIAC
A_2
A_1

600-W WITH TRIAC BLEEDER CURRENT—Prevents triac from going completely out of conduction, thereby preventing hysteresis and preventing turn-on at undesirably high illumination level.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 258.

12-V A-C LAMP DIMMER—Full-wave triac phase control circuit uses D13Q1 silicon bilateral switch as trigger to achieve hysteresis-free operation for control of low-voltage load. Choice of triac depends on load power.—W. R. Spofford, Jr., Applications of the New Silicon Bilateral Switch and the Silicon Unilateral Switch, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 8.

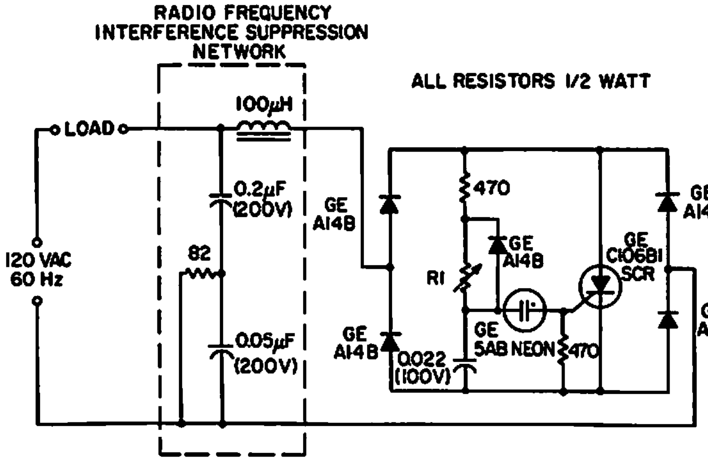

LOAD
10 K
100 K
1 MEG
D1
TRIAC
SBS
.1 μfd
D2

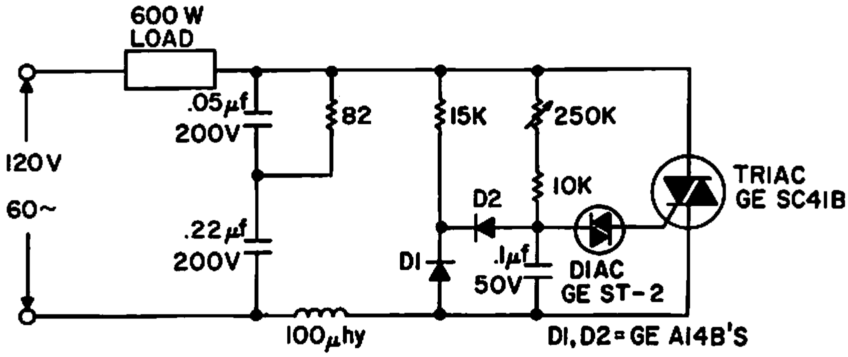
NOTE: D1 & D2- A14 OR SIMILAR HIGH CONDUCTANCE TYPE.


GE IN3571 (4)
CONTROL LEAD
BLACK
BALLAST GE 89G718
F40 T12 LAMP
117 VAC
GROUND PLANE
22 K 2W
RLB 33K 2W
WHITE
GE 2N1776
68K
INCR
150K
750K
CONTROL POTENTIOMETER
B2
E
B1
GE 2N1671A
47
0.1 MFD
0.2 MFD
POWER CIRCUIT
CONTROL CIRCUIT

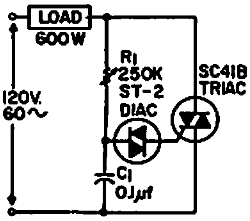
LOW-COST FLUORESCENT DIMMER—Uses rectified ballast voltage directly for control circuit, to reduce number of components while still giving satisfactorily smooth dimming. Does not include trim pot for making all lamps track when dimming large numbers in cove or valance lighting. Lamp requires ground plane (metal strip) 1" away as starting aid at low light levels. Excellent basic reference article on design requirements for fluorescent dimmers.—E. E. Von Zastrow, Fluorescent Lamp Dimming with SCR's and Associated Semiconductors, General Electric, Syracuse, N.Y., No. 200.18, 1962.

HIGH-INTENSITY LAMP DIMMER—Used to dim miniature low-voltage desk lamps operating from small transformer. Includes rfi filter that also serves to prevent transients from triggering scr. R1 should be 250K. Can also serve as speed control for 120-V a-c shaded-pole fan motors rated up to 1.5 A, if R1 is changed to 100K. Speed range is about 3:1.—D. R. Grafham, Fan Motor Speed Control—"Hi-Intensity" Lamp Dimmer, General Electric, Syracuse, N.Y., No. 201.16, 1966.

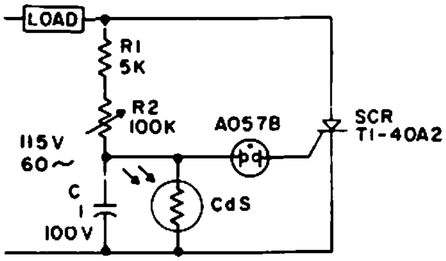

RADIO FREQUENCY INTERFERENCE SUPPRESSION NETWORK
ALL RESISTORS 1/2 WATT
LOAD
100μH
0.2μF (200V)
82
0.05μF (200V)
120 VAC 60 Hz
GE A14B
470
GE A14B
R1
GE C106B1 SCR
GE A14B
GE A14B
GE 5AB NEON
470
0.022 (100V)
GE A14B


600 W LOAD
.05μf 200V
82
15K
250K
120V
60~
10K
TRIAC GE SC41B
D2
.22μf 200V
D1
.1μf 50V
DIAC GE ST-2
100μhy
D1, D2 = GE A14B'S

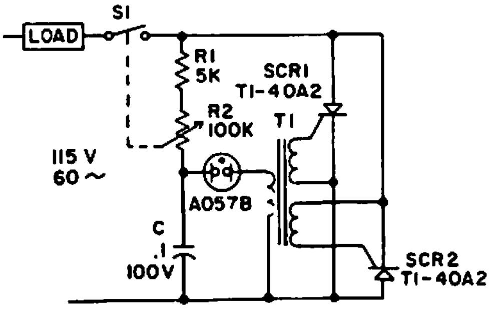
600-W TRIAC LAMP DIMMER—Includes built-in damping for L-C filter to maintain proper operation of triac during dimming action.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 10.


LOAD
600W
120V.
60~
R1
250K
ST-2
DIAC
SC41B
TRIAC
C1
0.1μf

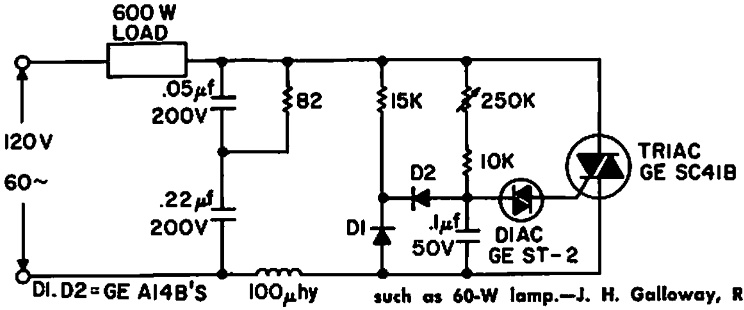
FULL-WAVE 600-W TRIAC—Provides manual dimming of lamp load with R1, but over limited range. For photoelectric control, replace R1 with cadmium sulfide photocell such as G-E B425. To reverse function of photoelectric control, place photocell in parallel with C1 and change R1 to 10K. Can also be used for heater and fan control.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 15.


LOAD
R1
5K
R2
100K
A057B
SCR
TI-40A2
115V
60~
C
.1
100V
CdS

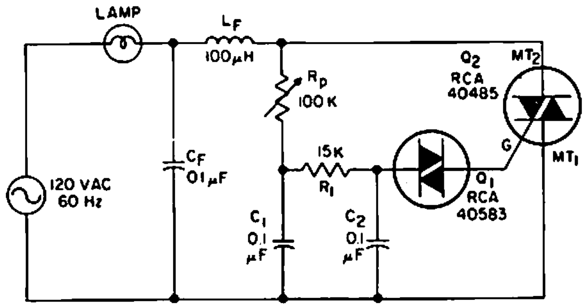
PHOTOCELL-CONTROLLED DIMMER—Initial light level is set with R2 when CdS cell is dark. As cell is exposed to light, neon lamp triggers scr and power to lamp load decreases. Choice of cadmium sulfide cell determines light sensitivity of circuit.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 124.


S1
LOAD
R1
5K
SCR1
TI-40A2
R2
100K
T1
115 V
60~
A057B
C
.1
100V
SCR2
TI-40A2

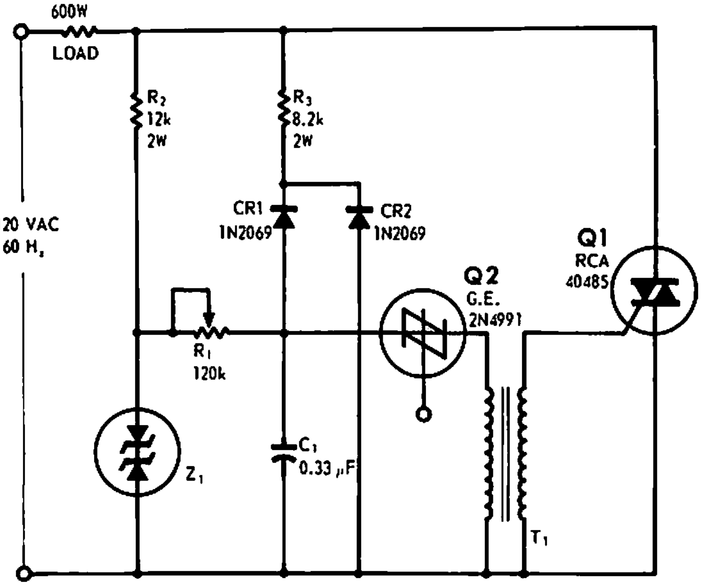
FLICKERLESS DIMMER—Since both scr's are fired by same timing circuit made up of neon lamp and pulse transformer, unsymmetrical firing problem is eliminated and there is no flickering of lamp load at low light levels. T1 may be Sprague 31Z286 or equivalent 1:1:1 with 40 turns per winding. S1 is ganged to R2 to disconnect load.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 123.


600 W
LOAD
120V
60~
.05μf
200V
82
.22μf
200V
15K
250K
10K
D2
D1
.1μf
50V
DIAC
GE ST-2
TRIAC
GE SC41B
D1. D2=GE A14B'S
100μhy

600-W DIAC-TRIAC DIMMER—Circuit includes damped r-f filter for suppression of rfi without affecting triggering of triac at small loads such as 60-W lamp.—J. H. Galloway, RF Filter Considerations for Triac and SCR Circuits, General Electric, Syracuse, N.Y., No. 201.19, 1966.


LAMP
LF
100μH
Rp
100 K
Q2
RCA
40485
MT2
MT1
G
15K
R1
Q1
RCA
40583
120 VAC
60 Hz
CF
.01μF
C1
0.1
μF
C2
0.1
μF

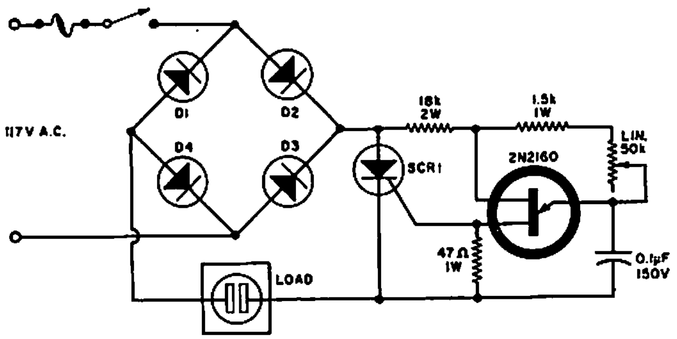
LOW-HYSTERESIS DIMMER—Provides continuous control up to maximum conduction angle. If Rp is set for high resistance (low illumination) and line voltage drops momentarily, high breakover voltage of diac Q1 combined with high resistance could cause circuit misfire, with lamp remaining extinguished until control is readjusted to higher light level.—G. J. Granieri, AC Voltage Regulators Using Thyristors, RCA, Harrison, N.J., AN-3886, 1969.


600W
LOAD
120 VAC
60 H,
R2
12k
2W
R3
8.2k
2W
CR1
1N2069
CR2
1N2069
Q1
RCA
40485
Q2
G.E.
2N4991
R1
120k
Z1
C1
0.33 μF
T1

Z1- MOTOROLA TRIGGER MPT-1 OR ZENER DIODE PAIR WITH V_Z = 30V

T1- 1 TO 1 RATIO, 15 TURNS NO. 30 WIRE
ON 1/2-IN POWDERED-IRON ROD, 1/4-INCH IN DIAM

600-W A-C LOAD CONTROL—Provides smooth control of lamp or other load from 2% to 98% of full power, with R1 changing conduction angle for both halves of cycle.—J. J. Klinikowski, Cheap, Simple AC Power Control, *EDN*, Jan. 15, 1970, p 63.


117V A.C.
D1
D2
D4
D3
18k 2W
1.5k 1W
LIN. 50k
SCR1
2N2160
47Ω 1W
0.1µF 150V
LOAD

	FOR LAMPS UP TO 400 WATTS OR SMALL MOTORS (UP TO 2 AMPS)	FOR LAMPS UP TO 1000 WATTS OR LARGER MOTORS (UP TO 5 AMPS)
D1-D4 =	3F20-D	20HB20
SCR1 =	2N1774	2N685

LAMP DIMMER—With 2N1774 for SCR1 and 3F20-D diodes, circuit will handle lamps up to 400 W or motors drawing up to 2 A. With 2N685 for SCR1 and 20HB20 diodes, will handle up to 100 W lamp load or motors drawing up to 5 A.—D. Cooper, SCR's and Triacs—the Revolution Continues, *Electronics World*, Aug. 1968, p 25–28.

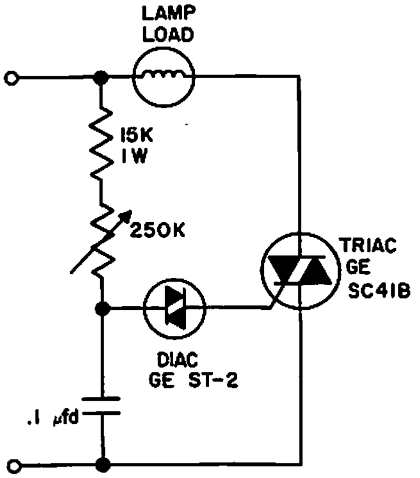
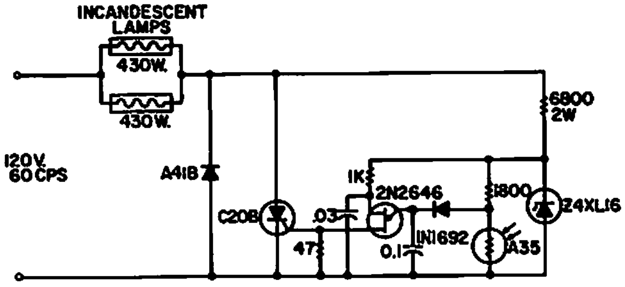
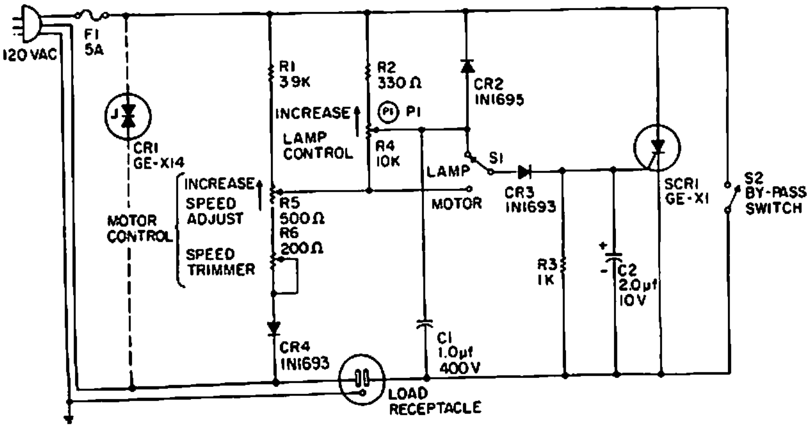

LAMP LOAD
15K 1W
250K
TRIAC GE SC41B
DIAC GE ST-2
.1 µfd

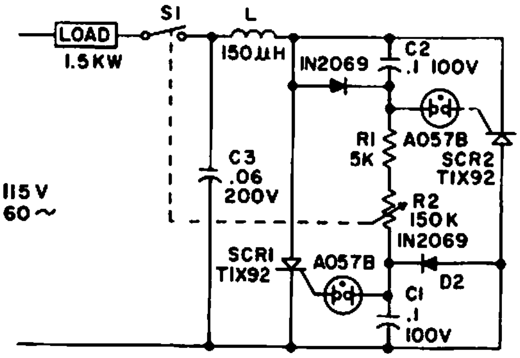
TABLE LAMP DIMMER—Designed for mounting inside lamp, where space is usually at a premium. Only drawback is slight hysteresis effect. Circuit takes advantage of availability of both sides of lamp load.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 19.

LIMITED-RANGE CONTROL—Provides control only over range from half to full power, which is sufficient for most illumination control applications. Rectifier supplies one half-cycle uncontrolled, with scr providing ramp-and-pedestal phase control for other half-cycle. Low-resistance photocell is used to give fast response time and eliminate hunting. —F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 13.


INCANDESCENT LAMPS
430W.
430W.
120V. 60CPS
A41B
C20B
.03
47
1K
2N2646
0.1
1N1692
1800
A35
6800 2W
Z4XL16

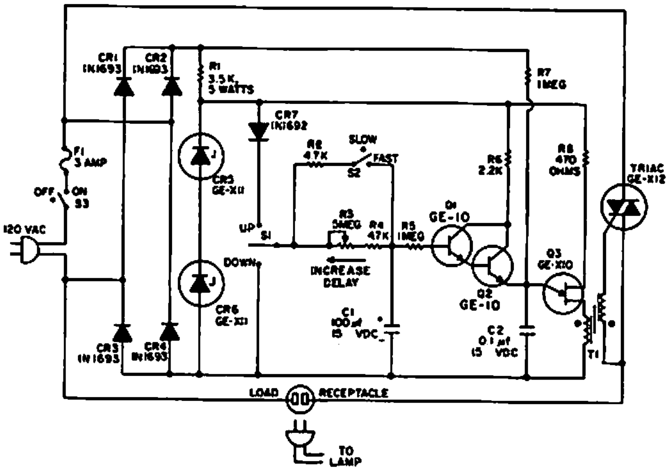

120 VAC
F1 5A
CR1 GE-X14
MOTOR CONTROL
INCREASE
SPEED ADJUST
SPEED TRIMMER
R1 39K
INCREASE
LAMP CONTROL
R2 330Ω
P1 P1
R4 10K
R5 500Ω
R6 200Ω
CR4 1N1693
CR2 1N1695
S1
LAMP
MOTOR
CR3 1N1693
C1 1.0µf 400V
R3 1K
C2 2.0µf 10V
SCR1 GE-X1
S2 BY-PASS SWITCH
LOAD RECEPTACLE

HALF-WAVE LAMP-MOTOR CONTROL—Dual-purpose single-scr control circuit varies output voltage from zero to about 70% of a-c line voltage (up to 84 V). When S1 is in LAMP position, incandescent lamp plugged into load outlet is controlled by P1 from zero brightness to about 30% of its normal visual light output. Closing bypass switch S2 bypasses scr to give full lamp brightness. With S1 in MOTOR position, control circuit includes feedback feature that tends to maintain constant speed for universal motor plugged into outlet. Use only on motors having commutator and brushes.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 146.



LOAD
1.5KW
S1
L
150µH
IN2069
C2
.1 100V
R1
5K
A057B
SCR2
TIX92
C3
.06
200V
115 V
60 ~
R2
150 K
IN2069
SCR1
TIX92
A057B
D2
C1
.1
100V

DUAL-SCR WITH NEONS—Supplies power over full cycle, using neon lamps to trigger scr's. Filter L-C3, used to reduce rfi caused by fast turn-on of scr's, is unnecessary with highly inductive loads such as universal motors. Full counterclockwise rotation of R2 opens S1, cutting off power to load. Can be used as dimmer for incandescent lamps.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 126.



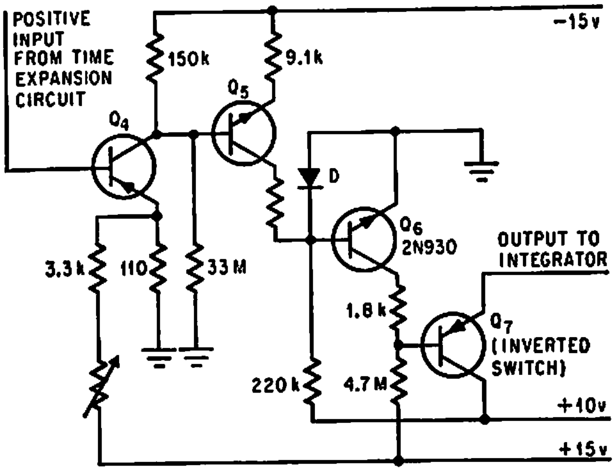
CR1
1N1693
CR2
1N1693
R1
3.5K
5 WATTS
R7
1MEG
CR7
1N1692
R8
4.7K
SLOW
FAST
S2
R6
2.2K
R8
470
OHMS
TRIAC
GE-X12
F1
3 AMP
OFF
ON
S3
CR5
GE-X11
120 VAC
UP
S1
R3
5MEG
R4
47K
R5
1MEG
Q1
GE-10
Q3
GE-X10
DOWN
INCREASE
DELAY
Q2
GE-10
CR6
GE-X11
C1
100 µf
15 VDC
C2
0.1 µf
15 VDC
CR3
1N1693
CR4
1N1693
T1
LOAD
RECEPTACLE
TO
LAMP

SOFT-OFF DIMMER—When switch is closed, lamp load up to 500 W plugged into load receptacle will be slowly dimmed over adjustable period of 15–20 min as determined by setting of R3, when S1 is in DOWN position. Ideal for control of room lights in bedroom after children have been put to bed. With S1 in UP position, room lights will be turned up slowly over same period, under control of clock timer, for those who must get up before sunrise. Combination of S2 and R4 gives option of fixed fast turn-on and turn-off.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 134.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 45

Laser Circuits

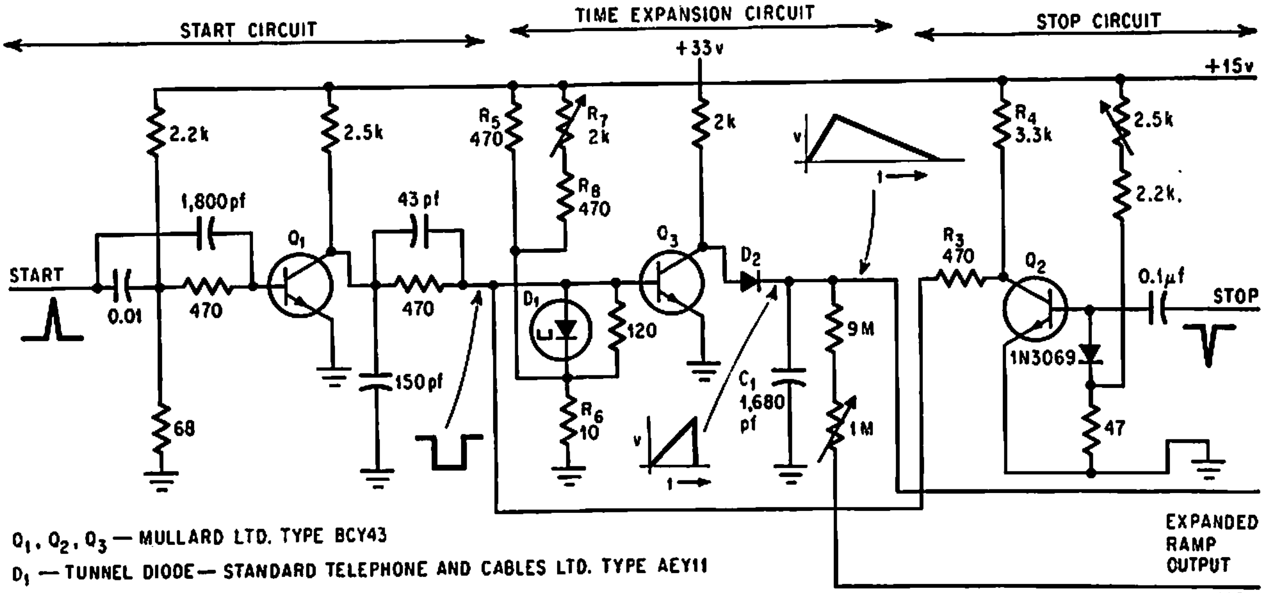


POSITIVE INPUT FROM TIME EXPANSION CIRCUIT
−15v
150k
9.1k
Q5
Q4
D
Q6
2N930
OUTPUT TO INTEGRATOR
3.3k
110
33M
1.8k
Q7
(INVERTED SWITCH)
220k
4.7M
+10v
+15v

Q_4 — MULLARD LTD. TYPE BCY32 Q_7 — MULLARD LTD. TYPE OC2

Q_5 — MULLARD LTD. TYPE BCY43 D — MULLARD LTD. TYPE OA2

RAMP-TRIGGERED RECTANGULAR PULSE—Pulse-forming circuit senses when ramp voltage of time-expansion circuit in laser cloud height radar exceeds predetermined threshold value. Q4 is then cut off, cutting off Q5 and turning on Q6, to close electronic switch Q7 and start production of 10-V rectangular output pulse. Width of pulse is 1,000 times that of interval being measured, permitting observation on low-speed oscilloscope.—G. M. Ettinger, Chronometer Expands Pulses to Measure Nanosecond Intervals, *Electronics*, Jan. 23, 1967, p 108–112.



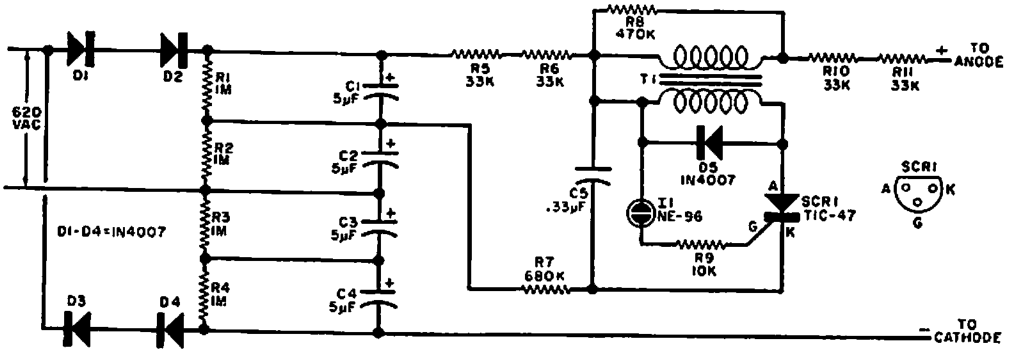
START CIRCUIT
TIME EXPANSION CIRCUIT
STOP CIRCUIT
+33v
+15v
2.2k
2.5k
R5 470
R7 2k
R8 470
2k
R4 3.3k
2.5k
2.2k
1,800pf
43pf
Q1
Q3
D2
R3 470
Q2
0.1μf
START
STOP
0.01
470
470
D1
120
9M
1N3069
150pf
R6 10
C1 1,680 pf
1M
47
68
v
t
EXPANDED RAMP OUTPUT
−110v

Q_1, Q_2, Q_3 — MULLARD LTD. TYPE BCY43

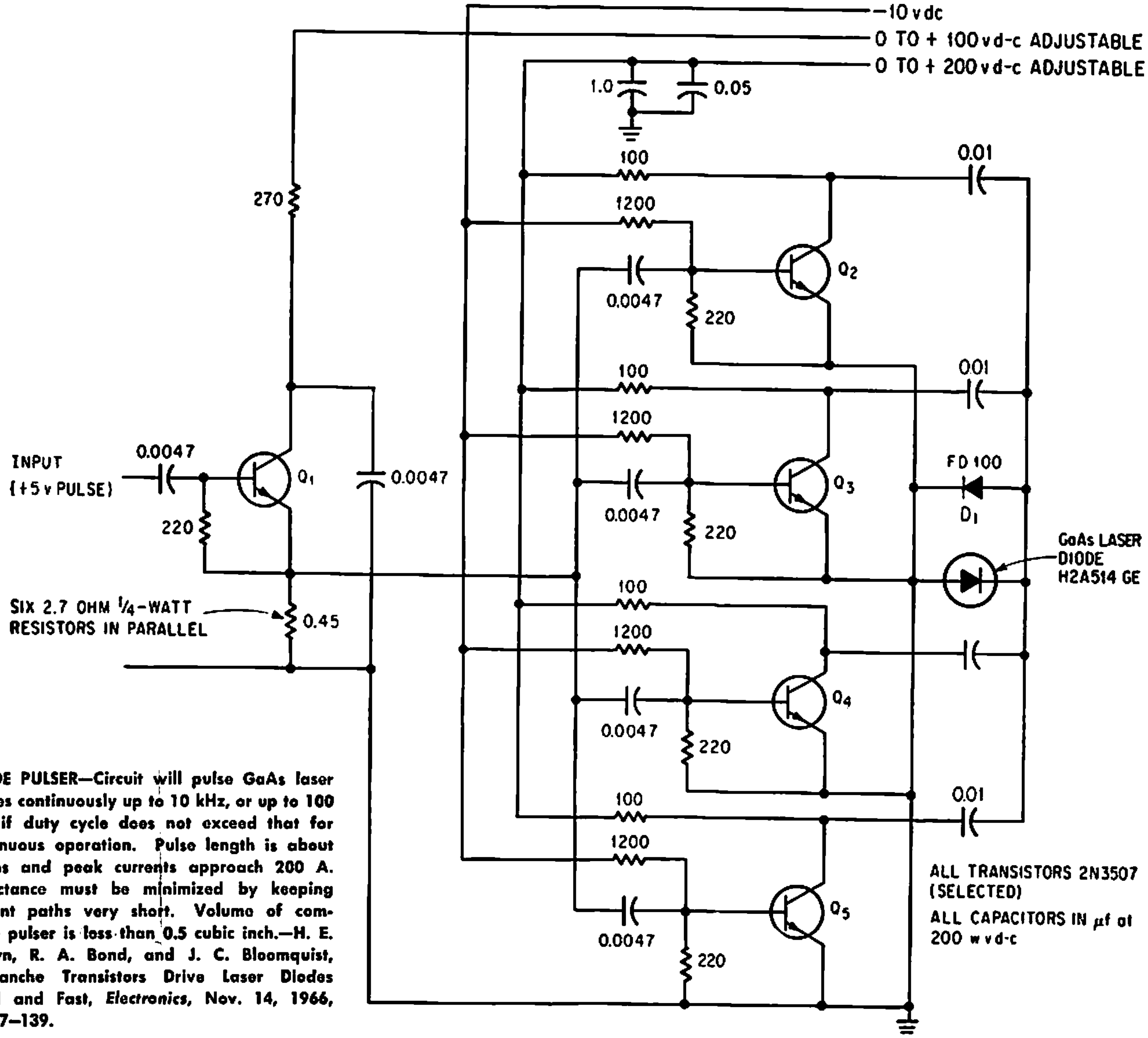
D_1 — TUNNEL DIODE — STANDARD TELEPHONE AND CABLES LTD. TYPE AEY11

D_2 — FAIRCHILD TYPE FD6005

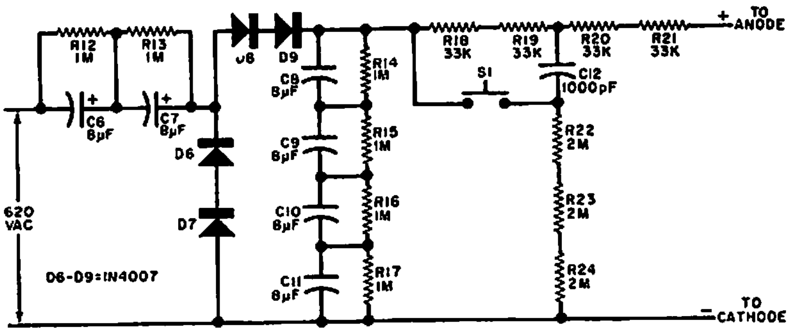
TIME-INTERVAL EXPANDER—Used in laser cloud height radar to resolve time intervals down to 10 ns and make it possible to display time interval data on low-speed scope. Converts input pulses to proportionately longer pulses from which range information can be derived. Value of C1 and 9-meg resistor are given for 8-μs range. Output is ramp waveform 1,000 times longer than time interval between start and stop pulses. Can also be used for very short-range conventional radar and for detection of nuclear particles.—G. M. Ettinger, Chronometer Expands Pulses to Measure Nanosecond Intervals, *Electronics*, Jan. 23, 1967, p 108–112.


D1
D2
620 VAC
R1 1M
R2 1M
R3 1M
R4 1M
D1-D4=1N4007
D3
D4
C1 5µF
C2 5µF
C3 5µF
C4 5µF
R5 33K
R6 33K
R8 470K
T1
C5 .33µF
I1 NE-96
D5 1N4007
SCR1 TIC-47
A
G
K
R7 680K
R9 10K
R10 33K
R11 33K
+ TO ANODE
− TO CATHODE
SCR1

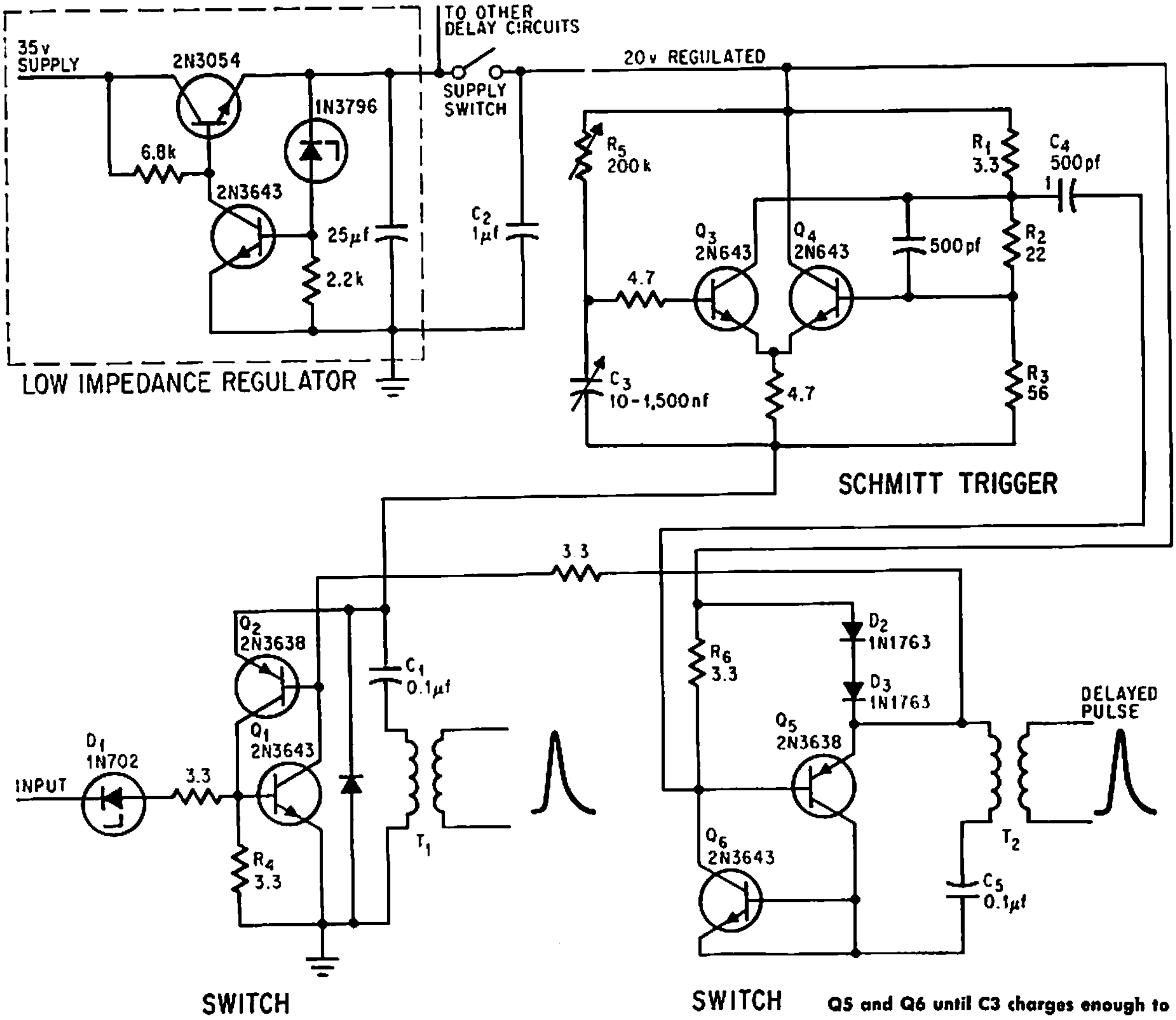
1,600-V AUTOMATIC-START LASER SUPPLY—Will fire laser automatically shortly after 620 V a-c is applied by means of step-up transformer connected to a-c line. T1 is 200:1 conventional auto ignition coil that is critically damped with resistor across secondary to produce single spike. Amglo MT-55 flashtube trigger transformer may be used instead. Caution: Circuit is dangerous when power is applied.—C. H. Knowles, Experimenters' Laser, *Popular Electronics*, Dec. 1969, p 27–32 and 110–111.


−10 vdc
0 TO + 100vd-c ADJUSTABLE
0 TO + 200vd-c ADJUSTABLE
1.0
0.05
100
1200
0.0047
220
0.01
270
INPUT (+5v PULSE)
0.0047
220
Q1
0.0047
Q2
Q3
Q4
Q5
FD 100 D1
GaAs LASER DIODE H2A514 GE
SIX 2.7 OHM ¼-WATT RESISTORS IN PARALLEL
0.45
ALL TRANSISTORS 2N3507 (SELECTED)
ALL CAPACITORS IN µf at 200 wvd-c

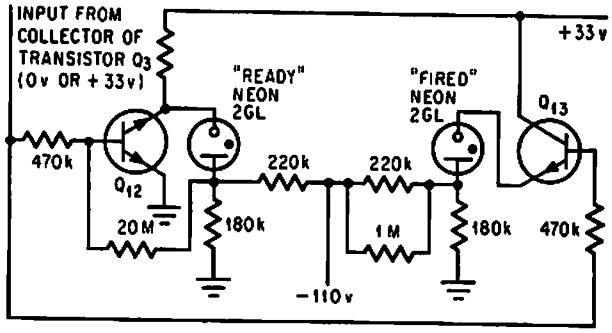
DIODE PULSER—Circuit will pulse GaAs laser diodes continuously up to 10 kHz, or up to 100 kHz if duty cycle does not exceed that for continuous operation. Pulse length is about 60 ns and peak currents approach 200 A. Inductance must be minimized by keeping current paths very short. Volume of complete pulser is less than 0.5 cubic inch.—H. E. Brown, R. A. Bond, and J. C. Bloomquist, Avalanche Transistors Drive Laser Diodes Hard and Fast, *Electronics*, Nov. 14, 1966, p 137–139.


R12
1M
R13
1M
C6
8μF
C7
8μF
D6
D7
620
VAC
D6-D9=IN4007
D8
D9
C8
8μF
C9
8μF
C10
8μF
C11
8μF
R14
1M
R15
1M
R16
1M
R17
1M
R18
33K
R19
33K
R20
33K
R21
33K
S1
C12
1000pF
R22
2M
R23
2M
R24
2M
+ TO ANODE
− TO CATHODE

1,600-V MANUAL-START LASER SUPPLY—After 620-V a-c is applied by means of step-up transformer connected to a-c line, switch S1 must be closed to fire laser. Caution: Circuit is dangerous once power is applied.—C. H. Knowles, Experimenters' Laser, *Popular Electronics*, Dec. 1969, p 27–32 and 110–111.

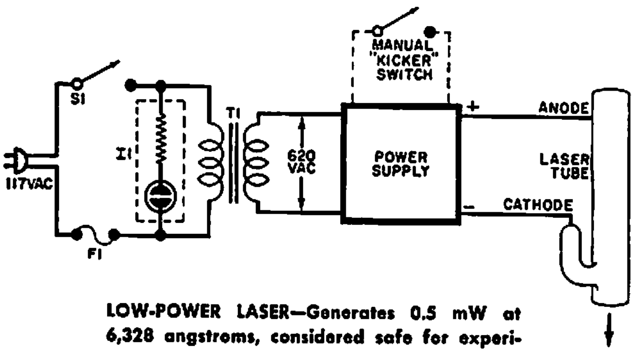

35v
SUPPLY
2N3054
6.8k
2N3643
1N3796
25μf
2.2k
LOW IMPEDANCE REGULATOR
TO OTHER
DELAY CIRCUITS
SUPPLY
SWITCH
C2
1μf
20v REGULATED
R5
200k
4.7
C3
10-1,500nf
Q3
2N643
Q4
2N643
4.7
500pf
R1
3.3
C4
500pf
R2
22
R3
56
SCHMITT TRIGGER
3.3
Q2
2N3638
Q1
2N3643
D1
1N702
INPUT
3.3
R4
3.3
C1
0.1μf
T1
SWITCH
R6
3.3
D2
1N1763
D3
1N1763
Q5
2N3638
Q6
2N3643
DELAYED
PULSE
T2
C5
0.1μf
SWITCH

FIRING PULSE CONTROL—Combination of Schmitt trigger with stable linear R-C charging keeps time intervals accurate within 1% for pulses that fire gas discharge lasers in ionization experiments. Input pulse makes Q1 and Q2 conduct, but has no effect on Q5 and Q6 until C3 charges enough to trigger Q3. Opening switch resets timer.—P. F. Howden, RC-Biased Schmitt Trigger Times Pulses Accurately, *Electronics*, April 1, 1968, p 64.


INPUT FROM
COLLECTOR OF
TRANSISTOR Q3
(0v OR +33v)
+33v
"READY"
NEON
2GL
"FIRED"
NEON
2GL
Q13
470k
Q12
20M
180k
220k
220k
1M
180k
470k
−110v

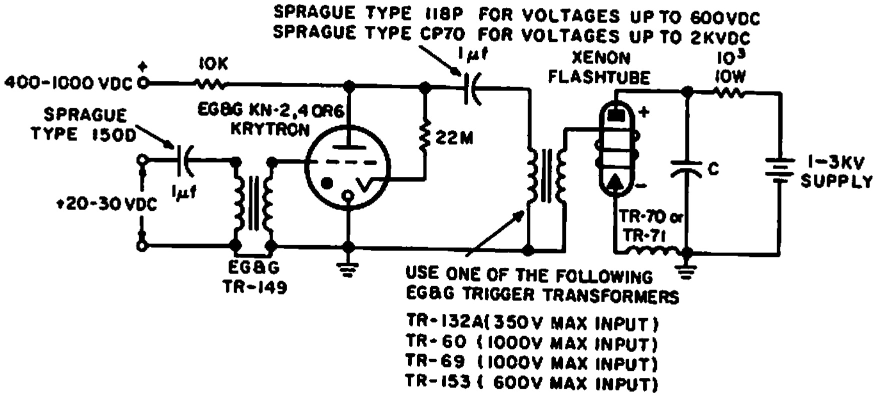
Q_{12}, Q_{13} — MULLARD LTD. TYPE BCY43

ECHO AMBIGUITY RESOLVER—Used in laser cloud height radar to eliminate ambiguity between echoes below 50 feet and extremely distant echoes (over 1 mile). Operates by sensing state of transistor switch in chronometer circuit after each laser firing pulse, and energizing one of two neon lamps to tell observer whether or not chronometer has been reset and is ready for next echo.—G. M. Ettinger, Chronometer Expands Pulses to Measure Nanosecond Intervals, *Electronics*, Jan. 23, 1967, p 108–112.

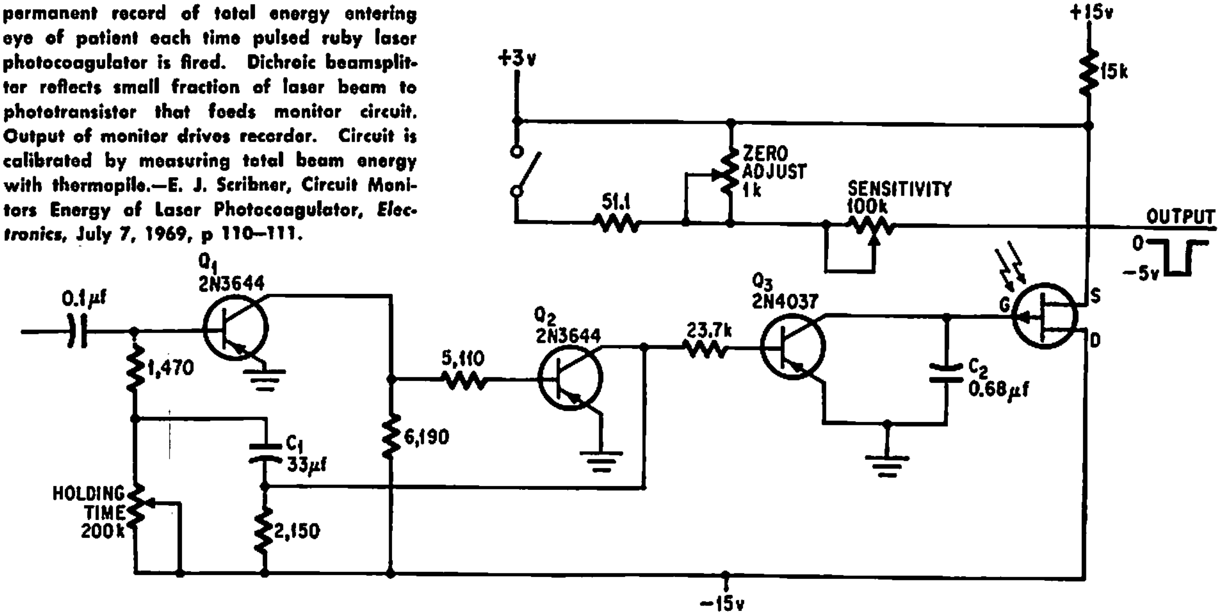

MANUAL
"KICKER"
SWITCH
S1
117VAC
I1
F1
T1
620
VAC
POWER
SUPPLY
+
ANODE
LASER
TUBE
−
CATHODE
LASER
BEAM

LOW-POWER LASER—Generates 0.5 mW at 6,328 angstroms, considered safe for experimentation in schools and homes. Requires 1,600-V d-c power supply, for which automatic and manual-start versions are given in article along with construction details and sources for laser and other special parts. Caution: do not aim at eyes; light is extremely bright and temporarily blinding.—C. H. Knowles, Experimenters' Laser, *Popular Electronics*, Dec. 1969, p 27–32 and 110–111.

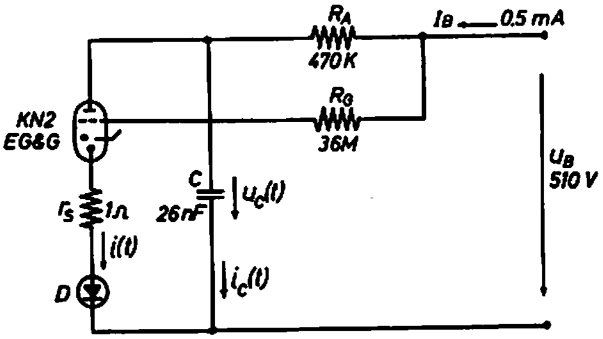
LASER PUMP—Uses xenon annular flashtube developed primarily for optical pumping of laser crystals. Designed so crystal rod is surrounded by gas discharge plasma. Outer surface of flashtube can then be wrapped with aluminum or silver foil serving both as reflector and trigger electrode. Requires 25 to 30 kV trigger voltage from trigger transformer.—FX-53C-3, FX-53Z-3 Annular Xenon Flashtubes, EG&G Inc., Boston, Mass., No. 1007-3, 1968.

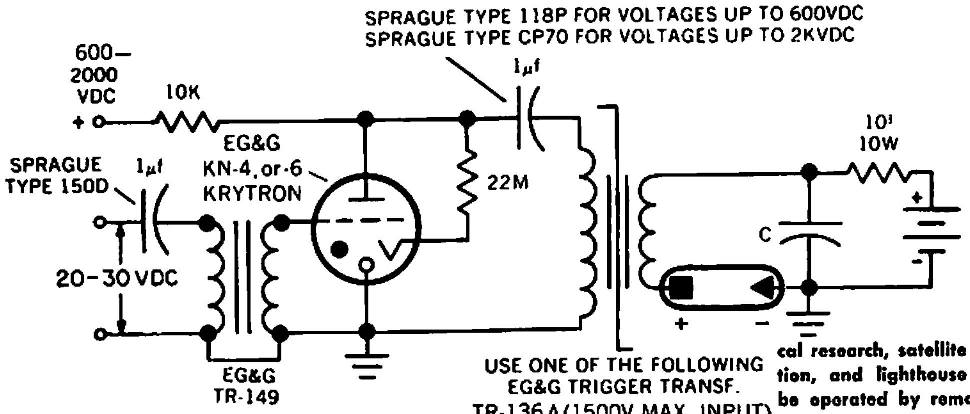

SPRAGUE TYPE 118P FOR VOLTAGES UP TO 600VDC
SPRAGUE TYPE CP70 FOR VOLTAGES UP TO 2KVDC
1μf
XENON
FLASHTUBE
10³
10W
400-1000 VDC
+
10K
SPRAGUE
TYPE 150D
EG&G KN-2,4 OR 6
KRYTRON
22M
+20-30 VDC
1μf
+
−
C
1-3KV
SUPPLY
TR-70 or
TR-71
EG&G
TR-149
USE ONE OF THE FOLLOWING
EG&G TRIGGER TRANSFORMERS
TR-132A (350V MAX INPUT)
TR-60 (1000V MAX INPUT)
TR-69 (1000V MAX INPUT)
TR-153 (600V MAX INPUT)

LASER ENERGY MONITOR—Circuit provides permanent record of total energy entering eye of patient each time pulsed ruby laser photocoagulator is fired. Dichroic beamsplitter reflects small fraction of laser beam to phototransistor that feeds monitor circuit. Output of monitor drives recorder. Circuit is calibrated by measuring total beam energy with thermopile.—E. J. Scribner, Circuit Monitors Energy of Laser Photocoagulator, *Electronics*, July 7, 1969, p 110–111.

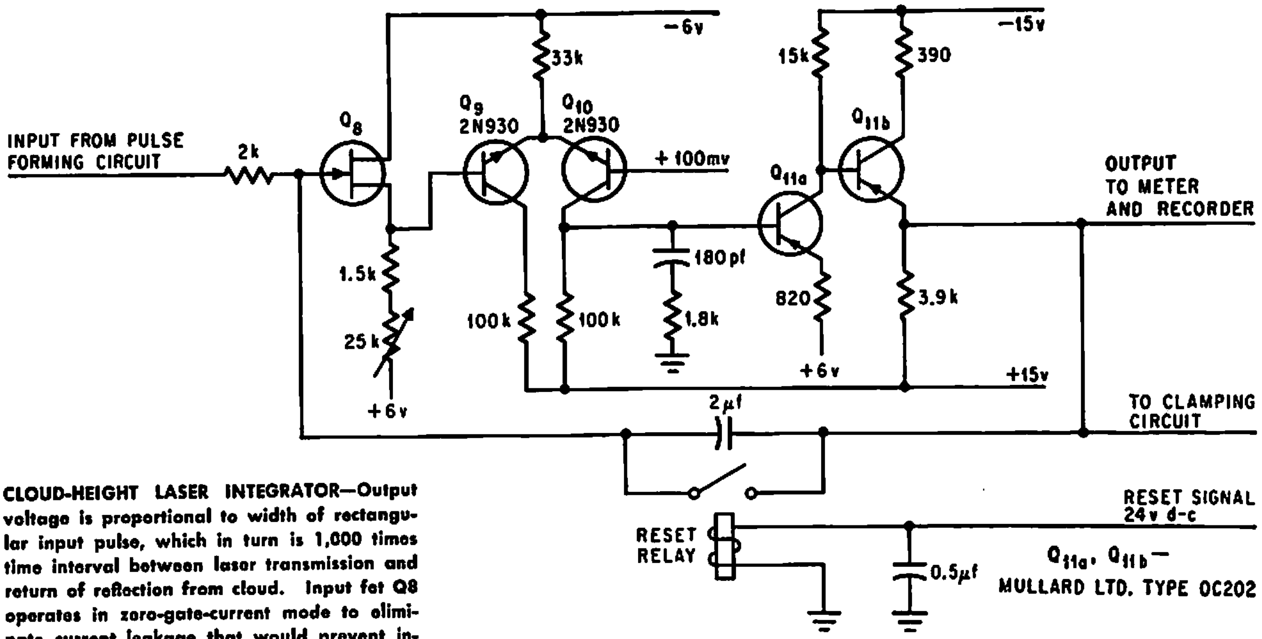

+3v
+15v
15k
ZERO
ADJUST
1k
51.1
SENSITIVITY
100k
OUTPUT
0
−5v
Q1
2N3644
0.1μf
1,470
Q2
2N3644
5,110
Q3
2N4037
23.7k
G
S
D
C2
0.68μf
C1
33μf
6,190
HOLDING
TIME
200k
2,150
−15v

INJECTION LASER PULSE GENERATOR—EG&G Krytron pulser produces peak currents of several thousand amperes at repetition rates up to 500 pulses per second, for pulsing high-power injection lasers at room temperature. Outstanding features are simplicity, small size, and low cost. Capacitor C is charged from 510-V d-c source, then discharged through laser diode D and Krytron switch.—W. Koechner, Extremely Small and Simple Pulse Generator for Injection Lasers, *Review of Scientific Instruments*, Jan. 1967, p 17–20.


R_A
470K
I_B ← 0.5 mA
R_G
36M
KN2
EG&G
C
26nF
$u_c(t)$
U_B
510 V
r_s
1Ω
$i(t)$
$i_c(t)$
D


SPRAGUE TYPE 118P FOR VOLTAGES UP TO 600VDC
SPRAGUE TYPE CP70 FOR VOLTAGES UP TO 2KVDC
1μf
600–2000 VDC
+
10K
EG&G
KN-4, or-6
KRYTRON
SPRAGUE TYPE 150D
1μf
20–30VDC
22M
10³
10W
0-3 KVDC SUPPLY
C
+
−
EG&G
TR-149
USE ONE OF THE FOLLOWING
EG&G TRIGGER TRANSF.
TR-136A(1500V MAX. INPUT)
TR-146A(1500V " ")
TR-170 (2000V " ")
TR-179 (800V " ")

SERIES INJECTION TRIGGERING—Circuit shown may be used with many different sizes and types of linear pulsed xenon flashtubes, for such applications as laser pumping, medical research, satellite flashers, photoreproduction, and lighthouse beacons. Trigger may be operated by remote control. Voltage required for series injection triggering ranges from 15 to 35 kV depending on flashtube.—Linear Xenon Flashtubes, EG&G Inc., Boston, Mass., No. 1002-B, 1967.

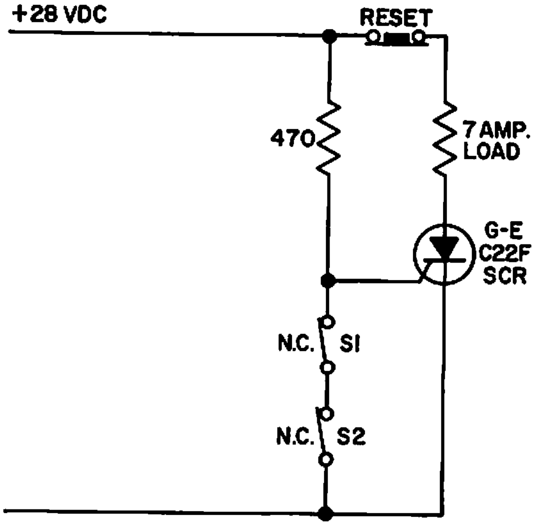

INPUT FROM PULSE FORMING CIRCUIT
2k
Q_8
1.5k
25k
+6v
−6v
33k
Q_9
2N930
Q_{10}
2N930
+100mv
100k
100k
180pf
1.8k
15k
390
−15v
Q_{11a}
Q_{11b}
820
+6v
3.9k
+15v
OUTPUT TO METER AND RECORDER
2μf
TO CLAMPING CIRCUIT
RESET RELAY
RESET SIGNAL 24v d-c
0.5μf
Q_{11a}, Q_{11b}—
MULLARD LTD. TYPE OC202

CLOUD-HEIGHT LASER INTEGRATOR—Output voltage is proportional to width of rectangular input pulse, which in turn is 1,000 times time interval between laser transmission and return of reflection from cloud. Input fet Q8 operates in zero-gate-current mode to eliminate current leakage that would prevent information from being stored in integrator without degradation between measurements. Relay shorts integrator capacitor to reset to zero.—G. M. Ettinger, Chronometer Expands Pulses to Measure Nanosecond Intervals, *Electronics*, Jan. 23, 1967, p 108–112.

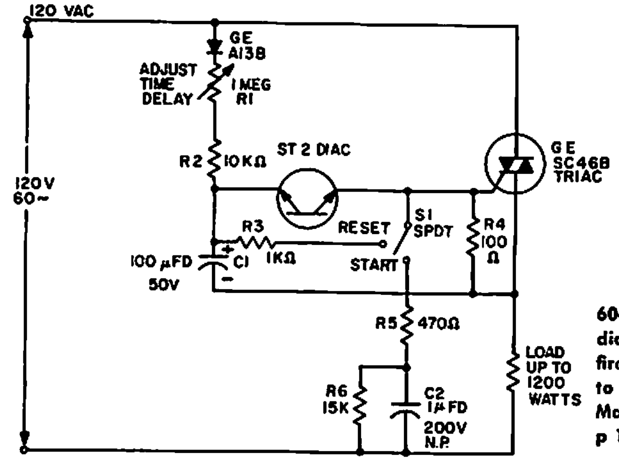
CHAPTER 46

Latching Circuits

D-C LATCH FOR ALARM—Momentary opening of either switch triggers scr, which then latches and provides full load power until reset switch is pushed. Can be used for alarms, firing of explosive squibs, protection circuits, and display lamps.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 3.

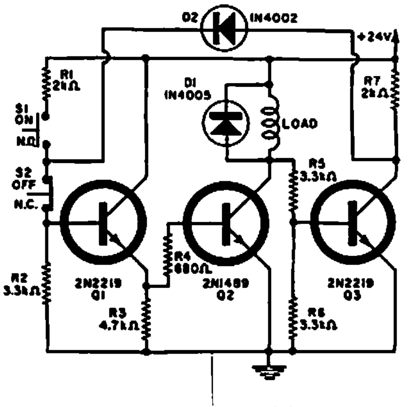


+28 VDC
RESET
470
7 AMP. LOAD
G-E C22F SCR
N.C.
S1
N.C.
S2



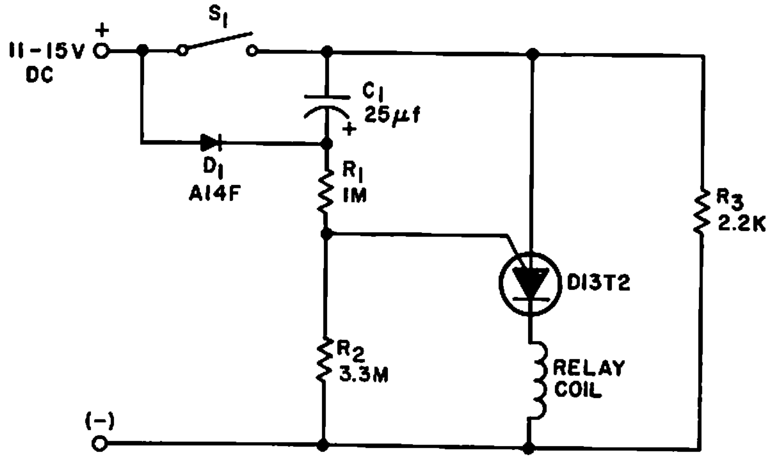
120 VAC
GE A13B
ADJUST TIME DELAY
1 MEG R1
120V 60~
R2
10KΩ
ST 2 DIAC
GE SC46B TRIAC
R3
RESET
S1 SPDT
R4 100 Ω
100 μFD 50V
C1
1KΩ
START
R5
470Ω
R6 15K
C2 1μFD 200V N.P.
LOAD UP TO 1200 WATTS

60-S LATCHING DELAY—When C1 charges to diac voltage, in 60 s for values shown, triac fires and energizes load until S1 is operated to discharge C1 through R3 and R4.—"SCR Manual," 4th Edition, General Electric, 1967, p 148.



D2
1N4002
+24V
R1 2kΩ
S1 ON N.O.
S2 OFF N.C.
D1 1N4005
LOAD
R7 2kΩ
R5 3.3kΩ
R4 680Ω
R2 3.3kΩ
2N2219 Q1
R3 4.7kΩ
2N1489 Q2
2N2219 Q3
R6 3.3kΩ

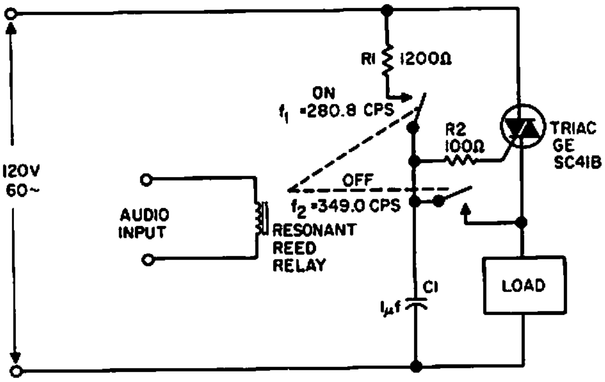
SOLENOID DRIVER WITH LATCH—Momentary closing of S1 energizes solenoid load, and circuit holds in this condition until S2 is momentarily opened. Load current can be up to 5 A.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.



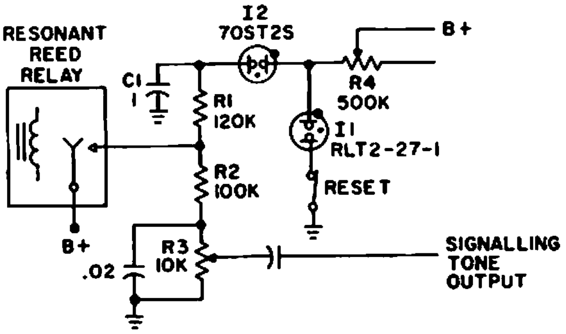
S1
+
11-15V DC
C1 25μf
+
D1 A14F
R1 1M
R3 2.2K
D13T2
R2 3.3M
RELAY COIL
(-)

TIME DELAY 40-60 SECS. WITH COMPONENTS SHOWN.

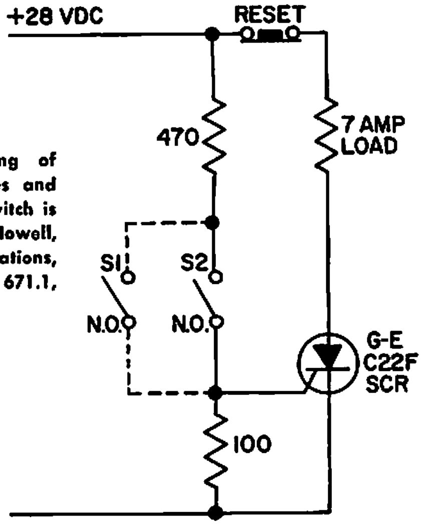
60-S DELAY WITH LATCHING—Uses D13T2 programmable ujt for both timing and latching of relay. High gate sensitivity makes long delays possible with reasonable resistor and capacitor sizes.—E. K. Howell, Small Scale Integration in Low Cost Control Circuits, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 18.


120V
60~
R1 1200Ω
ON
f_1 =280.8 CPS
R2
100Ω
TRIAC
GE
SC41B
OFF
f_2 =349.0 CPS
AUDIO
INPUT
RESONANT
REED
RELAY
C1
1µf
LOAD

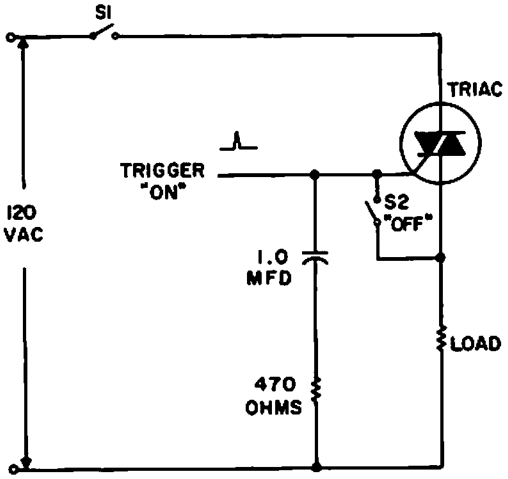
TRIAC TONE-ACTUATED SWITCH—Resonant reed relay is pulled in by 280.8-Hz audio tone, to apply trigger that turns on and latches triac, to apply a-c line voltage to load. Relay releases when tone stops, but latch action of triac keeps load energized. Only 349-Hz tone can make relay pull in the OFF armature and bypass trigger long enough for triac to open or block.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 6.


RESONANT
REED
RELAY
I2
70ST2S
B+
C1
1
R1
120K
R4
500K
I1
RLT2-27-1
R2
100K
RESET
B+
.02
R3
10K
SIGNALLING
TONE
OUTPUT

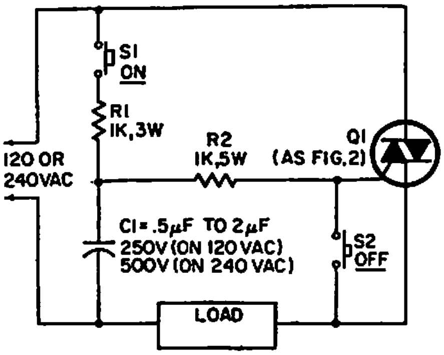
STATION CALL INDICATOR—Serves as memory device in selective calling of unattended two-way radios. Signalling tone from transmitter causes relay to apply total circuit voltage to "call" indicator neon I1, which lights. Circuit remains latched until operator returns and throws reset switch.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 71.


+28 VDC
RESET
470
7 AMP
LOAD
S1
S2
N.O.
N.O.
G-E
C22F
SCR
100

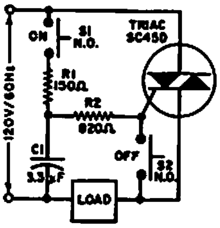
28 V D-C LATCH—Momentary closing of switch triggers scr, which then latches and provides full load power until reset switch is pushed.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 3.


S1
TRIAC
TRIGGER
"ON"
S2
"OFF"
120
VAC
1.0
MFD
LOAD
470
OHMS

TRIAC A-C LATCH—When triac is triggered on by external pulse, voltage developed across capacitor by load voltage triggers triac on each succeeding cycle, until momentary closing of S2 discharges capacitor without triggering triac. Choose triac to meet load requirements.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 8.


S1
ON
R1
1K,3W
R2
1K,5W
Q1
(AS FIG.2)
120 OR
240VAC
C1= .5µF TO 2µF
250V (ON 120 VAC)
500V (ON 240 VAC)
S2
OFF
LOAD

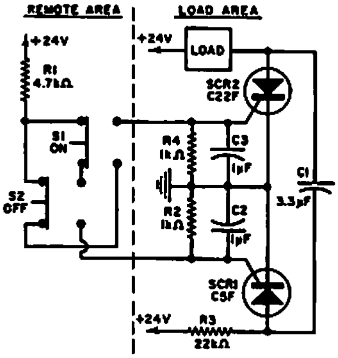
SELF-LATCHING TRIAC—Momentary closing of S1 makes triac stay on continuously until S2 is momentarily closed, to give latching control of current through 6-A load. Use RCA 40429 triac for 120 V and 40430 for 240 V.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.



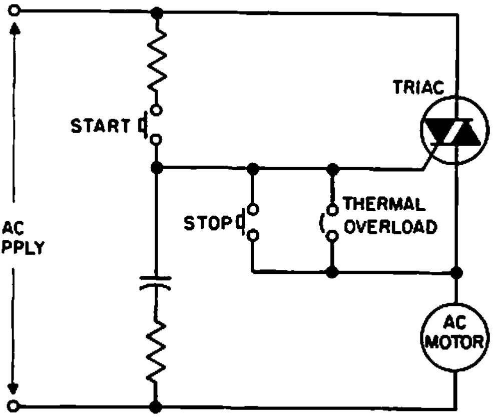
120V/60Hz
ON
S1
N.O.
TRIAC
SC45D
R1
150Ω
R2
820Ω
C1
3.3μF
OFF
S2
N.O.
LOAD

TRIAC LATCH—When S1 is closed, triac saturates and C1 charges. At end of first half-cycle, C1 discharges through gate and triggers triac into saturation for next half-cycle. Process continues, to give latching action, until S2 is closed. Triac then cuts off at next zero crossover and stays off.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.

REMOTE-CONTROL LATCH—Uses two scr's rated at 7.4 A, with momentary-contact switches that can be remotely located. When S1 is actuated, SCR2 is gated on by remote power supply voltage acting through R1, and load receives current. When S2 is actuated, SCR1 is gated on and acts through C1 to turn off SCR2 by lowering its anode voltage. The scr's thus operate in flip-flop action so when one is cut off, the other is conducting.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.

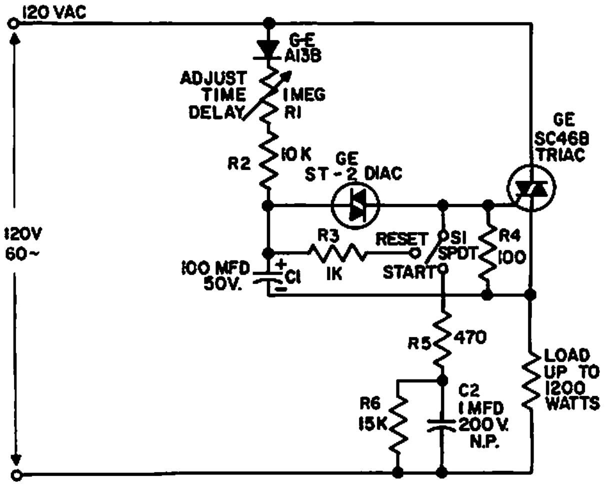


REMOTE AREA
LOAD AREA
+24V
R1
4.7kΩ
S1
ON
S2
OFF
+24V
LOAD
SCR2
C22F
R4
1kΩ
C3
1μF
C1
3.3μF
R2
1kΩ
C2
1μF
SCR1
C5F
+24V
R3
22kΩ



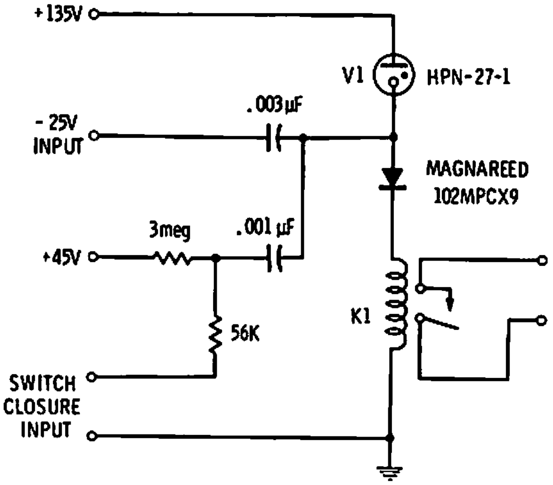
TRIAC
START
STOP
THERMAL OVERLOAD
AC SUPPLY
AC MOTOR

TRIAC A-C MOTOR STARTER—Serves as solid-state equivalent of magnetic a-c motor starter. Choice of triac depends on motor current rating and on a-c line voltage. Resistor and capacitor values in voltage divider are chosen to give trigger voltage required for triac chosen; capacitor is generally 0.1 μF. Triac latches when start button is pressed momentarily, and is then retriggered each half-cycle. Press stop button momentarily to turn off motor.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 6.



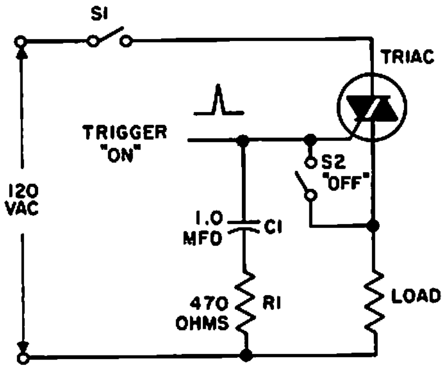
120 VAC
GE
A13B
ADJUST TIME DELAY
1MEG
R1
R2
10K
GE
ST-2 DIAC
GE
SC46B
TRIAC
120V
60~
R3
1K
RESET
S1
SPDT
START
R4
100
100 MFD
50V.
C1
R5
470
R6
15K
C2
1 MFD
200V.
N.P.
LOAD UP TO 1200 WATTS

1,200-W TRIAC WITH DELAY—Adjustable delay applies trigger to triac at predetermined time after S1 is set at START, after which triac latches on and applies full line voltage to load. Moving switch to RESET opens triac and recharges capacitor for next operation. —J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 6.

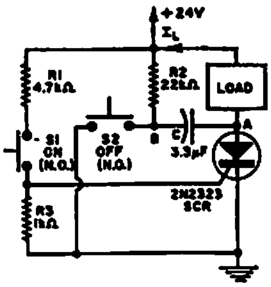


+135V
V1
HPN-27-1
.003μF
-25V INPUT
MAGNAREED
102MPCX9
3meg
.001μF
+45V
56K
K1
SWITCH CLOSURE INPUT

MEMORY FOR MOMENTARY CONTACT—Shorting of switch contacts discharges 0.001-μF capacitor through neon, firing it and holding relay closed until 135-V supply line is opened.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 66.

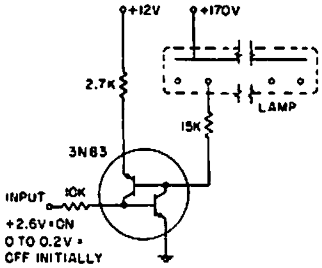

S1
TRIAC
TRIGGER "ON"
S2 "OFF"
120 VAC
1.0 MFD
C1
470 OHMS
R1
LOAD

BASIC TRIAC LATCH—Used as switch for applying power to load when trigger pulse reaches input terminal. Can be turned off either by interrupting power with S1 or bypassing trigger with S2. Triac is initially blocking when load is applied, and latches to conducting state because it is retriggered by a-c line each half-cycle after being turned on by external trigger. Triac used must be specially selected for triggering in III+ mode (third quadrant, positive gate current and voltage), at load current required. For 220-V line, change C1 to 0.5 μF.—J. H. Galloway, *Using the Triac for Control of AC Power*, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 6.

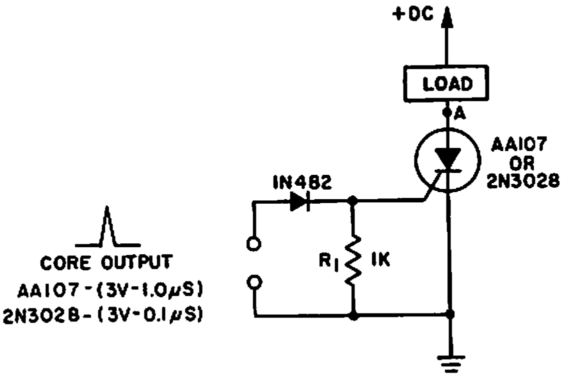

+24V
I_L
R1 4.7kΩ
R2 22kΩ
LOAD
S1 ON (N.O.)
S2 OFF (N.O.)
C 3.3μF
A
2N2323 SCR
R3 1kΩ

SCR LATCH—Closing S1 momentarily makes scr saturate, sending up to 1.6 A through load. Closing S2 momentarily causes commutating capacitor C to begin discharging, thereby turning off scr and keeping it off until another gate pulse is applied by S1.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.

LATCHING LAMP DRIVER—Uses single planar pnpn switch, equivalent to pnp-npn complementary transistor pair, as low-cost driver for Nixie tubes, alphanumeric display tubes, and neon lamps. Circuit is immune to triggering by line transients.—Planar Neon Driver Silicon Controlled Switch 3N83, General Electric, Syracuse, N.Y., No. 65.17, 1964.


+12V
+170V
2.7K
LAMP
15K
3N83
INPUT
10K
+2.6V = ON
0 TO 0.2V = OFF INITIALLY

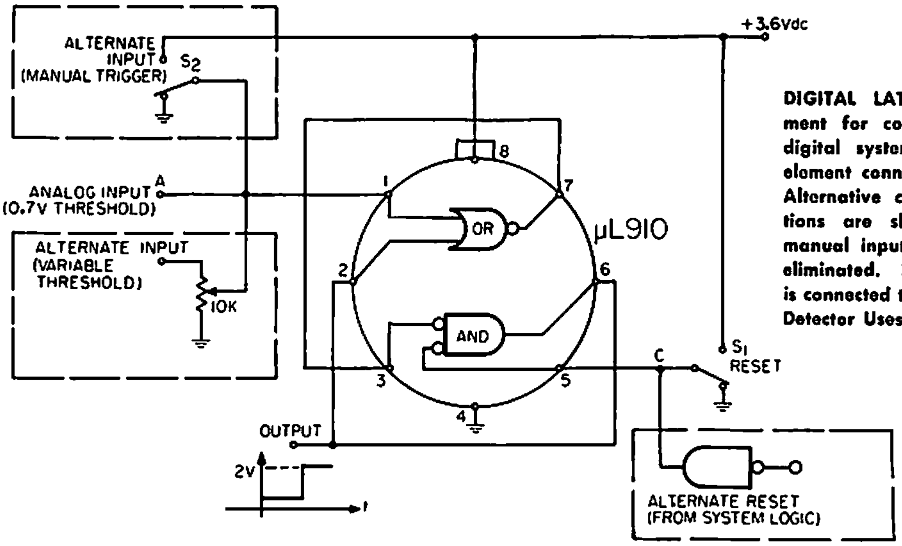
MAGNETIC-CORE READOUT—Provides high-level output through scr for solenoids, magnetic clutches or brakes, and squibs without intermediate amplifier stages. Once circuit is triggered on, it remains on until reset by opening d-c anode supply.—High Level Readout From Magnetic Cores, Solid State Products, Salem, Mass., No. 2.


+DC
LOAD
A
AA107 OR 2N3028
1N482
R_1
1K
CORE OUTPUT
AA107-(3V-1.0μS)
2N3028-(3V-0.1μS)

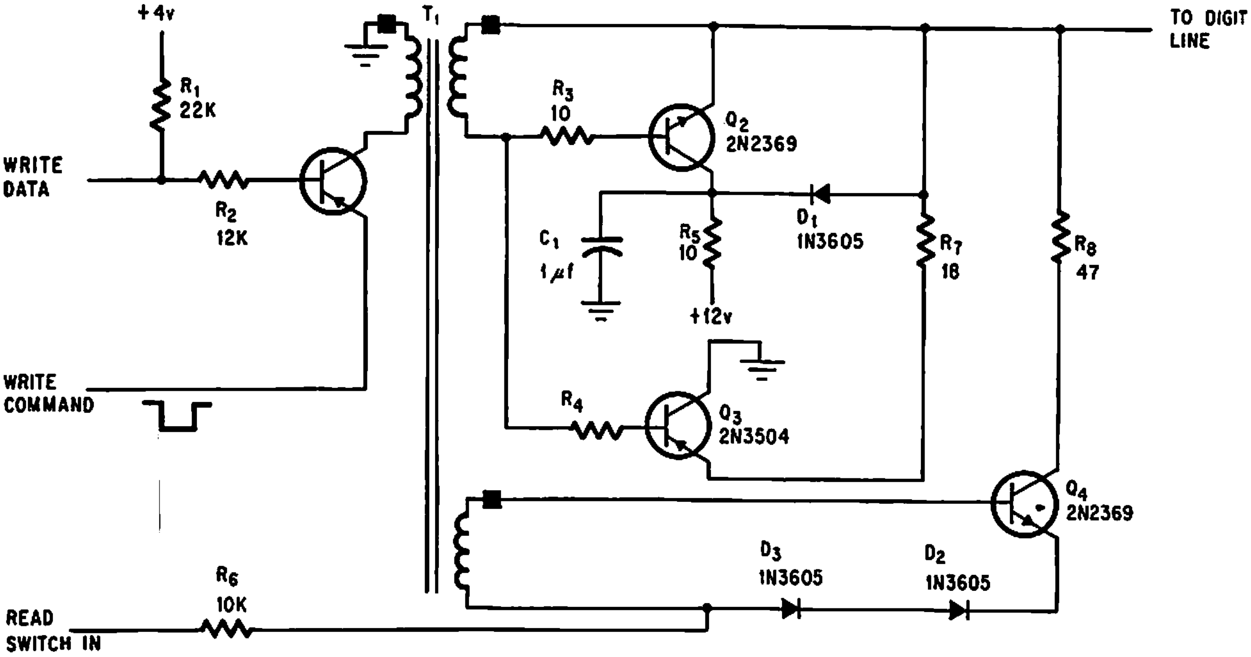
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 47

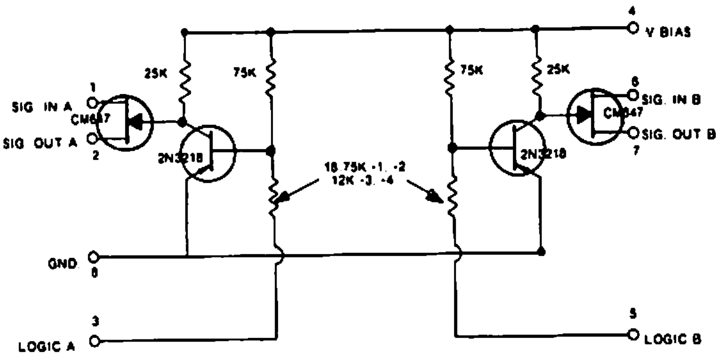
Logic Circuits


+3.6Vdc
ALTERNATE INPUT (MANUAL TRIGGER)
S2
ANALOG INPUT A
(0.7V THRESHOLD)
ALTERNATE INPUT (VARIABLE THRESHOLD)
10K
8
1
7
2
6
3
5
4
OR
AND
μL910
C
S1
RESET
OUTPUT
2V
t
ALTERNATE RESET (FROM SYSTEM LOGIC)

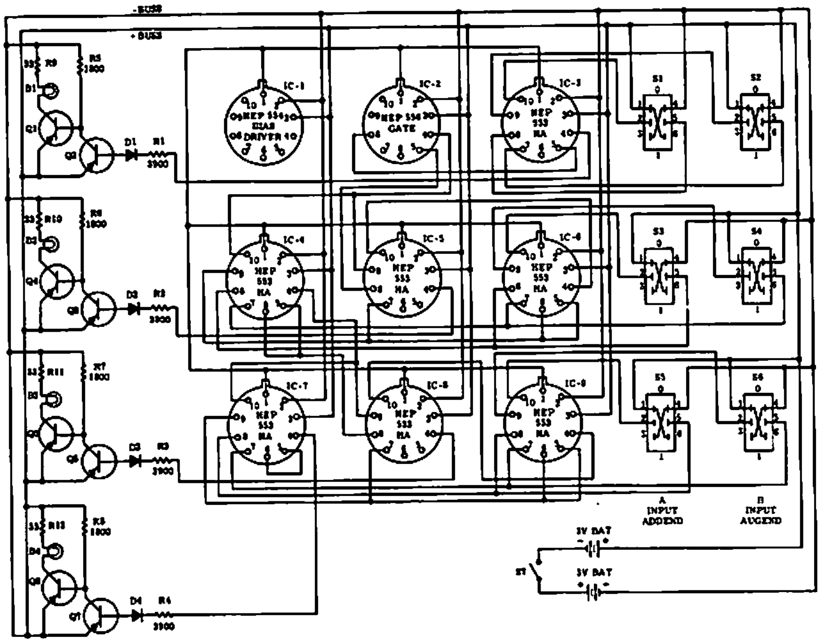
DIGITAL LATCH—Provides low-cost replacement for conventional threshold circuits in digital systems. Uses only dual-gate logic element connected to give positive feedback. Alternative connections for various applications are shown in dashed boxes. With manual input S2, effect of switch bounce is eliminated. For variable threshold, 10K pot is connected to input A.—N. Neidich, Threshold Detector Uses IC, *EEE*, Jan. 1967, p 114.


+4v
R_1 22K
WRITE DATA
R_2 12K
WRITE COMMAND
T_1
R_3 10
Q_2 2N2369
C_1 1μf
R_5 10
+12v
D_1 1N3605
R_7 18
R_8 47
TO DIGIT LINE
R_4
Q_3 2N3504
Q_4 2N2369
D_3 1N3605
D_2 1N3605
R_6 10K
READ SWITCH IN

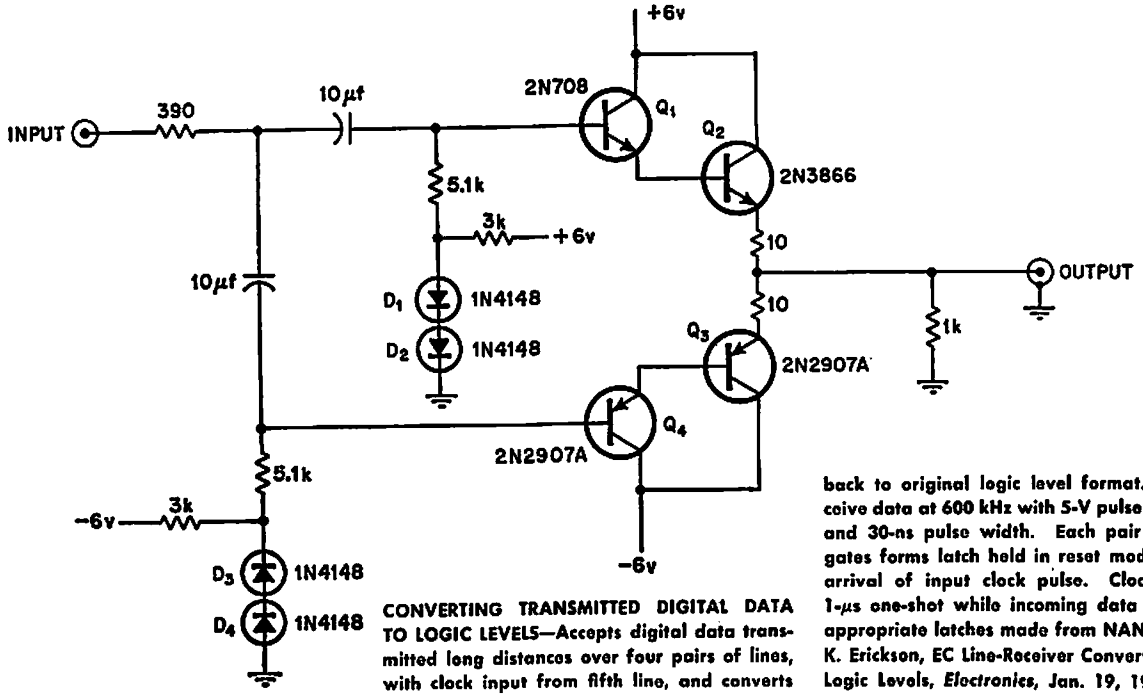
MEMORY WRITE DRIVER—Write-command signal and binary 1 on write data line together turn off Q4 and turn on Q2, to make 12-V signal appear on digit line. End of command pulse turns off Q2 and turns on Q3, for fast discharge of digit line, after which Q4 turns on again to ground line. Used in computer storage developed for long space trips.—D. E. Brewer, S. Nissim, and G. V. Podraza, Suitcase-size Memory for Longer Space Trips, *Electronics*, Nov. 13, 1967, p 138–146.


4
V BIAS
25K
75K
75K
25K
1
SIG IN A
CM647
SIG OUT A
2
2N3218
18 75K -1, -2
12K -3, -4
6
SIG IN B
CM647
SIG OUT B
7
2N3218
GND
8
3
LOGIC A
5
LOGIC B

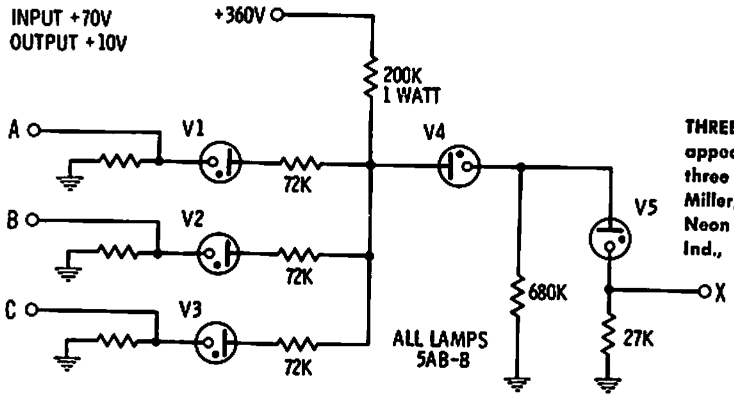
DUAL FET ANALOG SWITCH—Crystalonics CDA2 hybrid package contains pair of basic fet switches with integral drivers, working directly from logic. Intended for switching analog signals to ground or virtual ground only. Logic current drain and power consumption are kept low, by tradeoff with switching speed. Can also be used as integrator reset. —Hybrid IC's, Crystalonics, Cambridge, Mass., 1969.


-BUSS
+BUSS
R9
R5 1800
D1
Q1
Q2
D1 R1 3900
IC-1
HEP 554 BIAS DRIVER
IC-2
HEP 554 GATE
IC-3
HEP 553 HA
S1
S2
S3
S4
S5
S6
IC-4
IC-5
IC-6
IC-7
IC-8
IC-9
A INPUT ADDEND
B INPUT AUGEND
3V BAT
S7
3V BAT

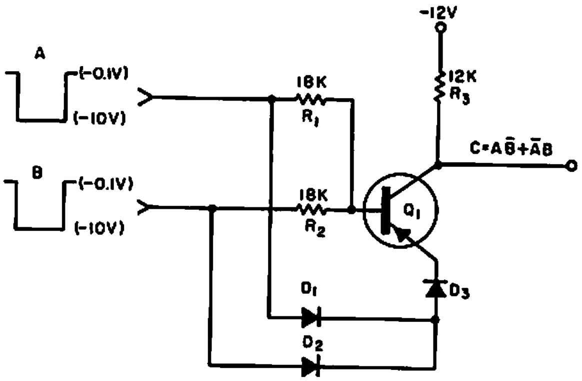
IC BINARY COMPUTER—Simple 3-bit adder is excellent for illustrating binary arithmetic. All transistors are Motorola HEP-51 and all diodes are HEP-154. S1-S6 are dpdt slide switches, and lamps B1-B4 are GE No. 48. Article gives construction details.—"Integrated Circuit Projects," Motorola, Phoenix, Ariz., 1966, p 19–31.


+6v
INPUT
390
10μf
2N708
Q_1
Q_2
2N3866
5.1k
3k
+6v
10
OUTPUT
10μf
D_1
1N4148
D_2
1N4148
10
Q_3
2N2907A
1k
Q_4
2N2907A
5.1k
-6v
3k
-6v
D_3
1N4148
D_4
1N4148

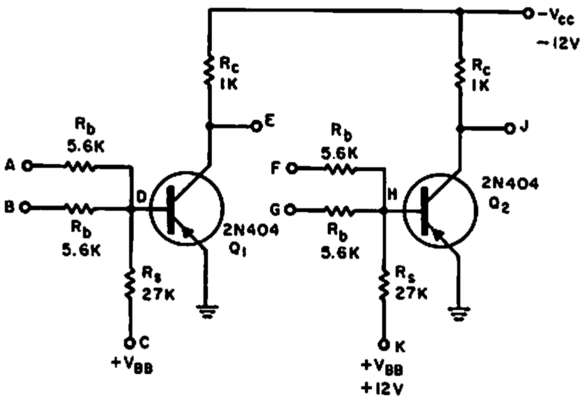
CONVERTING TRANSMITTED DIGITAL DATA TO LOGIC LEVELS—Accepts digital data transmitted long distances over four pairs of lines, with clock input from fifth line, and converts back to original logic level format. Will receive data at 600 kHz with 5-V pulse amplitude and 30-ns pulse width. Each pair of NAND gates forms latch held in reset mode prior to arrival of input clock pulse. Clock triggers 1-μs one-shot while incoming data pulses set appropriate latches made from NAND gates.—K. Erickson, EC Line-Receiver Converts Pulse to Logic Levels, *Electronics*, Jan. 19, 1970, p 94.


INPUT +70V
OUTPUT +10V
+360V
200K
1 WATT
A
B
C
V1
V2
V3
V4
V5
72K
72K
72K
680K
27K
X
ALL LAMPS
5AB-B

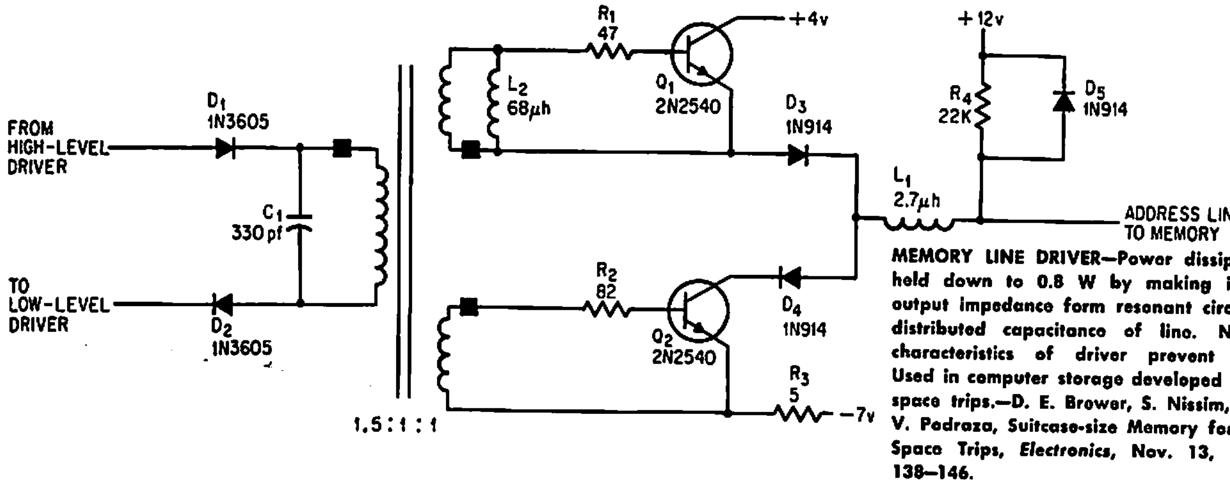
THREE-INPUT MAJORITY GATE—10-V output appears at X whenever at least two of the three lamps (V1, V2, V3) extinguish.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 53.


A
(-0.1V)
(-10V)
B
(-0.1V)
(-10V)
-12V
12K
R3
18K
R1
18K
R2
C=AB̄+ĀB
Q1
D1
D2
D3

EXCLUSIVE-OR—Uses only one transistor and three diodes, none of which are critical as to type. Q1 is off when A and B are both at −0.1 V or when both are at −10 V. Q1 is on when A and B are at different levels. D3 may not be needed if binary data levels are maintained within a few tenths of a volt.—A. J. Franchi, Exclusive-Or Circuit Uses Fewer Components, *Electronic Design*, Sept. 14, 1964, p 74–75.

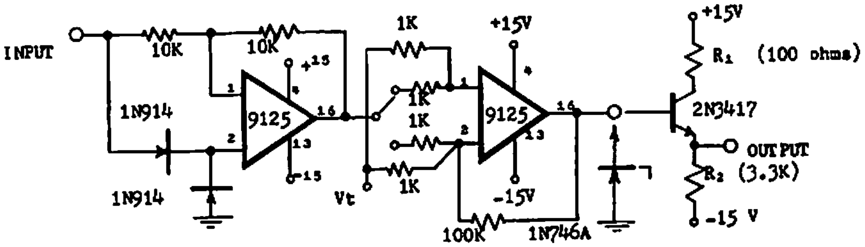

-Vcc
-12V
Rc
1K
Rc
1K
E
J
Rb
5.6K
Rb
5.6K
A
B
Rb
5.6K
Rb
5.6K
F
G
D
H
2N404
Q1
2N404
Q2
Rs
27K
Rs
27K
C
+VBB
K
+VBB
+12V

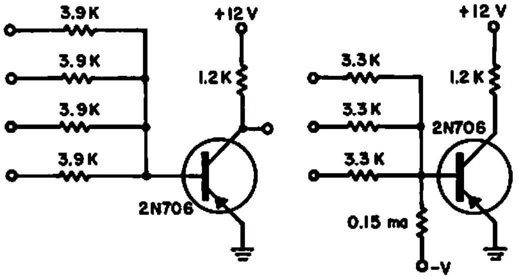
CONVERTING NOR LOGIC TO MVBR—Addition of timing capacitors to two transistor-resistor NOR logic circuits gives astable and monostable mvbr operations. Article gives equation for values of Rb and external C to give desired frequency. Flip-flop is obtained by adding R-C differentiator steering diode networks.—L. E. Frenzel, Jr., NOR Circuits Easily Convert to Multivibrators, *Electronic Design*, Feb. 15, 1965, p 76–77.


FROM
HIGH-LEVEL
DRIVER
TO
LOW-LEVEL
DRIVER
D1
1N3605
D2
1N3605
C1
330pf
1.5 : 1 : 1
L2
68μh
R1
47
Q1
2N2540
+4v
R2
82
Q2
2N2540
D3
1N914
D4
1N914
R3
5
-7v
+12v
R4
22K
D5
1N914
L1
2.7μh
ADDRESS LINE
TO MEMORY

MEMORY LINE DRIVER—Power dissipation is held down to 0.8 W by making inductive output impedance form resonant circuit with distributed capacitance of line. Nonlinear characteristics of driver prevent ringing. Used in computer storage developed for long space trips.—D. E. Brower, S. Nissim, and G. V. Pedraza, Suitcase-size Memory for Longer Space Trips, *Electronics*, Nov. 13, 1967, p 138–146.

INTERFACE—Provides logic 1 output at required level such as +3 V for any logic 1 input. Uses OEI 9125 opamp. First opamp is absolute-value circuit, and second is small-hysteresis that provides sharp transition from one stage to the other. Output is bound by single zener. When switch is up as shown, zero input gives logic 1 output. With switch down, zero input gives logic 0 output.—A Universal Digital Interface, Optical Electronics, Tucson, Ariz., No. 10132.

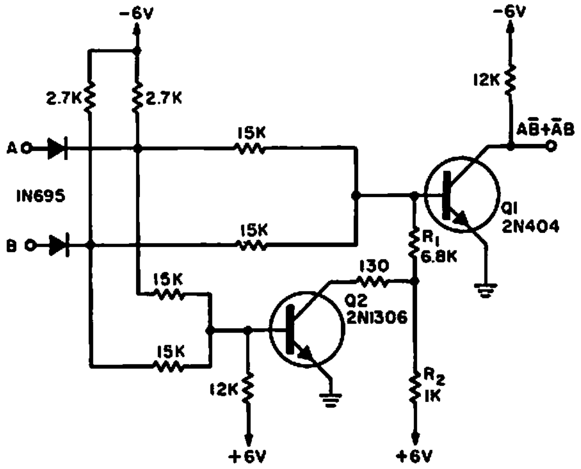

INPUT
10K
10K
1N914
1N914
9125
+15
-15
1
2
4
13
16
Vt
1K
1K
1K
1K
+15V
9125
-15V
100K
1N746A
+15V
R₁ (100 ohms)
2N3417
OUTPUT
R₂ (3.3K)
-15 V


3.9K
3.9K
3.9K
3.9K
+12 V
1.2K
2N706
3.3K
3.3K
3.3K
+12 V
1.2 K
2N706
0.15 meg
-V

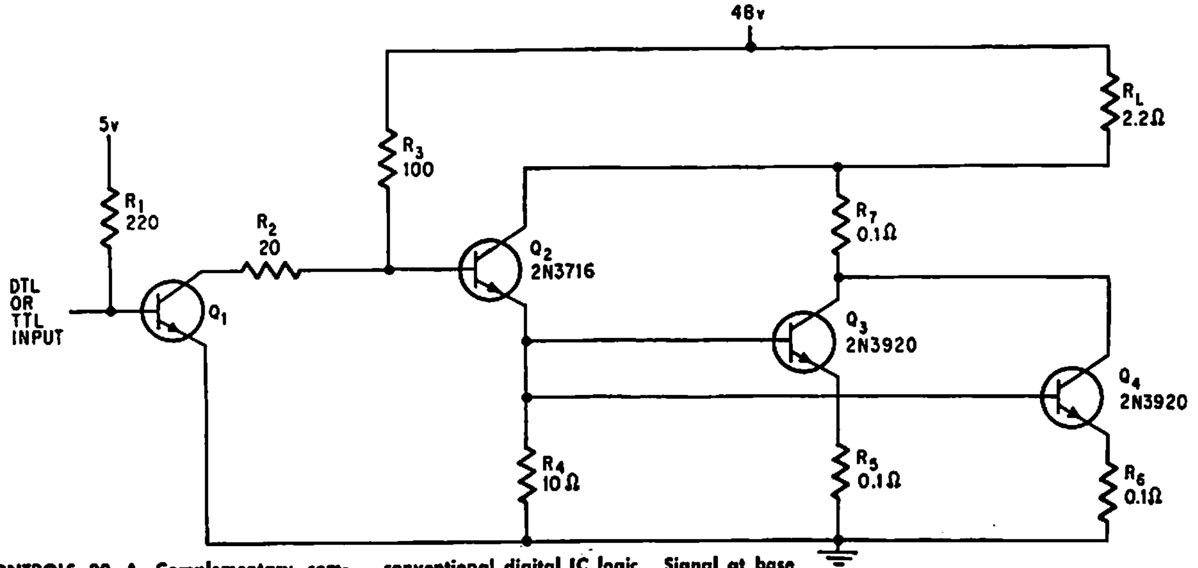
MODERATE TEMPERATURE VERSION

HIGH TEMPERATURE VERSION

TEMPERATURE EFFECTS ON NOR—Circuit at left permits fan-in and fan-out ratio of 4 for temperatures from −55 C up to moderate temperatures. For higher temperatures, negative voltage supply is needed to compensate for leakage current of transistor, and fan-in, fan-out ratio is reduced to 3. Logic speed of both versions is up to 4 MHz, but can be doubled by using 2N2369.—Basic NOR Logic Circuit, *Electronic Design*, April 13, 1964, p 66.

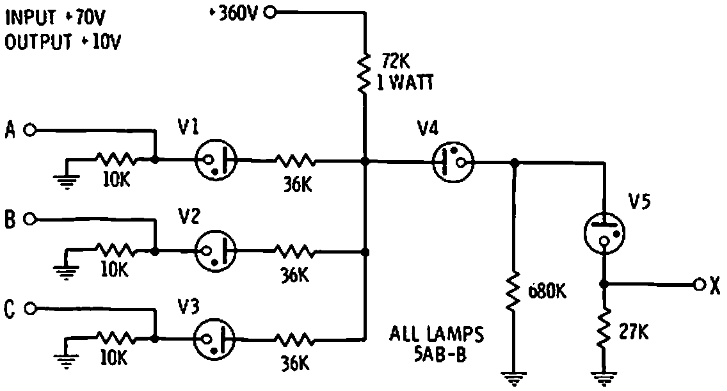

-6V
2.7K
2.7K
A
B
IN695
15K
15K
15K
15K
12K
+6V
130
Q2
2N1306
R₁
6.8K
R₂
1K
+6V
-6V
12K
AB̄+ĀB
Q1
2N404

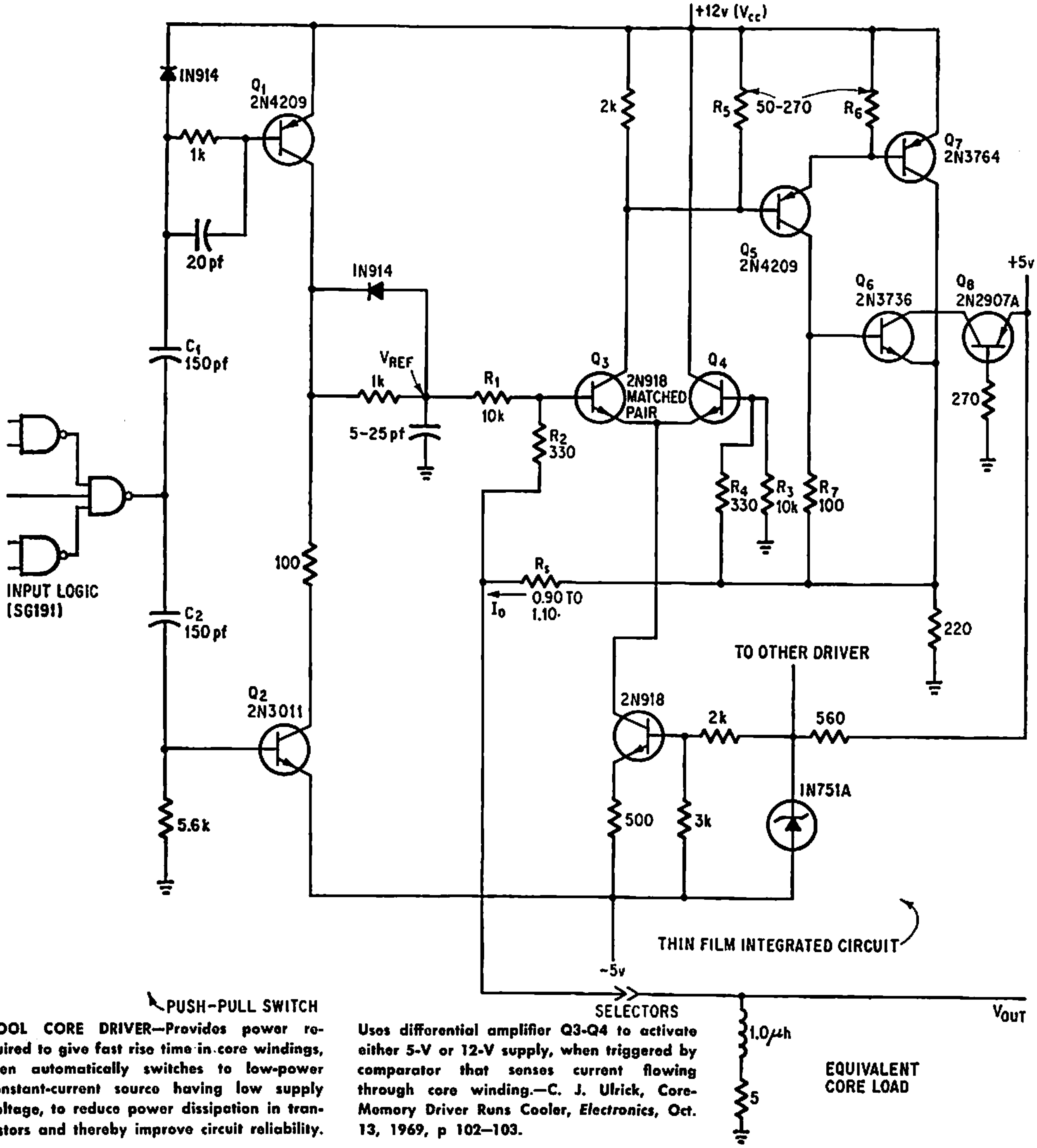
EXCLUSIVE-OR—Complementary transistors reduce cost and complexity. When inputs A and B are both logical zero (−6 V), output is logical zero. When either A or B is logical one (ground), output changes to logical one. When A and B are both logical one, output is logical zero.—J. L. Shagena, Complementary Transistors Reduce Exclusive-OR Size, *Electronic Design*, March 16, 1964, p 102.


48v
5v
R₁
220
DTL OR TTL INPUT
Q₁
R₂
20
R₃
100
Q₂
2N3716
R₄
10Ω
R₇
0.1Ω
Q₃
2N3920
R₅
0.1Ω
R_L
2.2Ω
Q₄
2N3920
R₆
0.1Ω

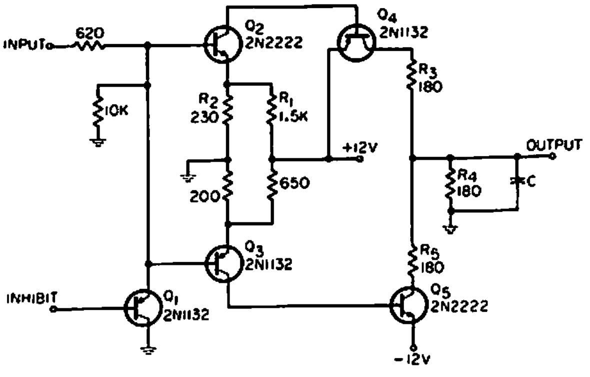
DTL CONTROLS 20 A—Complementary compound switch, operated by buffer transistor Q1, permits control of loads up to 20 A with conventional digital IC logic. Signal at base of Q1 saturates it, turning on Q2 and 10-A transistors Q3 and Q4.—L. S. Bell, High-Current Switch Is Driven by an IC, *Electronics*, Nov. 11, 1968, p 120.

THREE-INPUT OR GATE—Converts high-level (70-V) logic to value useful in solid-state circuits (10 V). Point X is at 10 V if either V1 or V2 or V3 is extinguished by 70-V input. Output is taken from voltage developed across 27K resistor when V5 fires.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 51.

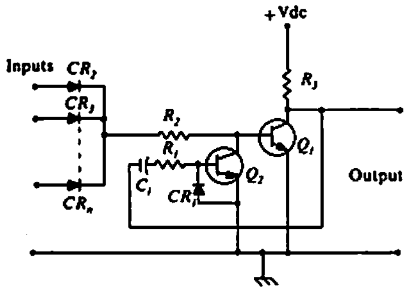

INPUT +70V
OUTPUT +10V
+360V
72K
1 WATT
A
B
C
V1
V2
V3
V4
V5
10K
10K
10K
36K
36K
36K
680K
27K
X
ALL LAMPS
5AB-B


+12v (Vcc)
1N914
Q1
2N4209
1k
20pf
C1
150pf
C2
150pf
INPUT LOGIC
(SG191)
1N914
VREF
1k
5-25pf
R1
10k
R2
330
Q3
Q4
2N918
MATCHED
PAIR
2k
R5
50-270
R6
Q7
2N3764
Q5
2N4209
Q6
2N3736
Q8
2N2907A
+5v
270
R4
330
R3
10k
R7
100
100
Rs
0.90 TO
1.10
Io
220
TO OTHER DRIVER
Q2
2N3011
5.6k
2N918
2k
560
1N751A
500
3k
THIN FILM INTEGRATED CIRCUIT
-5v
PUSH-PULL SWITCH
SELECTORS
VOUT
1.0μh
5
EQUIVALENT
CORE LOAD

COOL CORE DRIVER—Provides power required to give fast rise time in core windings, then automatically switches to low-power constant-current source having low supply voltage, to reduce power dissipation in transistors and thereby improve circuit reliability. Uses differential amplifier Q3-Q4 to activate either 5-V or 12-V supply, when triggered by comparator that senses current flowing through core winding.—C. J. Ulrick, Core-Memory Driver Runs Cooler, *Electronics*, Oct. 13, 1969, p 102–103.

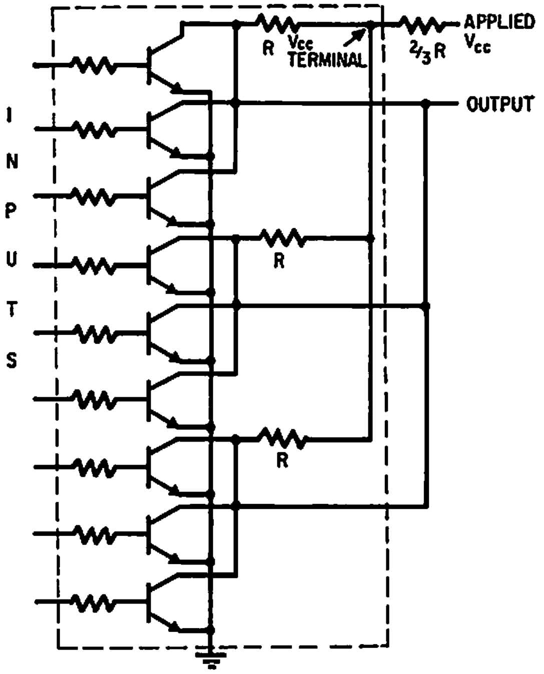

INPUT
620
10K
Q2
2N2222
Q4
2N1132
R3
180
R2
230
R1
1.5K
+12V
OUTPUT
200
650
R4
180
C
Q3
2N1132
R5
180
INHIBIT
Q1
2N1132
Q5
2N2222
-12V

LEVEL-SHIFTER—Converts unbalanced input pulses (0 V and +4 V) to balanced output pulses (−6 V and +6 V). With values shown, output impedance is 90 ohms. If inhibit terminal is grounded, output is held at −6 V regardless of input voltage. Circuit was originally used to convert fast-rise pulses to slow-rise pulses for transmission over long lines.—W. J. Travis, Unbalanced to Balanced Level-Shifter, *EEE,* Nov. 1966, p 155–156.

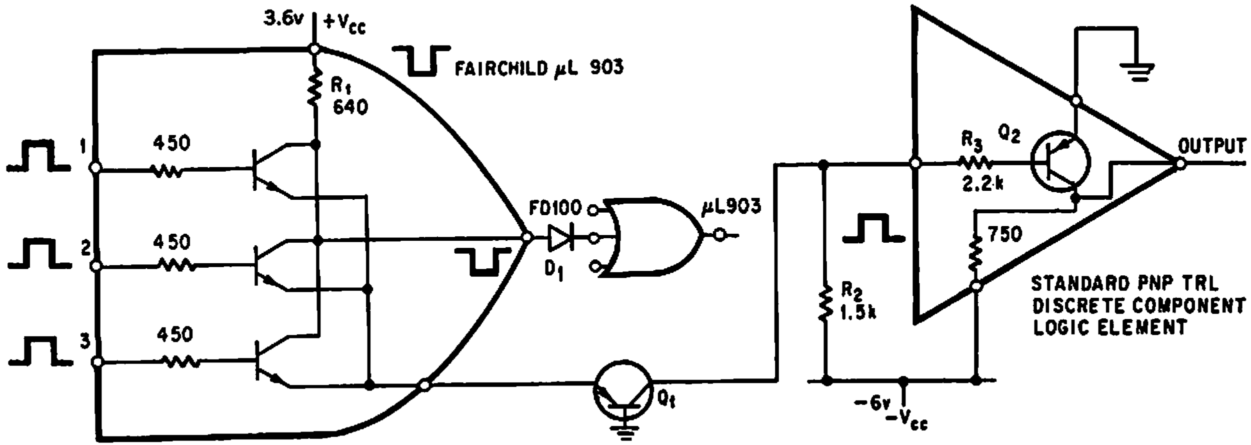

+Vdc
Inputs
CR_1
CR_2
CR_n
R_3
R_2
R_1
Q_1
Q_2
C_1
CR_1
Output

Transistors	2N708
Diodes	1N252
R_1	100K
R_2	10K
R_3	500K
C_1	0.001 µF

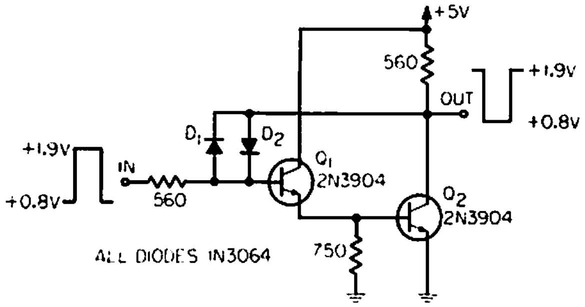
PULSE STRETCHER WITH NOR GATE—Provides output pulse having predetermined minimum duration of about 1 ms, as required in square-root computers and digital oscillators. With all inputs at ground, output is positive and current flow through C1-R1 turns on Q2 until C1 is charged. If inputs become positive while Q2 is still conducting, Q1 is not affected because its base is grounded by Q2. Inputs regain control when Q2 stops conducting.—"Selecting Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 78.


R
Vcc
TERMINAL
2/3R
APPLIED
Vcc
OUTPUT
I
N
P
U
T
S
R
R

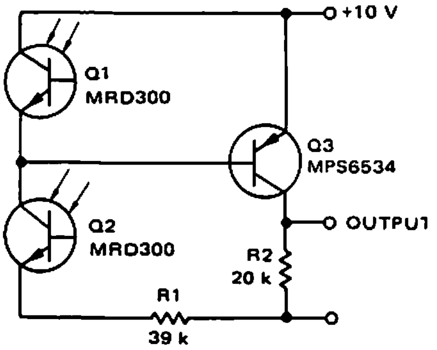
ADDING INPUTS TO NAND GATE—By changing value of Vcc and adding resistor, three triple-input gates in common package can be converted to single 9-input gate. Output is high only when negative voltage is applied to all inputs.—R. L. Frank, NAND Gate Inputs Expanded by Adding Resistor, *Electronics,* March 17, 1969, p 95–96.


3.6v
+Vcc
FAIRCHILD µL 903
R1
640
1
2
3
450
450
450
FD100
µL903
D1
Q1
R3
Q2
2.2k
750
R2
1.5k
OUTPUT
STANDARD PNP TRL
DISCRETE COMPONENT
LOGIC ELEMENT
-6v
-Vcc

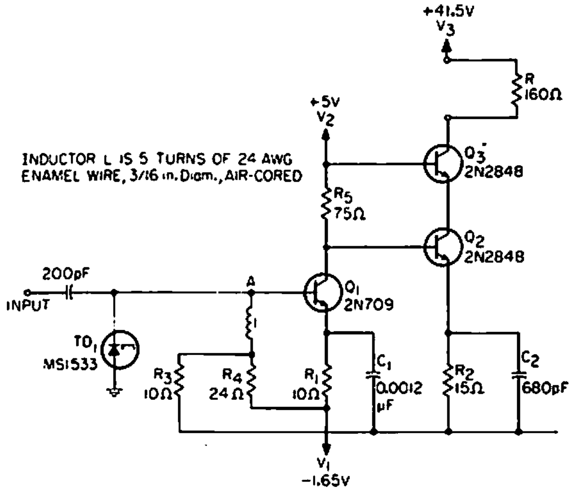
TRANSISTOR COUPLES NPN TO PNP—Germanium 2N1303 Q1 converts signals from npn IC to correct polarity and levels required by pnp discrete transistor at right. Arrangement also improves input noise rejection capability of IC at left.—G. D. Morant, Grounded-Base Amplifier Mates NPN To PNP, *Electronics,* Feb. 5, 1968, p 89.


+5V
560
+1.9V
OUT
+0.8V
D1
D2
Q1
2N3904
+1.9V
IN
+0.8V
560
Q2
2N3904
750
ALL DIODES IN3064

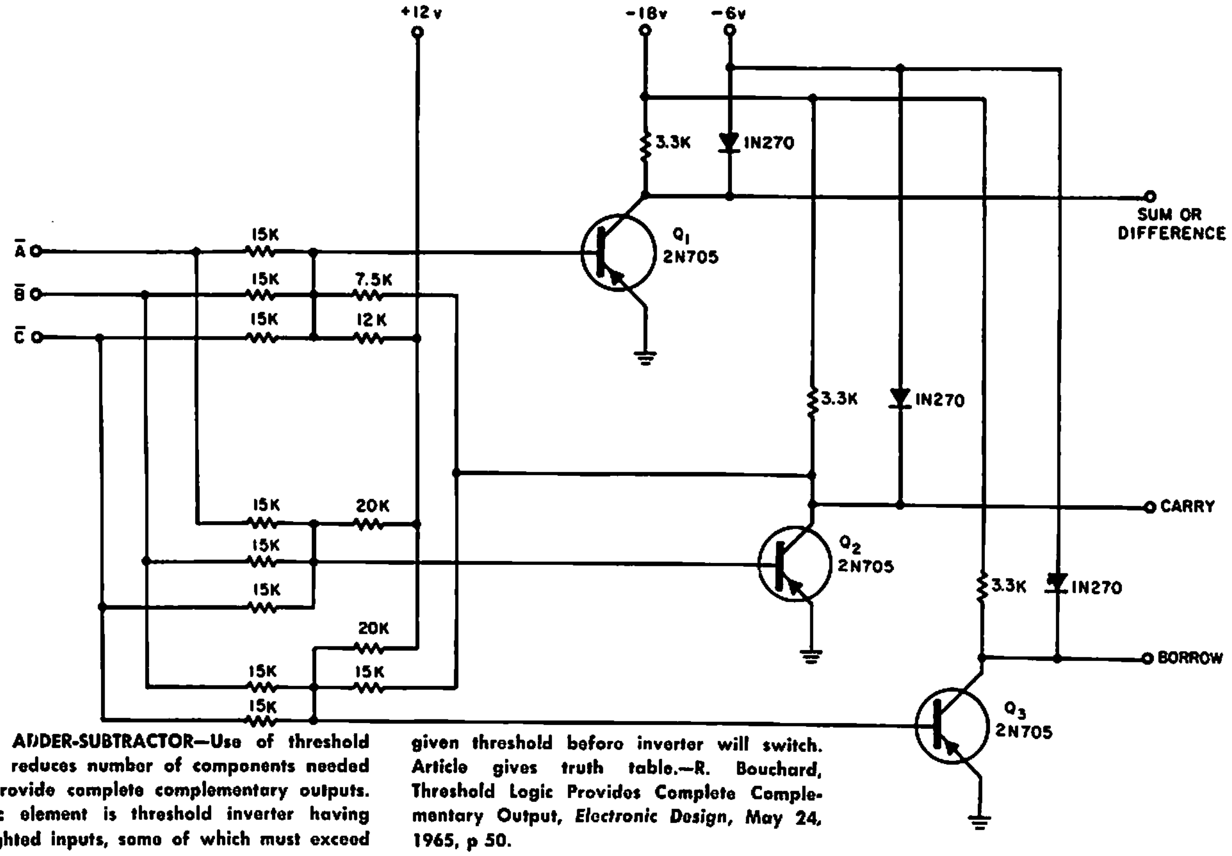
DIODES SPEED PULSE INVERTER—Diode feedback keeps transistors in their active region, avoiding saturation and cutoff. Delays are reduced to about 2 ns. Transistor capacitances have very little effect on switching speed, as long as diodes are fast-switching low-capacitance types.—A. P. Lipps, Fast Logic Circuits with High Noise-Immunity, *EEE*, Dec. 1968, p 100–103.


+10 V
Q1
MRD300
Q3
MPS6534
Q2
MRD300
OUTPUT
R2
20 k
R1
39 k

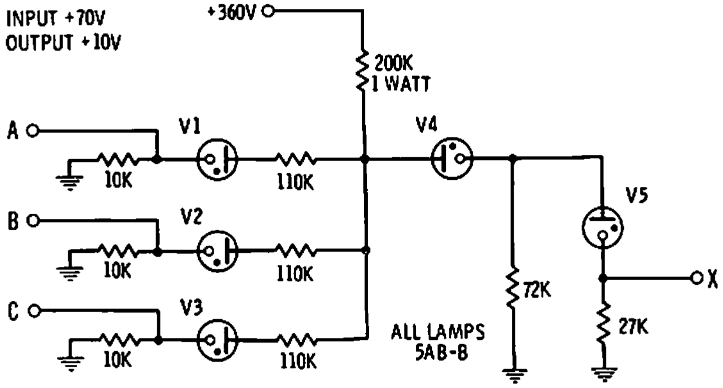
OPTICAL LOGIC DRIVER—Output is zero at all times except when Q2 is illuminated by about 220 foot-candles and Q1 is not. Q2 then saturates Q3 and gives positive output for driving 10-mA load. Can be used to furnish control signal for static switch.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–21.


+41.5V
V3
R
160Ω
+5V
V2
INDUCTOR L IS 5 TURNS OF 24 AWG ENAMEL WIRE, 3/16 in. Diam., AIR-CORED
Q3
2N2848
R5
75Ω
Q2
2N2848
200pF
INPUT
A
Q1
2N709
L
TD1
MS1533
R3
10Ω
R4
24Ω
R1
10Ω
C1
0.0012 μF
R2
15Ω
C2
680pF
V1
-1.65V

WORD-LINE DRIVER—Tunnel diode acts as one-shot to give fast switching speed and adjustable recovery time while delivering 220 mA to 160-ohm load. Delay time is 5 ns, while rise and fall times are 4 ns. Pulse width is adjustable from 15 to 22 ns.—W. W. Wu, Tunnel Diode Speeds Word-Line Driver, *EEE*, Jan. 1968, p 118 and 120.

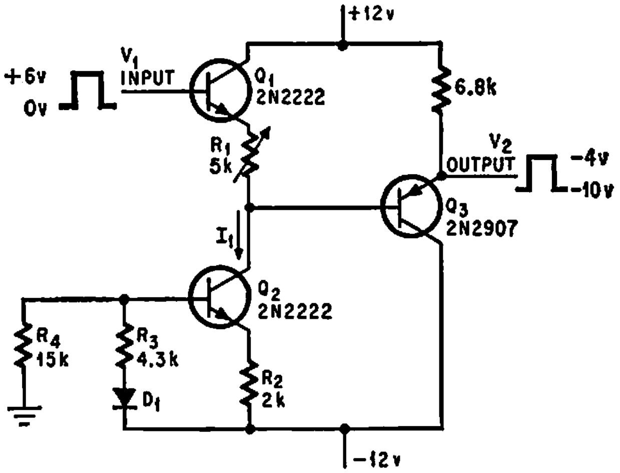

+12 v
-18v
-6v
3.3K
IN270
SUM OR DIFFERENCE
Ā
B̄
C̄
15K
15K
7.5K
15K
12K
Q1
2N705
3.3K
IN270
CARRY
15K
20K
15K
Q2
2N705
15K
3.3K
IN270
20K
BORROW
15K
15K
15K
Q3
2N705

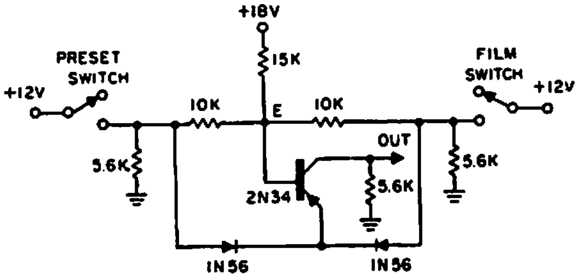
FULL ADDER-SUBTRACTOR—Use of threshold logic reduces number of components needed to provide complete complementary outputs. Basic element is threshold inverter having weighted inputs, some of which must exceed given threshold before inverter will switch. Article gives truth table.—R. Bouchard, Threshold Logic Provides Complete Complementary Output, *Electronic Design*, May 24, 1965, p 50.


INPUT +70V
OUTPUT +10V
+360V
200K
1 WATT
A
B
C
V1
V2
V3
V4
V5
10K
10K
10K
110K
110K
110K
72K
27K
X
ALL LAMPS
5AB-8

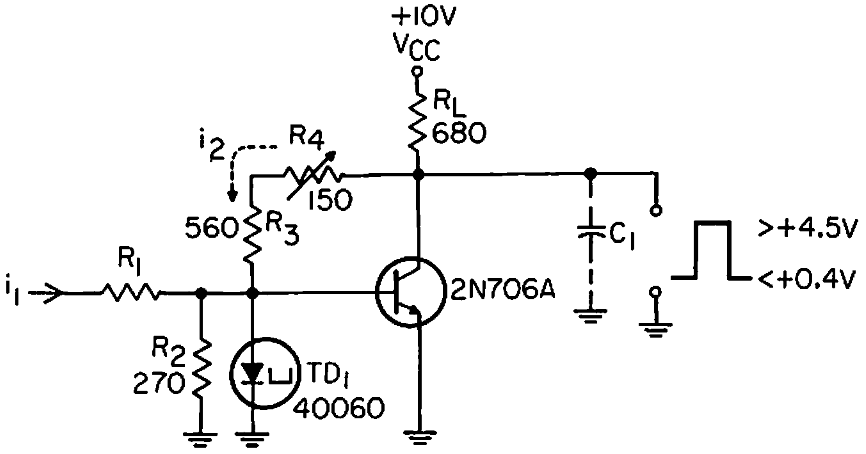
THREE-INPUT AND GATE—Converts high-level (70-V) logic to value useful in solid-state circuits (10 V). Output is taken from voltage developed across 27K resistor when V5 fires. This happens only when V1 and V2 and V3 are extinguished by 70-V inputs.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 52.

LOGIC-LEVEL SHIFTER—Although more complex than single-transistor circuits used to shift voltage levels in digital systems requiring two or more driving voltages, three-transistor version provides much more accurate control of output level, has good thermal stability, and has high input impedance. Signals can be shifted over 18-V range. One desirable application is interfacing.—J. E. Walters, Adding Transistors Makes Voltage Shifter Adjustable, *Electronics*, Dec. 12, 1966, p 108–109.

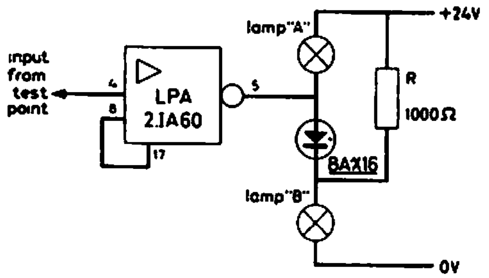

+12v
+6v
0v
V1
INPUT
Q1
2N2222
R1
5k
6.8k
V2
OUTPUT
-4v
-10v
Q3
2N2907
I1
Q2
2N2222
R4
15k
R3
4.3k
D1
R2
2k
-12v


+18V
15K
PRESET
SWITCH
+12V
10K
E
10K
FILM
SWITCH
+12V
OUT
5.6K
5.6K
5.6K
2N34
IN56
IN56

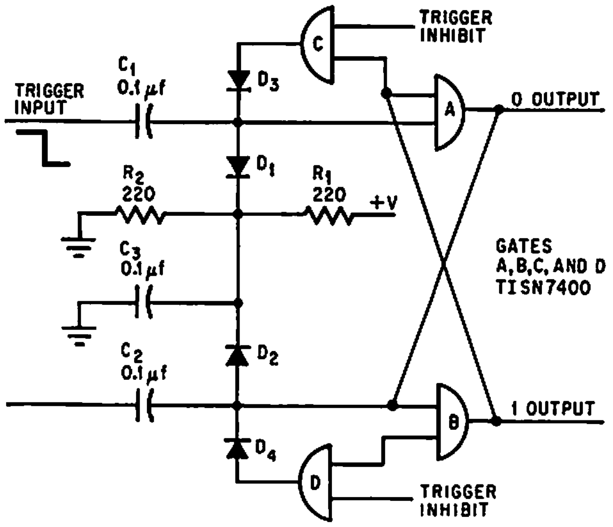
EXCLUSIVE-OR—Used to compare binary bits from film memory with binary numbers set on switches. If preset switch is open, output signal is high only if film switch is closed. With preset switch closed, output is high only if film switch is open. This gives exclusive-OR function. Both sets of conditions allow point E to drop below +12 V and turn on transistor.—F. Neu, Inverted Exclusive-OR Circuit Compares Binary Bits, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 83.


+10V
VCC
RL
680
i2
R4
150
560
R3
R1
i1
C1
2N706A
>+4.5V
<+0.4V
R2
270
TD1
40060

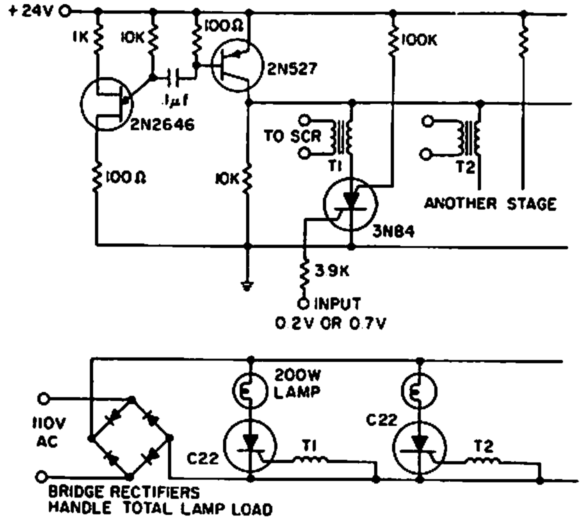
INTERFACE—Output levels of adjustable-hysteresis threshold circuit are compatible with TTL or DTL IC's. Tunnel diode switches to high-voltage state when input current is greater than peak current of diode, but does not switch back to low-voltage state until input current is less than sum of diode's valley current and transistor base current. Magnitude of I2 determines whether circuit hysteresis is positive, zero, or negative (unstable). Used for interfacing within digital computer.—O. A. Horna, Improved Tunnel-Diode Threshold Circuit Has Adjustable Hysteresis, *EEE*, Feb. 1968, p 125.


input from test point
LPA 2JA60
4
8
17
5
lamp "A"
lamp "B"
BAX16
R
1000Ω
+24V
0V

LOGIC LEVEL INDICATOR—Lamp A glows when output level of LPA Philips 60-series NORbit block is high, and lamp B glows when level is low. Display is fail-safe; if lamp A blows, lamp B immediately goes dim. Operation depends on use of lamps having different ratings; lamp A is 28 V and 0.1 A, while lamp B is 16 V and 40 mA. High level here is 11.4 to 30 V, and low level is 0 to 0.3 V.—Logic Level Indication By Two Lamps, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Application Note.

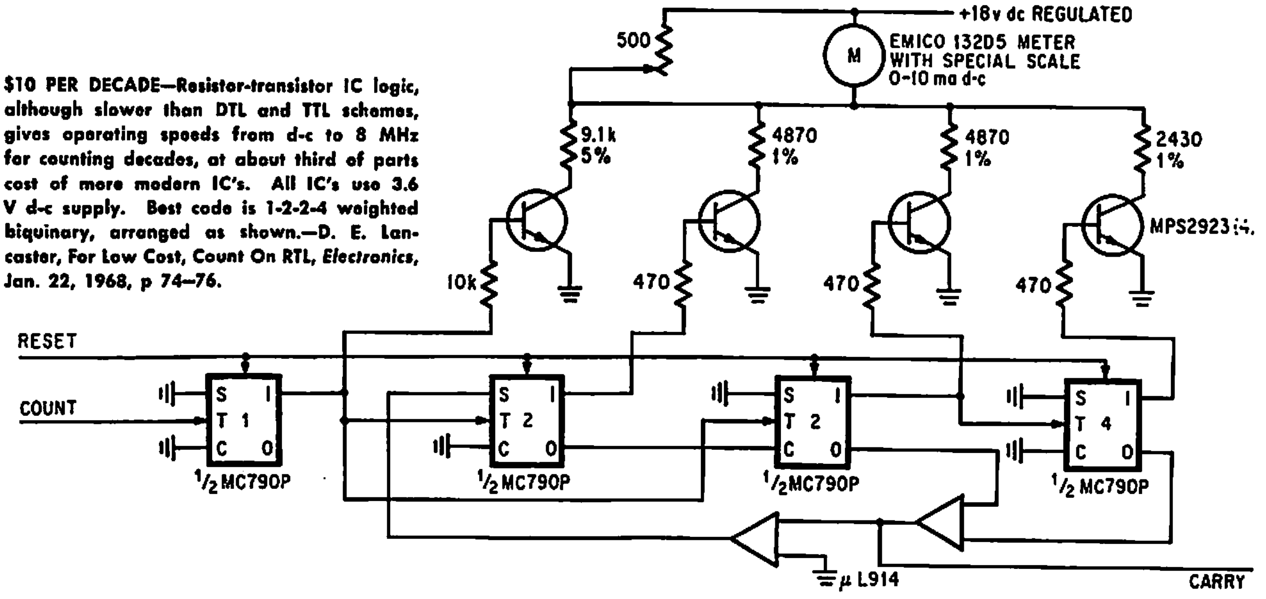

TRIGGER INPUT
C1 0.1 μf
R2 220
C3 0.1 μf
C2 0.1 μf
D3
D1
D2
D4
R1 220
+V
C
A
B
D
TRIGGER INHIBIT
0 OUTPUT
1 OUTPUT
GATES A,B,C, AND D TI SN7400
TRIGGER INHIBIT

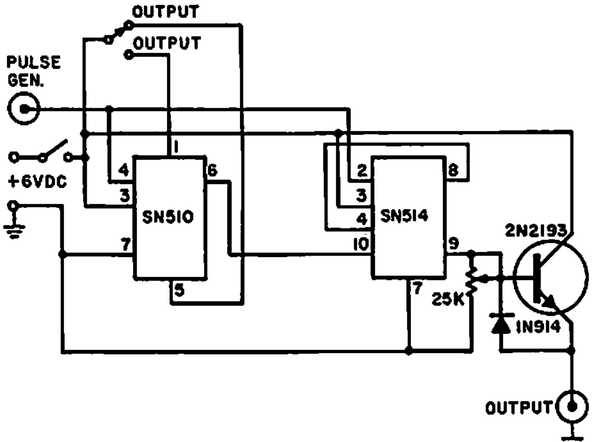
SET-RESET FLIP-FLOP—Use of four gates on single IC, connected as shown, is convenient low-cost method of obtaining common logic circuit not readily available in completely integrated form. Positive logic NAND gates A and B form d-c bistable flip-flop that changes state when trigger input to C1 goes to zero. To switch it back, trigger input to C1 must be returned to ONE state and negative input applied to gate B. Gates C and D provide fast recovery time. Will trigger on sine waves down to about 50 Hz and generate clean, symmetrical square waves.—R. Glasgal, Dual-Quad IC Gives Flip-Flop a Fast Recovery, *Electronics*, Feb. 5, 1968, p 86–87.


+24V
1K
10K
100Ω
.1μf
2N527
2N2646
100Ω
TO SCR
T1
10K
100K
T2
ANOTHER STAGE
3N84
39K
INPUT
0.2V OR 0.7V
110V AC
200W LAMP
C22
T1
C22
T2
BRIDGE RECTIFIERS HANDLE TOTAL LAMP LOAD

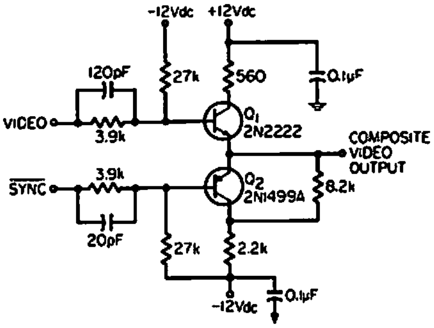
DRIVING LAMP WITH LOW-LEVEL LOGIC—Turns on 200-W lamp for 0.7-V upper logic level, giving normal brilliance, but does not turn on scs and lamp for 0.2-V lower logic level. 2N2646 oscillator turns on 2N527 for about 20 μs at 1-kHz rate; this pulse rate acts through transformer T1 to trigger scr C22 and give full brilliance of 110-V lamp.—Planar Silicon Controlled Switch 3N84/3N85, General Electric, Syracuse, N.Y., 65.18, 1964.

$10 PER DECADE—Resistor-transistor IC logic, although slower than DTL and TTL schemes, gives operating speeds from d-c to 8 MHz for counting decades, at about third of parts cost of more modern IC's. All IC's use 3.6 V d-c supply. Best code is 1-2-2-4 weighted biquinary, arranged as shown.—D. E. Lancaster, For Low Cost, Count On RTL, *Electronics*, Jan. 22, 1968, p 74–76.

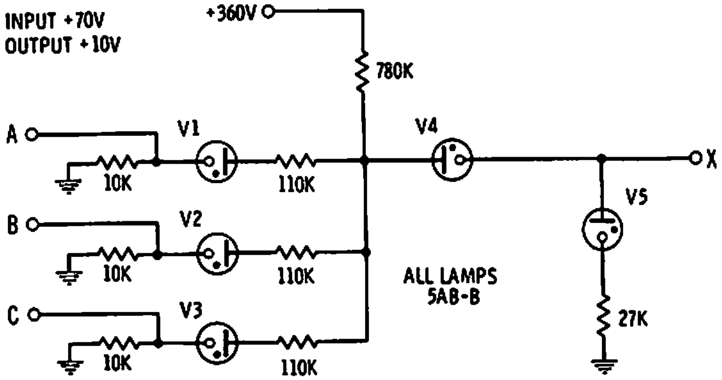

+18v dc REGULATED
500
M
EMICO 132D5 METER WITH SPECIAL SCALE 0-10 ma d-c
9.1k 5%
4870 1%
4870 1%
2430 1%
MPS2923
10k
470
470
470
RESET
COUNT
S I T 1 C O
S I T 2 C O
S I T 2 C O
S I T 4 C O
½MC790P
½MC790P
½MC790P
½MC790P
μL914
CARRY


OUTPUT
OUTPUT'
PULSE GEN.
+6VDC
SN510
1
4
3
7
6
5
2
3
4
10
8
9
7
SN514
2N2193
25K
1N914
OUTPUT

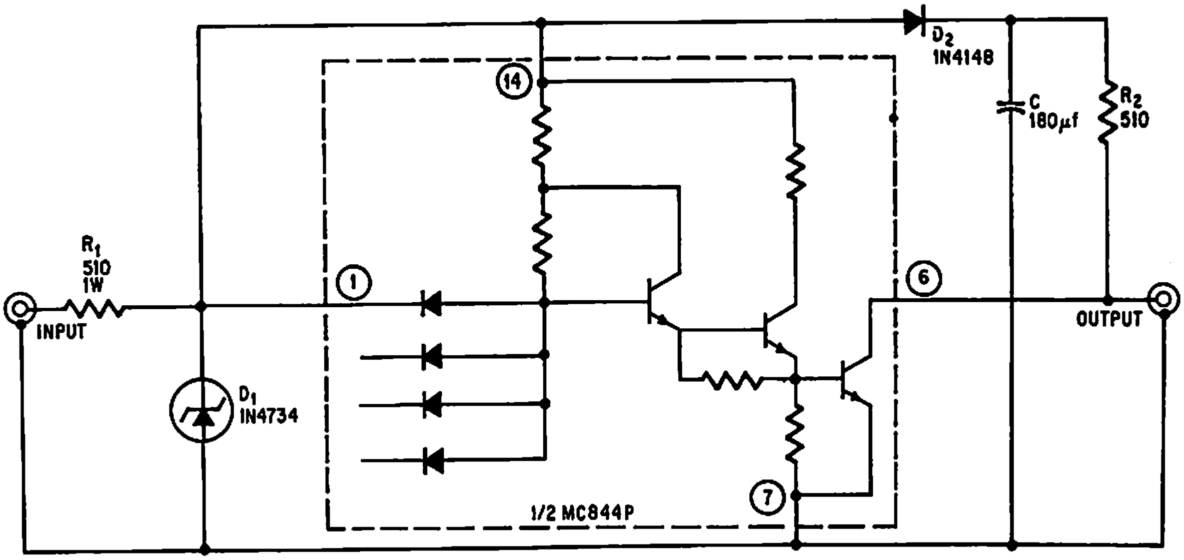
IC SWITCHING—R-S flip-flop IC SN510 acts as selector to provide switched output without interrupting pulse generator. Eliminates chatter caused by manual switch alone. When switch is in OUTPUT' position, +6 V is applied to reset line; output of flip-flop is then positive and no signal goes to SN514 dual NAND gate. In OUTPUT position, flip-flop is near ground and SN514 controls transistor driver that can furnish 4.5 V at up to 75 mA for several clock line pulses.—G. P. Carter, Circuit Prevents Pulse Interruption or Chatter, *Electronic Design*, March 16, 1964, p 106–107.


-12Vdc
+12Vdc
120pF
27k
560
0.1μF
VIDEO
3.9k
Q1
2N2222
COMPOSITE VIDEO OUTPUT
SYNC
3.9k
Q2
2N1499A
8.2k
20pF
27k
2.2k
-12Vdc
0.1μF

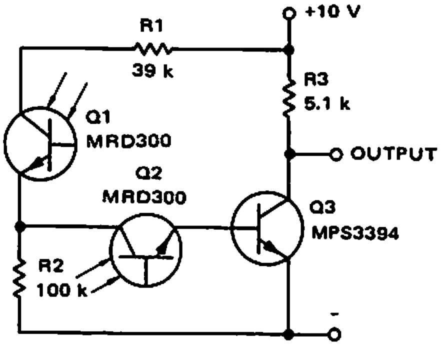
DIGITAL TV DISPLAY—Converts 5-V logic 1 and 0-V logic 0 signals to EIA standards for video (+1 V video, −0.1 V blanking, and 0.4 V sync) feeding into EIA standard 75-ohm load. Used for computer-generated digital television displays. Several crt monitors may be fed in parallel, with 70-ohm termination attached to last monitor. Frequency response is flat within 1 dB from d-c to 20 MHz.—T. A. Anderson, Inexpensive Video Distribution Amplifier Converts Logic Signals for TV Displays, *EEE*, Nov. 1967, p 124.


INPUT +70V
OUTPUT +10V
+360V
780K
A
V1
10K
110K
V4
X
B
V2
10K
110K
V5
ALL LAMPS 5AB-B
C
V3
10K
110K
27K

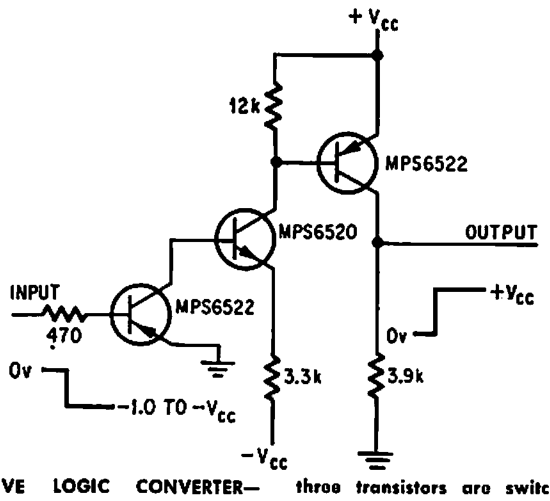
NEON AND GATE—Has 70-V input and same output for operating additional high-level logic circuits. V5 fires only when V1, V2, and V3 are extinguished.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 53.


D2
1N4148
14
C
180μf
R2
510
R1
510
1W
1
6
INPUT
OUTPUT
D1
1N4734
7
1/2 MC844P

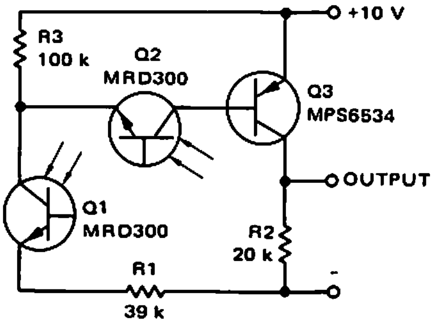
PROTECTING IC FROM NEGATIVE OVERDRIVE—Permits driving DTL, TTL, and other current-sinking logic with standard laboratory signal generators that produce output waveform symmetrical to ground and which therefore may exceed ratings of logic elements in negative direction. Voltage swings of 25 V negative will not damage IC. R1 and D1 clamp positive inputs to 5 V and negative to 0.7 V.—R. K. Underwood, Converted Generator Drives Heavy Logic Loads, *Electronics*, Feb. 17, 1969, p 97–98.


R1
39 k
+10 V
R3
5.1 k
Q1
MRD300
OUTPUT
Q2
MRD300
Q3
MPS3394
R2
100 k
-

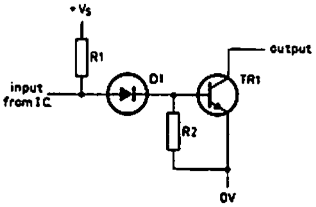
OPTICAL LOGIC DRIVER—Can be used for delivering control signal to static switch. Output is positive, providing 2 mA to load, at all times except when phototransistors Q1 and Q2 are both exposed to bright light of about 220 foot-candles.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–20.


$+V_{CC}$
12k
MPS6522
MPS6520
OUTPUT
$+V_{CC}$
INPUT
470
MPS6522
0v
0v
-1.0 TO $-V_{CC}$
3.3k
3.9k
$-V_{CC}$

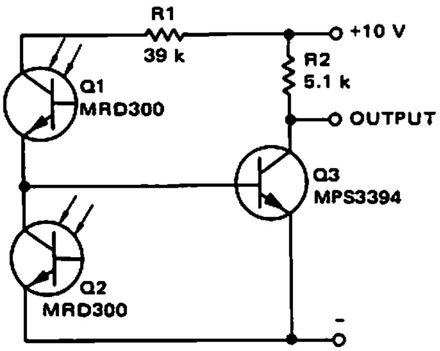
NEGATIVE-POSITIVE LOGIC CONVERTER—Transforms negative control signal into required positive logic for digital IC, at clock rates from d-c to above 2 MHz. Negative d-c voltage levels below zero are changed to positive logic level of system, in range of 3.6 to 7 V. When negative pulse reaches input, all three transistors are switched on, and inverted signal appears at output. Noise immunity is better that 400 mV for 0 to 100 C.—J. A. D'Cunha, Negative Signals Converted to Positive Logic, *Electronics*, March 17, 1969, p 97.


+10 V
R3
100 k
Q2
MRD300
Q3
MPS6534
OUTPUT
Q1
MRD300
R2
20 k
R1
39 k
-

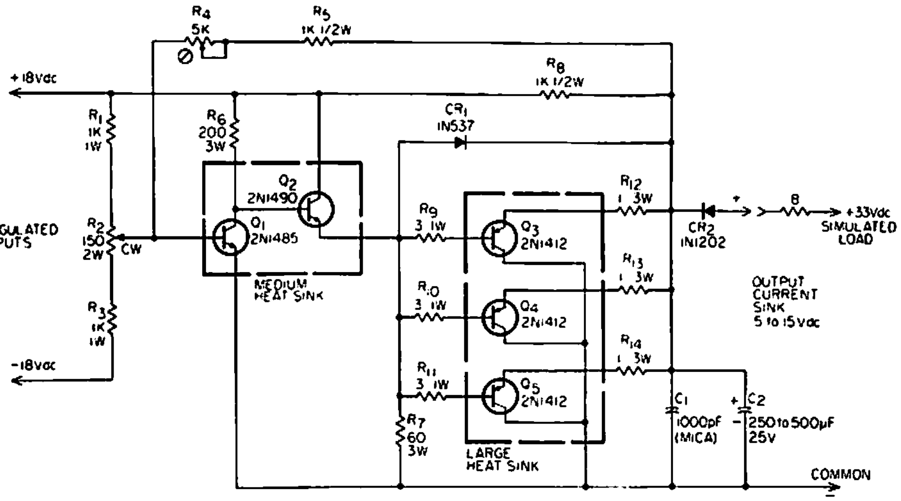
OPTICAL LOGIC DRIVER—Output is zero at all times except when both Q1 and Q2 are illuminated by about 220 foot-candles, in which case they saturate Q3 so it can provide at least 10 mA for static switch or other load. —"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–20.


+Vs
R1
output
input from IC
D1
TR1
R2
0V

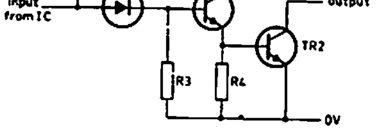
BOOSTING LOGIC OUTPUT—With input from IC and 6-V supply, low input gives 35 V maximum output at 5 μA, and high input gives 0.2 V maximum output at 100 mA. Diode is BAX13, R1 is 560 ohms, and R2 is 6.8K.—J. Deerson, FC Family of DTL Integrated Circuits, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1970, p 139.


R1
39 k
+10 V
R2
5.1 k
Q1
MRD300
OUTPUT
Q3
MPS3394
Q2
MRD300
-

OPTICAL LOGIC DRIVER—Provides positive output voltage for all combinations of illumination on phototransistors Q1 and Q2 except that when light is on Q1 but not on Q2. Will furnish 2 mA to load. About 220 foot-candles from flashlight shining on Q1 will saturate Q3 and reduce output to zero.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–20.


R4
5K
R5
1K 1/2W
+18Vdc
R8
1K 1/2W
R1
1K
1W
R6
200
3W
CR1
1N537
Q2
2N1490
R12
1 3W
+
8
+33Vdc
SIMULATED LOAD
REGULATED INPUTS
R2
150
2W
CW
Q1
2N1485
R9
3 1W
Q3
2N1412
CR2
1N1202
MEDIUM HEAT SINK
R13
1 3W
OUTPUT CURRENT SINK
5 to 15Vdc
R3
1K
1W
R10
3 1W
Q4
2N1412
R14
1 3W
-18Vdc
R11
3 1W
Q5
2N1412
C1
1000pF
(MICA)
C2
250 to 500μF
25V
R7
60
3W
LARGE HEAT SINK
COMMON

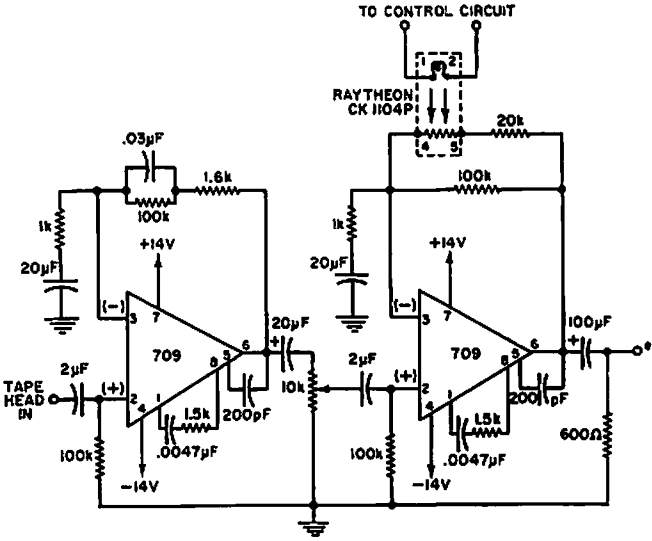
CONSTANT-VOLTAGE SINK FOR CLAMPED LOGIC—Gives any constant voltage from 5 to 15 V d-c and will sink up to 3 A of reverse current when serving as constant-voltage sink. Output voltage regulation is better than 2%. Circuit is similar to shunt-regulated power supply except for reversed load.—M. W. Raybin, Second Breakdown Gives Fast Pulses, *EEE*, March 1967, p 162 and 164.

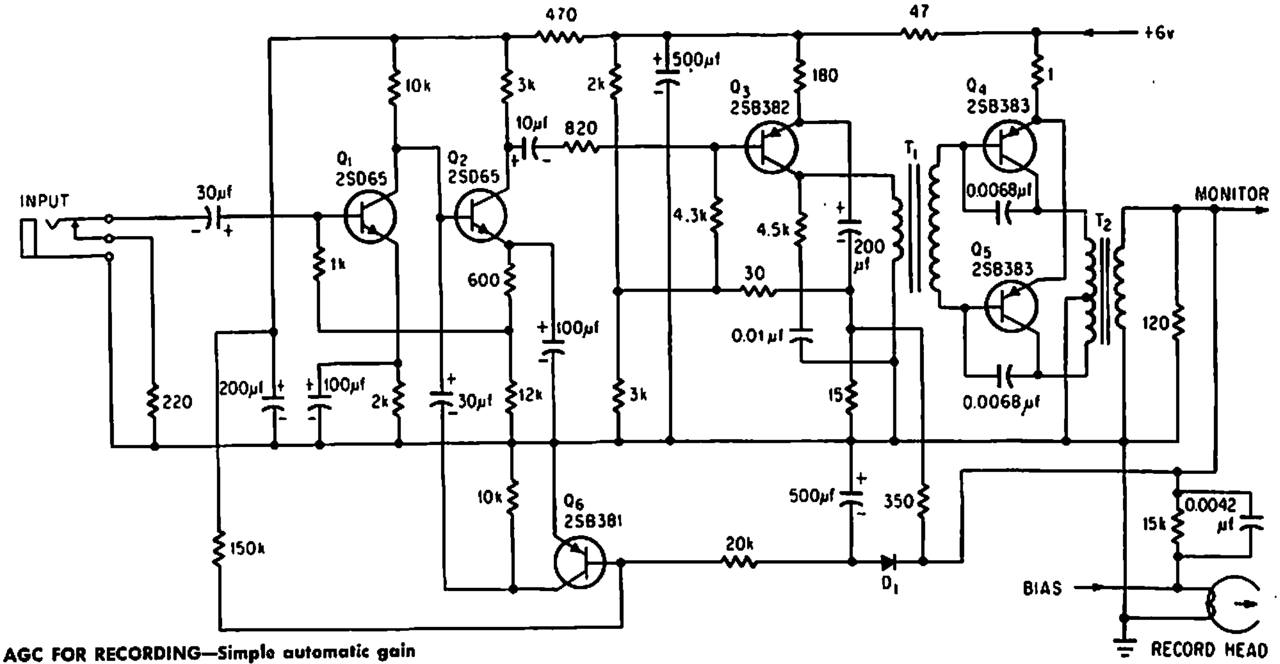

+Vs
R1
R2
D1
TR1
input from IC
output
TR2
R3
R4
0V

1-A LOW LOGIC—With input from IC logic unit and 6-V supply, low input gives 35 V maximum output at 5 μA and high input gives 1 V maximum output at 1 A. Values are: D1 BAX13; TR1 BFY51; TR2 BFY50 with heatsink; R1 560; R2 30; R3 6.8K; R4 470.—J. Deerson, FC Family of DTL Integrated Circuits, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1970, p 139.

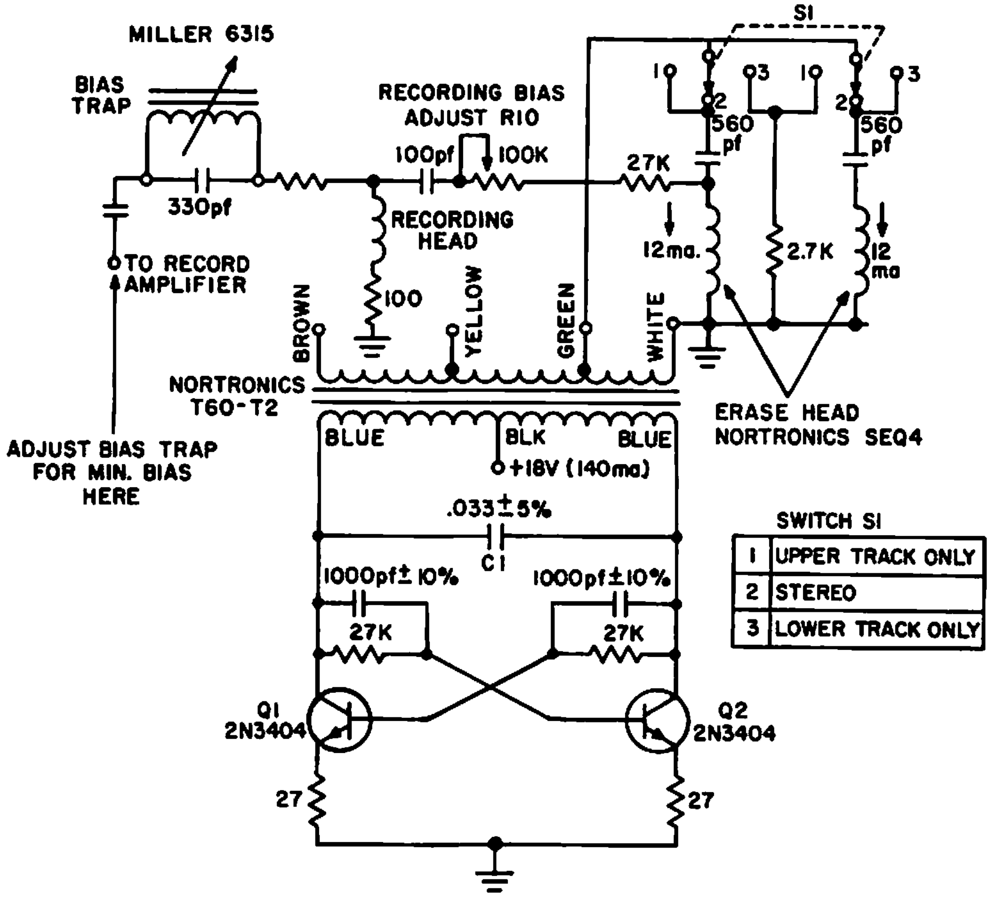
CHAPTER 48
Magnetic Tape Circuits

TAPE PREAMP—Output is flat within 1 dB from 20 to 20,000 Hz with NAB equalization. Gain is remotely controlled electro-optically; control circuit changes intensity of light source acting on photoresistor, altering effective feedback resistance. Technique provides completely noise-free control of gain. Uses Fairchild μA709 or National LM709 IC opamps.—S. L. Silver, IC Op Amps Boost Audio Circuit Performance, *Electronics World*, Sept. 1968, p 30–32.


TO CONTROL CIRCUIT
RAYTHEON CK 1104P
1
2
4
5
20k
100k
.03μF
1.6k
100k
1k
20μF
+14V
(−)
3
7
709
6
8
5
2
4
1
(+)
TAPE HEAD IN
2μF
100k
1.5k
200pF
.0047μF
−14V
20μF
10k
1k
20μF
+14V
(−)
3
7
709
6
8
5
2
4
1
(+)
2μF
100k
1.5k
200pF
.0047μF
−14V
100μF
600Ω
e₀

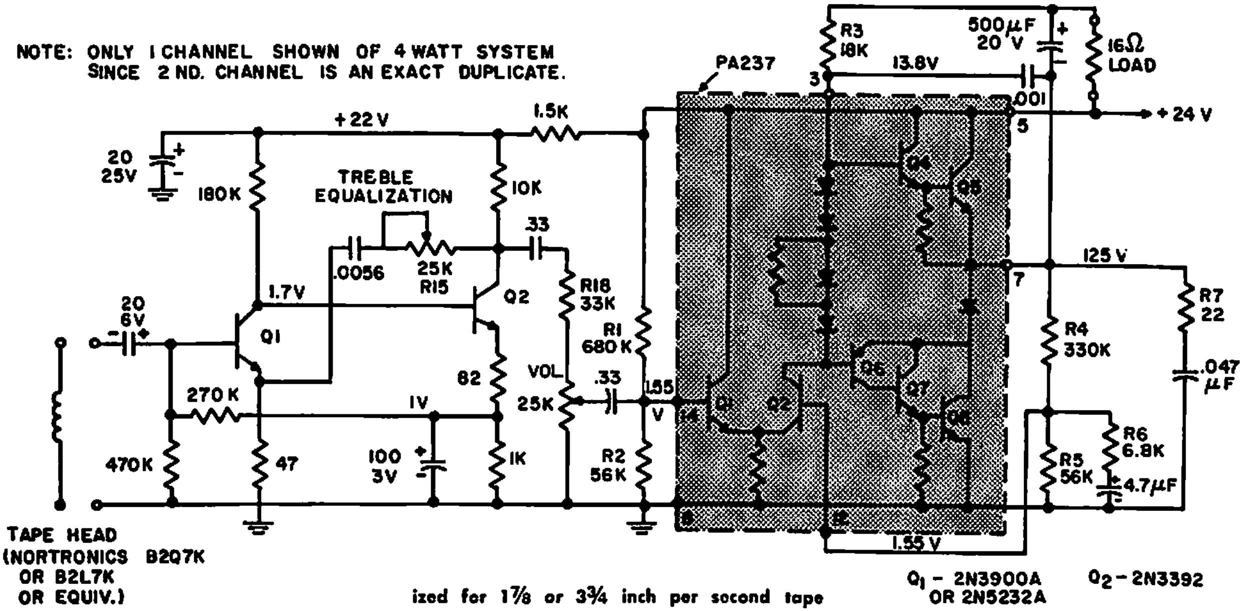

470
47
+6v
10k
3k
2k
500μf
180
1
Q₁ 2SD65
Q₂ 2SD65
10μf
820
Q₃ 2SB382
Q₄ 2SB383
T₁
T₂
INPUT
30μf
1k
600
4.3k
4.5k
200 μf
0.0068μf
Q₅ 2SB383
MONITOR
30
0.01μf
100μf
120
220
200μf
100μf
2k
30μf
12k
3k
15
0.0068μf
10k
Q₆ 2SB381
500μf
350
15k
0.0042 μf
150k
20k
D₁
BIAS
RECORD HEAD

AGC FOR RECORDING—Simple automatic gain control amplifier, used in Sonymatic TC-900 tape recorder, maintains proper recording level automatically within 10 dB, for input level changes up to 30 dB. Agc control transistor Q6 acts as variable shunt impedance at output of amplifier Q1, to adjust overall gain.—Recorder Gain Control Eliminates Level Indicator, *Electronics*, Nov. 14, 1966, p 165–166.

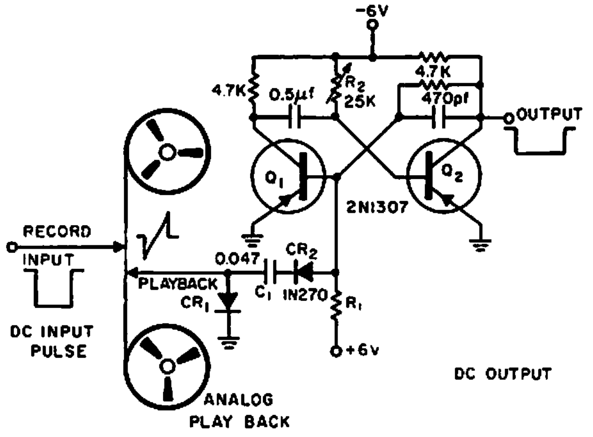

MILLER 6315
BIAS TRAP
330pf
TO RECORD AMPLIFIER
ADJUST BIAS TRAP FOR MIN. BIAS HERE
RECORDING BIAS ADJUST R10
100pf
100K
RECORDING HEAD
100
BROWN
YELLOW
GREEN
WHITE
27K
12ma.
2.7K
12 ma
S1
1
2
3
560 pf
NORTRONICS T60-T2
ERASE HEAD NORTRONICS SEQ4
BLUE
BLK
BLUE
+18V (140ma)
.033±5%
C1
1000pf± 10%
1000pf±10%
27K
27K
Q1 2N3404
Q2 2N3404
27
27

SWITCH S1	
1	UPPER TRACK ONLY
2	STEREO
3	LOWER TRACK ONLY

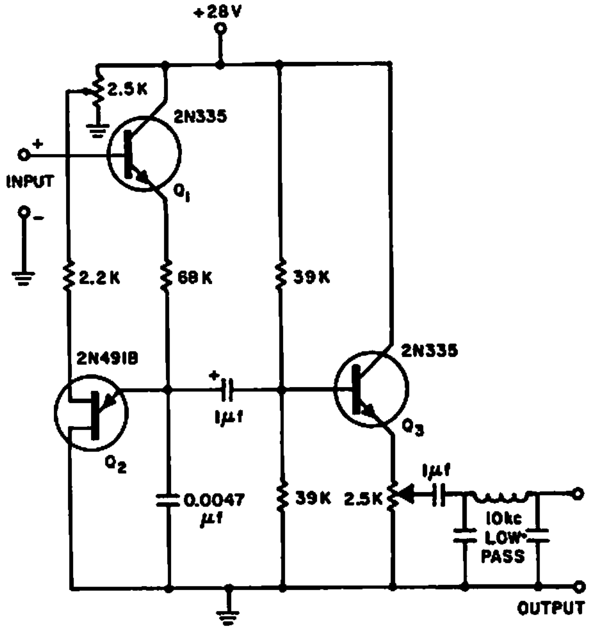
70-KHZ ERASE-BIAS OSCILLATOR—Uses low-cost silicon transistors requiring no heat sinks. Provides sufficient power (over 10 mA at 70 to 80 kHz) to give minimum of 60 dB erasure with stereo erase head. Total power output is 1.5 W, with 60% efficiency. Circuit is cross-coupled mvbr with tuned load.—D. V. Jones, Tape Erase and Bias Oscillator, General Electric, Syracuse, N.Y., No. 90.14, 1965.


NOTE: ONLY 1 CHANNEL SHOWN OF 4 WATT SYSTEM SINCE 2 ND. CHANNEL IS AN EXACT DUPLICATE.
PA237
R3 18K
500µF 20 V
16Ω LOAD
13.8V
.001
+24 V
+22 V
1.5K
20 25V
180K
TREBLE EQUALIZATION
10K
.33
.0056
25K R15
R18 33K
R1 680 K
1.7V
Q1
Q2
20 6V
270 K
82
VOL 25K
.33
1.55 V
1V
470K
47
100 3V
1K
R2 56K
Q1
Q2
Q4
Q5
Q6
Q7
Q8
125 V
R7 22
R4 330K
.047 µF
R6 6.8K
R5 56K
4.7µF
1.55 V
3
5
7
TAPE HEAD (NORTRONICS B2Q7K OR B2L7K OR EQUIV.)
Q1 - 2N3900A OR 2N5232A
Q2 - 2N3392

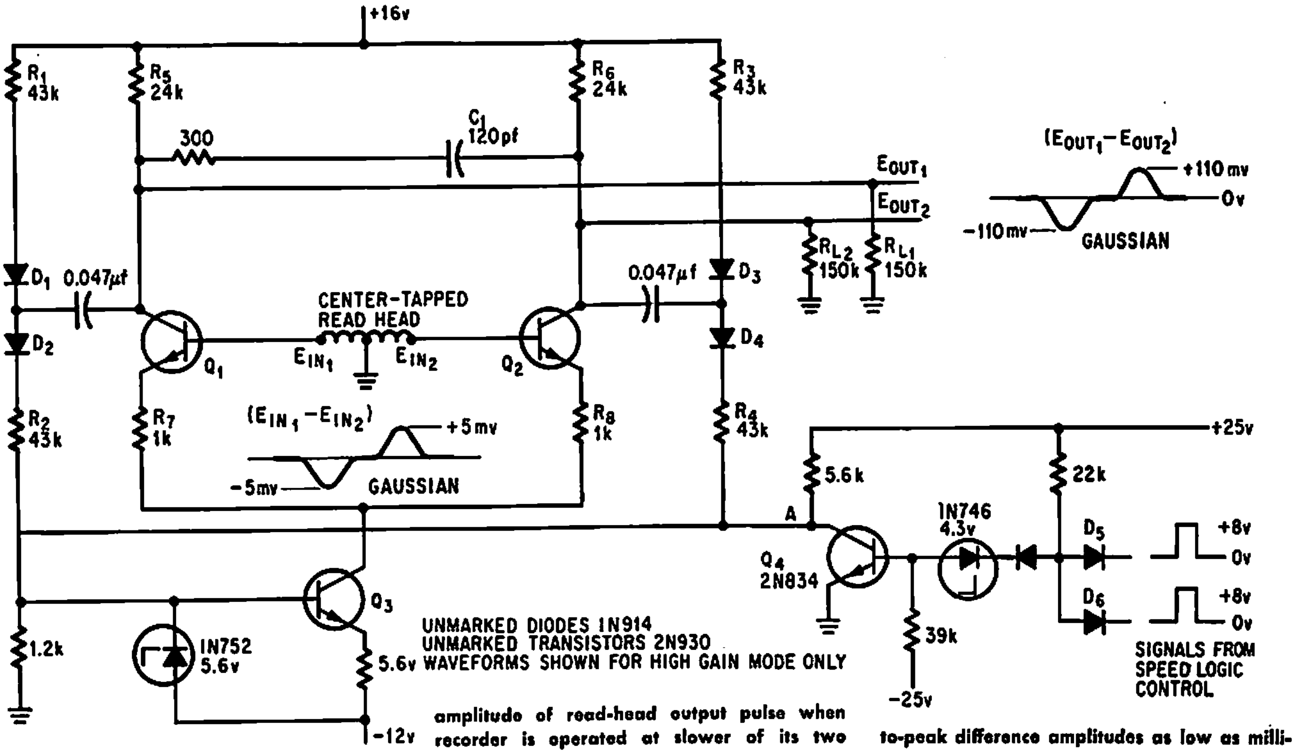
4-W IC STEREO TAPE CARTRIDGE SYSTEM—Uses GE PA-237 integrated circuit to drive 16-ohm load, with two-transistor preamp between tape head and IC. Preamp is equalized for 1⅞ or 3¾ inch per second tape speed. Treble equalization control is used to compensate for program material, tape head, speaker, or servo as ordinary tone control. Output is adequate for 8-track system.—Dwight V. Jones, Monolithic 2 Watt Integrated Amplifier—Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.73, 1968, p 13.


-6V
4.7K
0.5μf
R2
25K
4.7K
470pf
OUTPUT
Q1
Q2
2N1307
RECORD
INPUT
DC INPUT
PULSE
0.047
CR2
PLAYBACK
CR1
C1
IN270
R1
+6V
ANALOG
PLAY BACK
DC OUTPUT

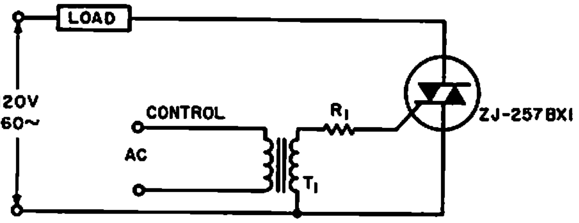
REGENERATING PULSES ON PLAYBACK—Simple one-shot mvbr regenerates d-c pulses recorded on analog tape. Pulse width, pulse amplitude, and time relationships of recorded waveform are thus preserved at output of channel. External voltage divider can be used to set output amplitude.—B. C. Tupper, Regenerator Restores Pulses Recorded on Analog Tape, *Electronic Design*, Nov. 23, 1964, p 61.


+28V
2.5K
2N335
Q1
INPUT
+
-
2.2K
68K
39K
2N4918
Q2
1μf
2N335
Q3
0.0047 μf
39K
2.5K
1μf
10kc
LOW-PASS
OUTPUT

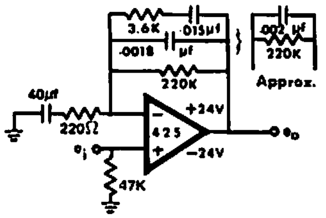
LINEAR LOW-FREQUENCY MODULATOR—Uses ujt to generate sawtooth whose period is controlled by input to give f-m signal for recording on magnetic tape. Low-pass filter at output attenuates sawtooth harmonics above audio frequencies to prevent them from heterodyning with bias oscillator of recorder. Original d-c signal can be restored by playing back into limiter, discriminator, and d-c amplifier.—J. H. Hammond, Inexpensive FM Modulator Has Good Linearity, *Electronic Design*, Nov. 9, 1964, p 72–75.


+16v
R1 43k
R5 24k
R6 24k
R3 43k
300
C1 120pf
EOUT1
EOUT2
(EOUT1−EOUT2)
+110mv
0v
−110mv
GAUSSIAN
RL2 150k
RL1 150k
D1
0.047μf
D2
CENTER-TAPPED READ HEAD
EIN1
EIN2
Q1
Q2
0.047μf
D3
D4
R2 43k
R7 1k
(EIN1−EIN2)
+5mv
−5mv
GAUSSIAN
R8 1k
R4 43k
+25v
5.6k
22k
A
1N746 4.3v
D5
+8v
0v
D6
+8v
0v
Q4 2N834
Q3
1.2k
IN752 5.6v
5.6v
39k
−25v
−12v
SIGNALS FROM SPEED LOGIC CONTROL
UNMARKED DIODES 1N914
UNMARKED TRANSISTORS 2N930
WAVEFORMS SHOWN FOR HIGH GAIN MODE ONLY

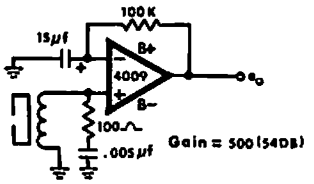
DIGITAL CONTROL—Two predetermined gain levels in preamplifier for digital magnetic tape transport are selected by digital command. Higher gain mode compensates for reduced amplitude of read-head output pulse when recorder is operated at slower of its two speeds. Speed-changing commands are derived automatically from speed control logic of recorder. Differential amplifier Q1-Q2 allows preamp to handle signals with peak-to-peak difference amplitudes as low as millivolts while rejecting common-mode noise.—I. W. Salmon, Digital Commands Control Differential Amplifier Gain, *Electronics*, July 24, 1967, p 85–86.


LOAD
120V
60~
CONTROL
AC
R1
T1
ZJ-257BX1

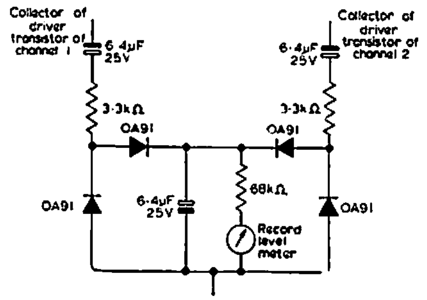
ELECTRICALLY ACTUATED SCR—Control signal for bilateral scr can be either properly phased 60-Hz or any signal above 600 Hz. If T1 is tuned, tones from tape recorder can be used to activate selectively two or more of these switches.—E. K. Howell, Bilateral SCR Lets Designers Economize on Circuitry, *Electronic Design*, Jan. 20, 1964, p 74–77.


3.6K
.015μf
.0018 μf
220K
.002 μf
220K
Approx.
40μf
220Ω
425
+24V
−24V
e_i
e_o
47K

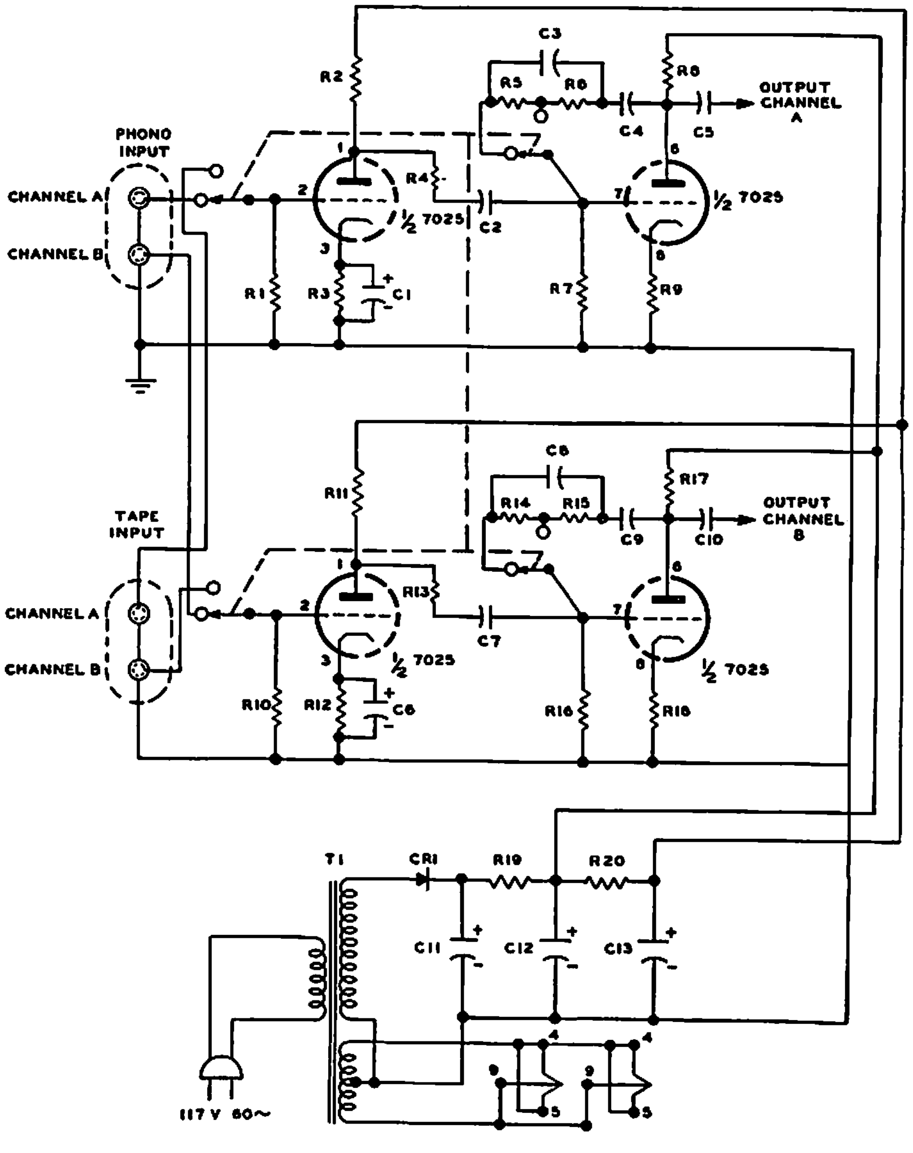
NAB EQUALIZATION—Uses Model 425 IC opamp in network giving standard equalization for magnetic tape. Simpler network at right will serve for less critical applications. —B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.


100K
15μf
B+
4009
B−
100Ω
.005μf
e_o
Gain = 500 (54DB)

TAPE HEAD PREAMP—R-C network across winding of tape head suppresses oscillation in Model 4009 d-c opamp. Gain is 500 (54 dB).—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.


Collector of driver transistor of channel 1
6.4μF 25V
Collector of driver transistor of channel 2
6·4μF 25V
3·3kΩ
3·3kΩ
OA91
OA91
OA91
OA91
6·4μF 25V
68kΩ
Record level meter

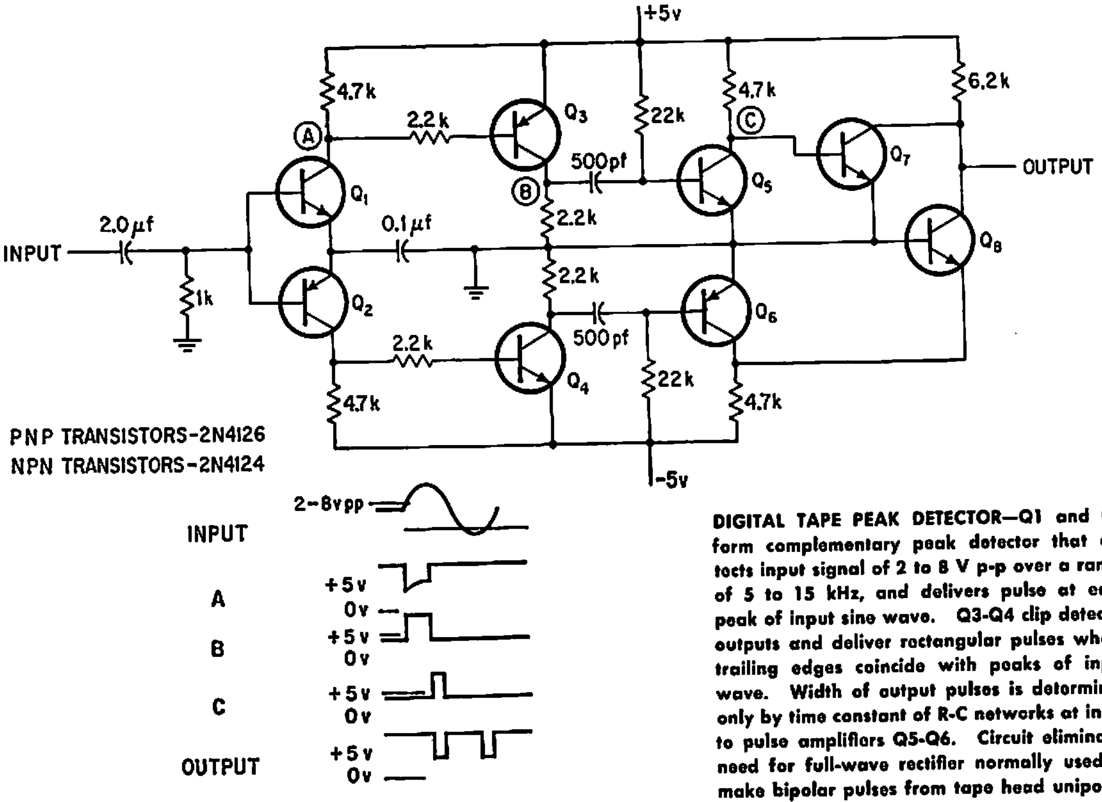
STEREO RECORDING LEVEL INDICATOR—Meter reading is proportional to peak-peak voltage at collector of driver transistor in channel having highest recording level. At input of 4 V rms, corresponding to point where distortion due to tape saturation becomes significant in typical recorder, direct current through meter is 95 μA.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 79.


PHONO INPUT
CHANNEL A
CHANNEL B
TAPE INPUT
CHANNEL A
CHANNEL B
R1
R2
R3
R4
C1
C2
½ 7025
C3
R5
R6
R7
R8
R9
C4
C5
½ 7025
OUTPUT CHANNEL A
R10
R11
R12
R13
C6
C7
½ 7025
C8
R14
R15
R16
R17
R18
C9
C10
½ 7025
OUTPUT CHANNEL B
T1
CR1
R19
R20
C11
C12
C13
117 V 60~
1
2
3
6
7
8
4
5
9

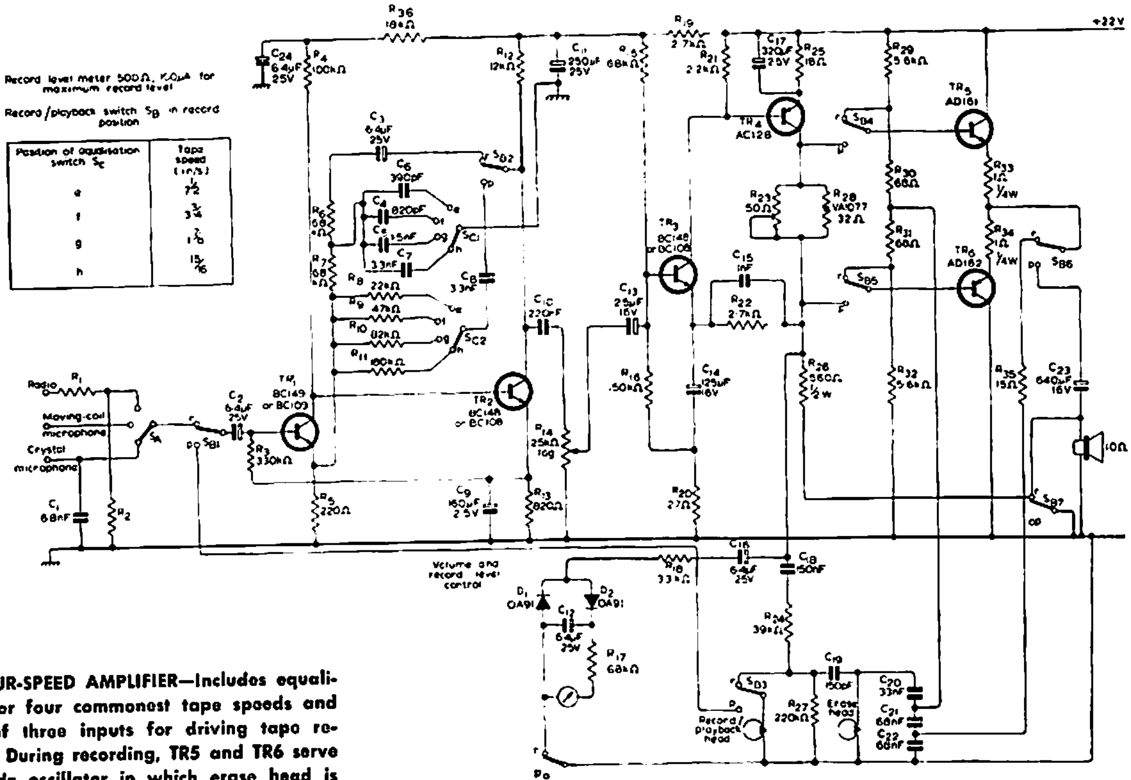
C_1 C_6—30 μf 25V
C_2 C_7—0.1 μf 400V
C_3 C_8—330 μμf
C_4 C_9—0.001 μf
C_5 C_{10}—0.047 μf 400V
C_{11}—50 μf 150V
C_{12} C_{13}—20 μf 150V
CR_1—Selenium Rectifier 15 Ma DC
R_1 R_{10}—47 K
R_2 R_{11}—270 K

R_3 R_{12}—5.1 K
R_4 R_{13}—51 K
R_5 R_{14}—160 K
R_6 R_{15}—75 K
R_7 R_{16}—1 Meg
R_8 R_{17}—100 K
R_9 R_{18}—1 K
R_{19}—10 K
R_{20}—22 K
T_1—Power Transformer: Sec—125V. 15Ma; 6.3V. 0.6A

PHONO-TAPE PREAMP—Developed for stereo magnetic phono cartridges and stereo tape heads. Ganged switch provides R1AA equalization at phono setting and NARTB equalization for tape setting.—"Essential Characteristics", General Electric, Owensboro, Ky., 13th Edition, 1969, p 363.


+5v
4.7k
2.2k
Q3
22k
4.7k
Ⓒ
6.2k
Ⓐ
Q7
OUTPUT
Q1
500pf
Q5
Ⓑ
2.0μf
INPUT
0.1μf
2.2k
Q8
1k
Q2
2.2k
Q6
2.2k
500pf
Q4
22k
4.7k
4.7k
PNP TRANSISTORS-2N4126
NPN TRANSISTORS-2N4124
-5v
2-8vpp
INPUT
A
+5v
0v
B
+5v
0v
C
+5v
0v
OUTPUT
+5v
0v

DIGITAL TAPE PEAK DETECTOR—Q1 and Q2 form complementary peak detector that detects input signal of 2 to 8 V p-p over a range of 5 to 15 kHz, and delivers pulse at each peak of input sine wave. Q3-Q4 clip detector outputs and deliver rectangular pulses whose trailing edges coincide with peaks of input wave. Width of output pulses is determined only by time constant of R-C networks at input to pulse amplifiers Q5-Q6. Circuit eliminates need for full-wave rectifier normally used to make bipolar pulses from tape head unipolar.—C. A. Herbst, Peak Detector Senses Bipolar Inputs, *Electronics*, July 21, 1969, p 81.


Record level meter 500Ω, 100μA for maximum record level

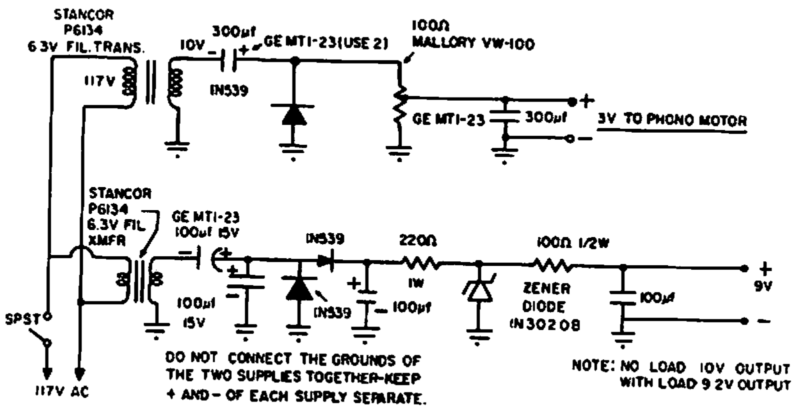
Record/playback switch S_B in record position

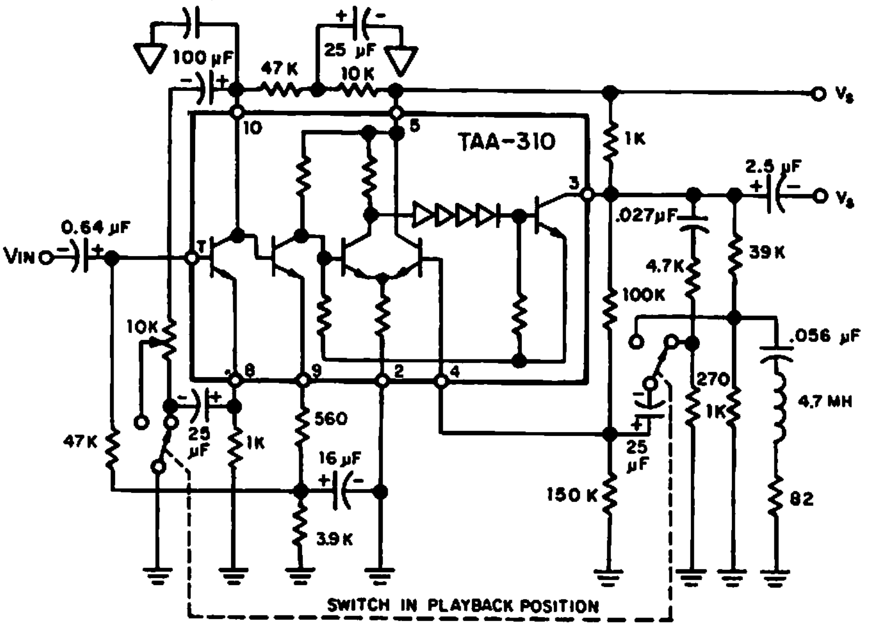
Position of equalisation switch S_C	Tape speed (in/s)
e	7½
f	3¾
g	1⅞
h	15/16

R36
18kΩ
R19
2.7kΩ
+22V
C24
64μF
25V
R4
100kΩ
R12
12kΩ
C11
250μF
25V
R15
68kΩ
R21
2.2kΩ
C17
320μF
25V
R25
18Ω
R29
5.6kΩ
TR5
AD161
C3
64μF
25V
C6
390pF
S02
TR4
AC128
S04
C4
820pF
R23
50Ω
R28
VA1077
32Ω
R30
68Ω
R33
1Ω
½W
C5
15nF
SC1
C7
3.3nF
R6
68kΩ
R7
68kΩ
TR3
BC148
or BC108
R31
68Ω
TR6
AD162
R34
1Ω
½W
SB6
C8
3.3nF
R8
22kΩ
C15
1nF
S05
R9
47kΩ
C10
220nF
C13
25μF
16V
R22
2.7kΩ
R10
82kΩ
SC2
R11
100kΩ
Radio
R1
TR1
BC149
or BC109
TR2
BC148
or BC108
R16
150kΩ
C14
125μF
6V
R26
560Ω
½W
R32
5.6kΩ
R35
15Ω
C23
640μF
16V
Moving-coil microphone
C2
64μF
25V
SA
SB1
R3
330kΩ
R14
25kΩ
log
10Ω
Crystal microphone
R5
220Ω
C9
160μF
2.5V
R13
820Ω
R20
27Ω
SB7
C1
68nF
R2
C16
64μF
25V
R18
33kΩ
C18
50nF
Volume and record level control
D1
OA91
D2
OA91
C12
64μF
25V
R24
39kΩ
R17
68kΩ
C19
150pF
SB3
C20
33nF
R27
220kΩ
Erase head
C21
68nF
C22
68nF
Record/playback head

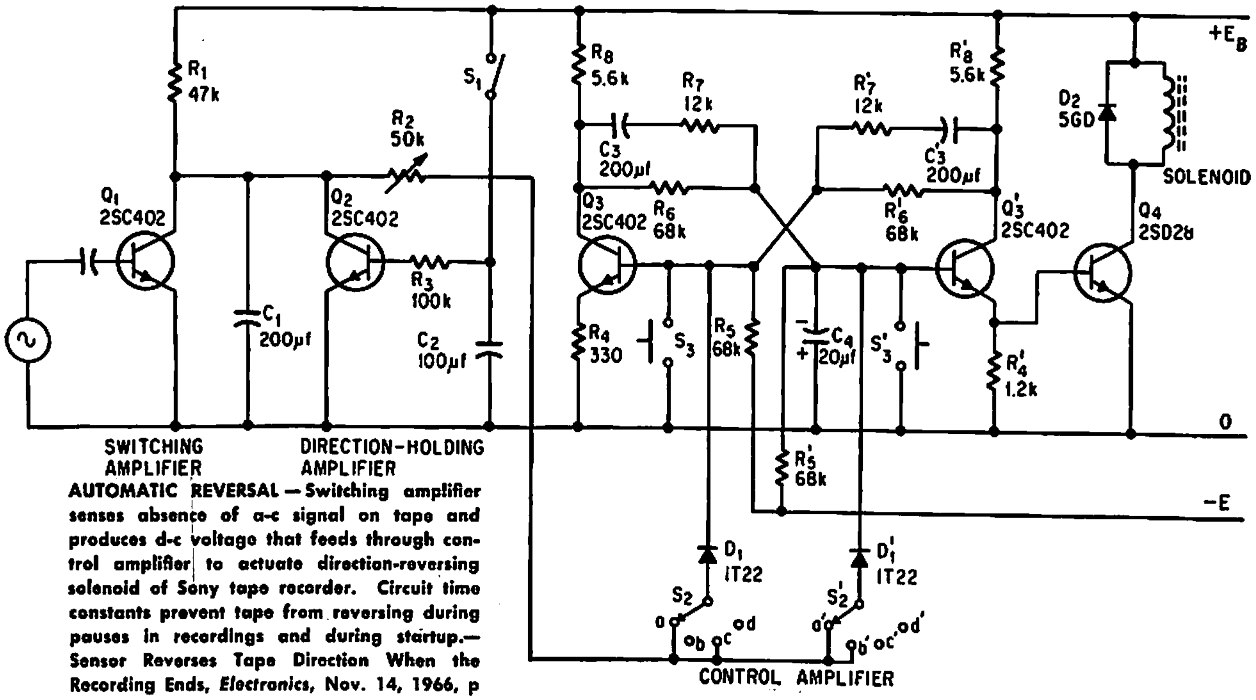
4-W FOUR-SPEED AMPLIFIER—Includes equalization for four commonest tape speeds and choice of three inputs for driving tape recorder. During recording, TR5 and TR6 serve as 50-kHz oscillator in which erase head is used as oscillator coil. Frequency response is flat within 3 dB from 55 to 20,000 Hz for 7.5-inch-per-s speed but cuts off at 12,000 and 6,000 Hz respectively for next two lower speeds.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 70.

TAPE RECORDER MOTOR SUPPLY—Used for quick checking of batteries in portable tape recorders and phonographs. Two outputs, for 3 and 9 V, handle practically all types of motors used in these applications. 3-V supply is variable, for checking motors at specified operating voltages.—L. Chioma, Tape Recorder Repair, *G-E Techni-Talk*, Fall 1967, p 1.

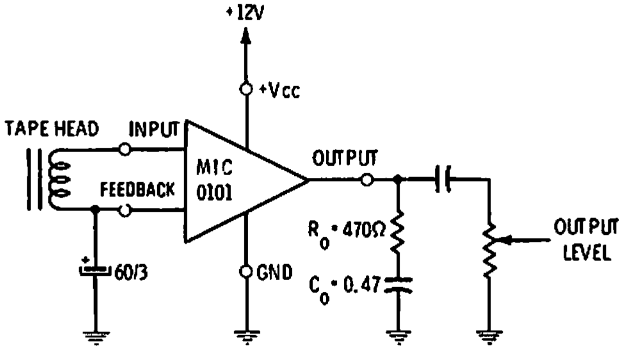

STANCOR P6134 6.3V FIL. TRANS.
117V
10V
300µf
GE MTI-23(USE 2)
1N539
100Ω MALLORY VW-100
GE MTI-23
300µf
3V TO PHONO MOTOR
STANCOR P6134 6.3V FIL XMFR
GE MTI-23 100µf 15V
100µf 15V
1N539
1N539
220Ω 1W
100µf
100Ω 1/2W
ZENER DIODE 1N3020B
100µf
9V
SPST
117V AC
DO NOT CONNECT THE GROUNDS OF THE TWO SUPPLIES TOGETHER-KEEP + AND - OF EACH SUPPLY SEPARATE.
NOTE: NO LOAD 10V OUTPUT WITH LOAD 9.2V OUTPUT


.001µF
100µF
47K
25µF
10K
Vs
10
5
TAA-310
1K
3
2.5µF
Vs
0.64µF
VIN
.027µF
4.7K
39K
100K
10K
.056µF
8
9
2
4
270
1K
4.7 MH
47K
25 µF
1K
560
16µF
25 µF
150 K
82
3.9K
SWITCH IN PLAYBACK POSITION

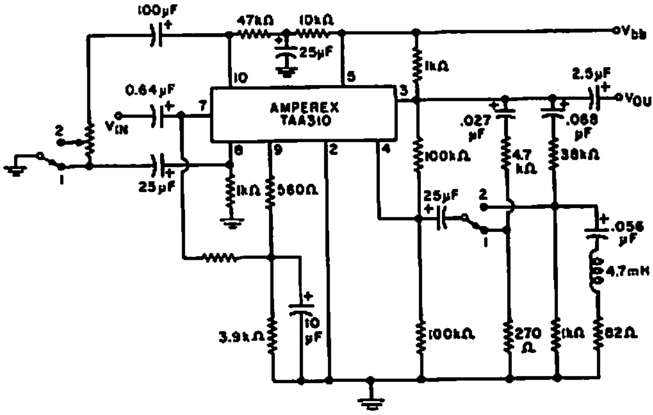
RECORD-PLAYBACK PREAMP—Uses TAA310 low-level linear IC amplifier having high input impedance, 90-dB voltage gain, and noise less than 4 dB. External components include frequency compensation networks and volume control. Designed to feed 1,000-ohm impedance. Report gives characteristic curves.—The Amperex TAA310 in Tape Recorder Preamplifiers, Amperex, Slatersville, R.I., S-132, 1967.


+EB
R1 47k
S1
R2 50k
R8 5.6k
R7 12k
R'7 12k
R'8 5.6k
D2 5GD
SOLENOID
Q1 2SC402
C1 200µf
Q2 2SC402
R3 100k
C2 100µf
C3 200µf
Q3 2SC402
R6 68k
C'3 200µf
R'6 68k
Q'3 2SC402
Q4 2SD28
R4 330
S3
R5 68k
C4 20µf
S'3
R'4 1.2k
0
R'5 68k
-E
D1 1T22
D'1 1T22
S2
S'2
a b c d
a' b' c' d'
SWITCHING AMPLIFIER
DIRECTION-HOLDING AMPLIFIER
CONTROL AMPLIFIER

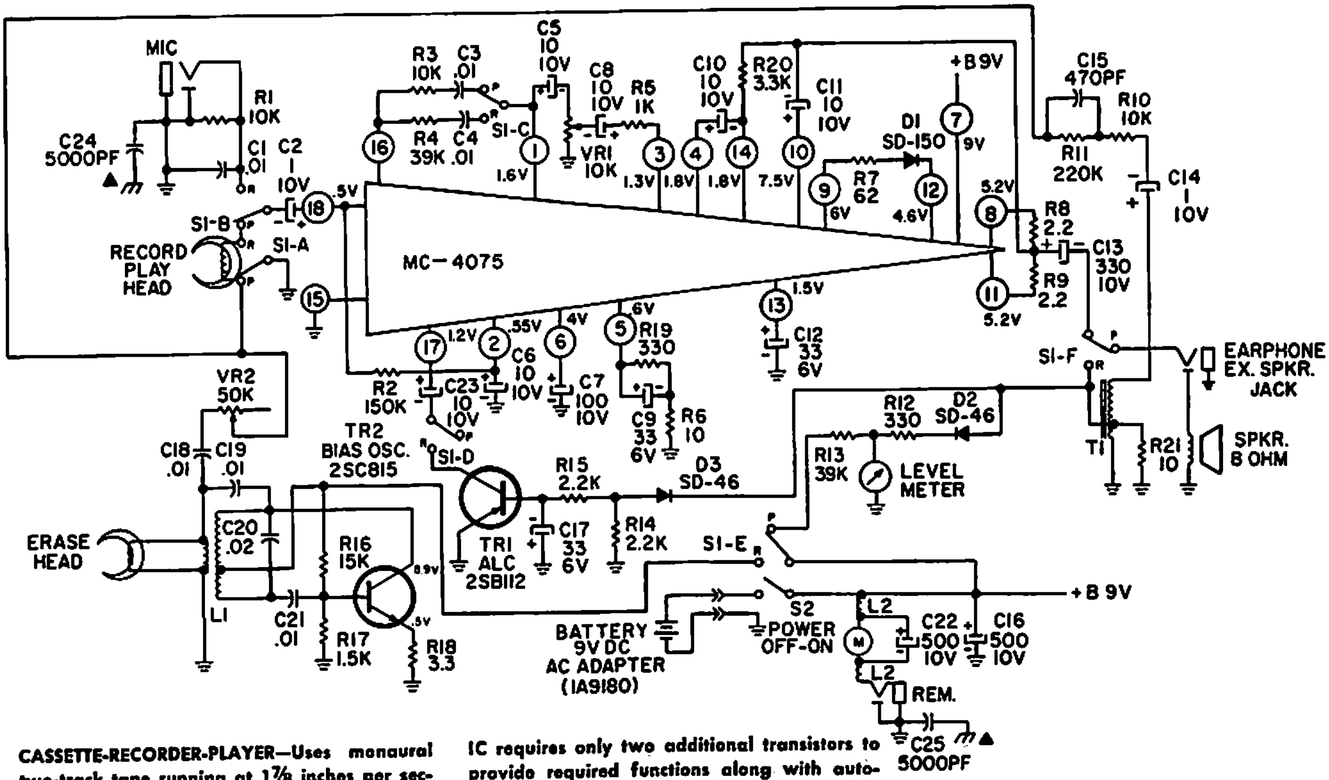
AUTOMATIC REVERSAL—Switching amplifier senses absence of a-c signal on tape and produces d-c voltage that feeds through control amplifier to actuate direction-reversing solenoid of Sony tape recorder. Circuit time constants prevent tape from reversing during pauses in recordings and during startup.—Sensor Reverses Tape Direction When the Recording Ends, *Electronics*, Nov. 14, 1966, p 163–165.


+12V
+Vcc
TAPE HEAD
INPUT
FEEDBACK
MIC 0101
OUTPUT
60/3
GND
R_0 = 470Ω
C_0 = 0.47
OUTPUT LEVEL

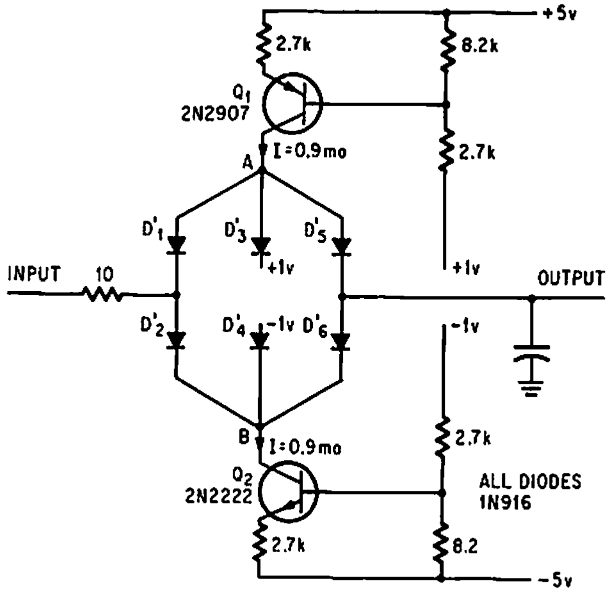
COMPENSATED PLAYBACK PREAMP—Uses Mallory MIC0101 IC audio preamp with R-C compensation network connected to output to compensate for increase in input signal with increasing recorded frequency. Gives essentially flat over-all response. Values of R and C should be selected to give flat response when NAB standard tape is played through head whose playback characteristics are known.—M. L. Deschler, Integrated Circuit Preamplifiers, Mallory, Indianapolis, Ind., APPN-2, 1968.


100μF
47kΩ
10kΩ
25μF
Vbb
1kΩ
2.5μF
VOUT
0.64μF
VIN
10
5
3
7
AMPEREX TAA310
.027 μF
.068 μF
2
1
8
9
2
4
100kΩ
4.7 kΩ
38kΩ
25μF
1kΩ
560Ω
25μF
2
1
.056 μF
4.7mH
10 μF
3.9kΩ
100kΩ
270 Ω
1kΩ
82Ω

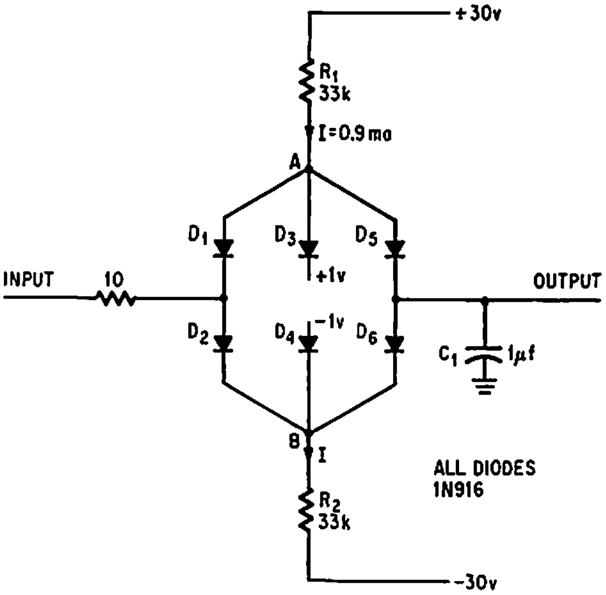
TAPE PREAMP—Uses audio integrated circuit with 7-V single-ended supply to provide 4-dB noise figure, 90-dB voltage gain, and uncompensated frequency limit of 15 kHz. Ideal for tape record-playback preamp. Values of unlabeled resistors should be chosen for optimum results.—D. E. Lancaster, Audio Integrated Circuits—What's Available?, *Electronics World*, Oct. 1967, p 34–36.


MIC
R1 10K
C24 5000PF
C1 .01
C2 1 10V
S1-B
RECORD PLAY HEAD
S1-A
R3 10K
C3 .01
R4 39K
C4 .01
S1-C
C5 10 10V
C8 10 10V
R5 1K
VR1 10K
C10 10 10V
R20 3.3K
C11 10 10V
D1 SD-150
R7 62
+B9V
C15 470PF
R10 10K
R11 220K
C14 1 10V
R8 2.2
C13 330 10V
R9 2.2
MC-4075
16
18
15
17
2
6
5
13
1
3
4
14
10
9
12
7
8
11
.5V
1.6V
1.3V
1.8V
1.8V
7.5V
6V
4.6V
9V
5.2V
5.2V
1.5V
1.2V
.55V
4V
.6V
R19 330
C12 33 6V
R2 150K
C23 10 10V
C6 10 10V
C7 100 10V
C9 33 6V
R6 10
S1-F
EARPHONE EX. SPKR. JACK
VR2 50K
C18 .01
C19 .01
TR2 BIAS OSC. 2SC815
S1-D
R15 2.2K
D3 SD-46
R12 330
D2 SD-46
R13 39K
LEVEL METER
T1
R21 10
SPKR. 8 OHM
ERASE HEAD
C20 .02
R16 15K
TR1 ALC 2SB112
C17 33 6V
R14 2.2K
S1-E
L1
C21 .01
R17 1.5K
R18 3.3
8.9V
.5V
BATTERY 9VDC
AC ADAPTER (1A9180)
S2 POWER OFF-ON
L2
M
C22 500 10V
C16 500 10V
+B 9V
REM.
C25 5000PF

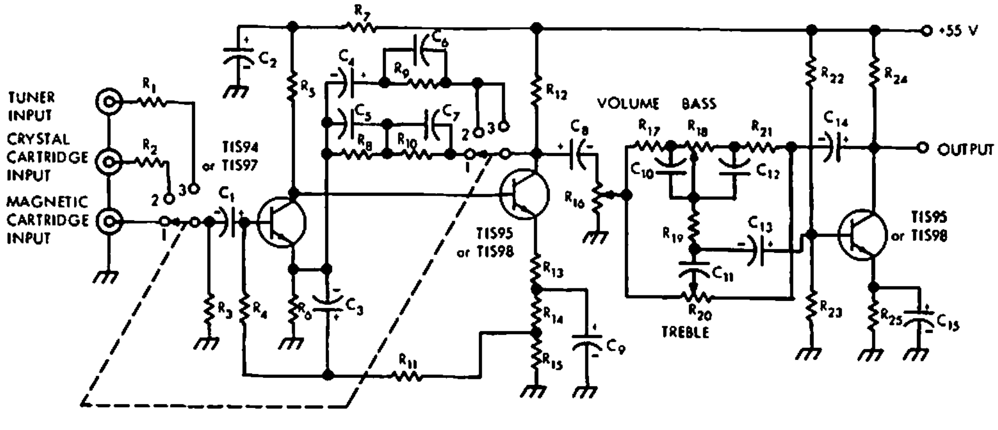
CASSETTE-RECORDER-PLAYER—Uses monaural two-track tape running at 1⅞ inches per second, and operating from either 9-V battery or equivalent a-c adapter. Special Magnavox IC requires only two additional transistors to provide required functions along with automatic level control and accidental-erasure prevention for prerecorded cassettes.—1V9019 Cassette Tape Recorder, Magnavox Service Manual 6293, Fort Wayne, Ind., 1969.


+5v
2.7k
8.2k
Q1
2N2907
I=0.9ma
A
2.7k
D'1
D'3
D'5
+1v
+1v
INPUT
10
OUTPUT
D'2
D'4
-1v
D'6
-1v
B
I=0.9ma
2.7k
Q2
2N2222
ALL DIODES
1N916
2.7k
8.2
-5v

LOW-HEAT F-M RATE LIMITER—Constant-current transistors Q1 and Q2 replace resistors in diode-bridge rate limiter for instrumentation tape recording, to reduce undesirable heat dissipation. Use of complementary transistors gives constant-current operation.—D. F. Franklin, Diodes Prevent Overload by Limiting Input's Slope, *Electronics*, Jan. 22, 1968, p 69–70.


+30v
R1
33k
I=0.9ma
A
D1
D3
D5
+1v
INPUT
10
OUTPUT
D2
D4
-1v
D6
C1
1μf
B
I
ALL DIODES
1N916
R2
33k
-30v

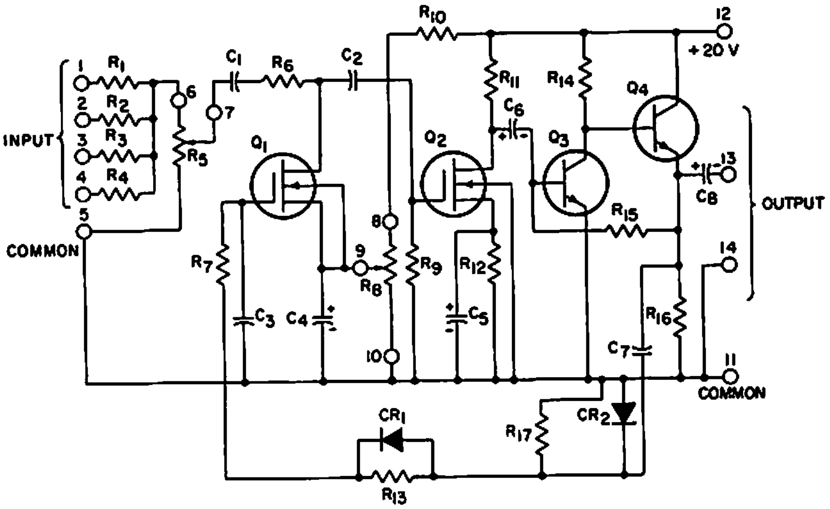
F-M RATE LIMITER—Prevents overloading caused by excessive rate of change and amplitude when recording random signals on magnetic tape for instrumentation, using wideband f-m. Slope of output signal is limited to rate of charge or discharge of C1 through D6. Has no effect on bandwidth. —D. F. Franklin, Diodes Prevent Overload by Limiting Input's Slope, *Electronics*, Jan. 22, 1968, p 69–70.


+55 V
TUNER INPUT
CRYSTAL CARTRIDGE INPUT
MAGNETIC CARTRIDGE INPUT
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
TIS94 or TIS97
TIS95 or TIS98
TIS95 or TIS98
VOLUME
BASS
TREBLE
OUTPUT
1
2
3

R_1: 1 MΩ
R_2: 2.7 MΩ
R_3: 47 kΩ
R_4: 100 kΩ
R_5: 150 kΩ
R_6: 330 Ω
R_7: 15 kΩ
R_8: 1.2 MΩ
R_9: 75 kΩ
R_{10}: 56 kΩ
R_{11}: 100 kΩ
R_{12}: 33 kΩ
R_{13}: 270 Ω
R_{14}: 2.2 kΩ
R_{15}: 1 kΩ
R_{16}: 0–100 kΩ
R_{17}: 82 kΩ
R_{18}: 0–1 MΩ
R_{19}: 47 kΩ
R_{20}: 0–500 kΩ
R_{21}: 82 kΩ
R_{22}: 470 kΩ
R_{23}: 56 kΩ
R_{24}: 39 kΩ
R_{25}: 4.7 kΩ
C_1: 10 μF, 3 V, electrolytic
C_2: 2 μF, 50 V, electrolytic
C_3: 50 μF, 3 V, electrolytic
C_4: 20 μF, 25 V, electrolytic
C_5: 0.0033 μF
C_6: 47 pF
C_7: 1200 pF
C_8: 1 μF, 50 V, electrolytic
C_9 : 50 μF, 6 V, electrolytic
C_{10}: 0.003 μF
C_{11}: 470 pF
C_{12}: 0.003 μF
C_{13}: 5 μF, 6 V, electrolytic
C_{14}: 1 μF, 25 V, electrolytic
C_{15}: 20 μF, 6 V, electrolytic

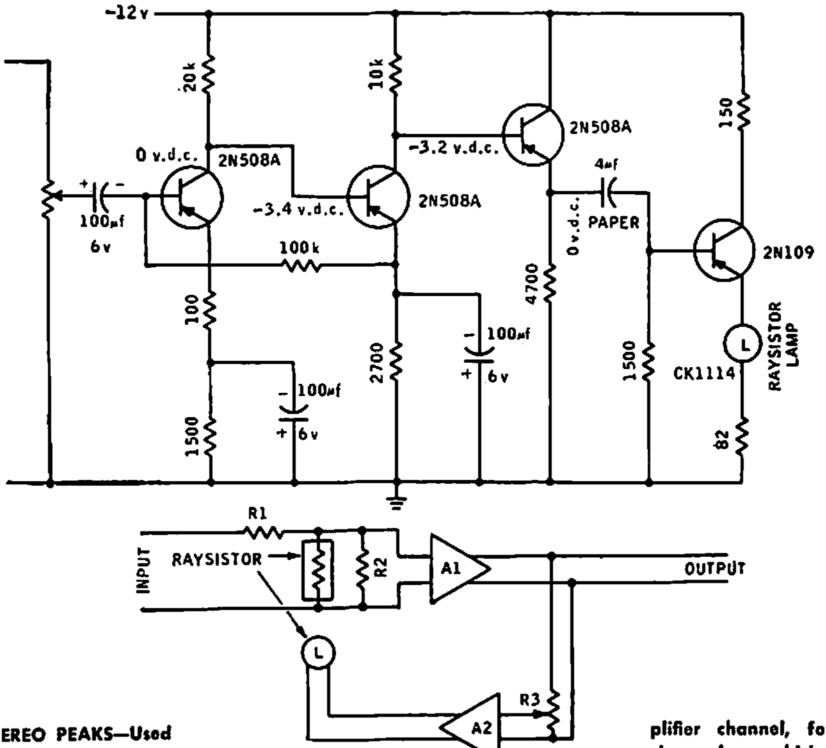
RIAA-COMPENSATED PREAMP—Compensation, for magnetic input only, is within 1 dB of ideal curve from 20 to 20,000 Hz. Circuit uses npn epitaxial planar silicon transistors. Output is 1 V for 4-mV magnetic cartridge input, 220-mV crystal cartridge input, and 100-mV tuner input. Response is within 1 dB from 20 to 20,000 Hz, and total harmonic distortion below 0.14% for any input.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, CC101, 1968, p 1054.

$C_1C_2C_3C_7$ = 0.1 microfarad, paper
C_4 = 10 microfarads, 12 volts, electrolytic
C_5 = 15 microfarads, 6 volts, electrolytic
C_6 = 5 microfarads, 25 volts, electrolytic
C_8 = 50 microfarads, 25 volts, electrolytic
CR_1 CR_2 = silicon rectifier, type 1N270
Q_1 Q_2 = MOS field-effect transistor, type 3N128
Q_3Q_4 = transistor, RCA SK3020
R_1 R_2 R_3 R_4 R_7 = 100,000 ohms, 1/2 watt, 10%
R_5 = potentiometer, 10,000 ohms, audio taper
R_6 = 180,000 ohms, 1/2 watt, 10%
R_8 = potentiometer, 5000 ohms, straight taper
R_9 R_{13} = 1 megohm, 1/2 watt, 10%
R_{10} = 15,000 ohms, 1/2 watt, 10%
R_{11} = 10,000 ohms, 1/2 watt, 10%
R_{12} = 1500 ohms, 1/2 watt, 10%

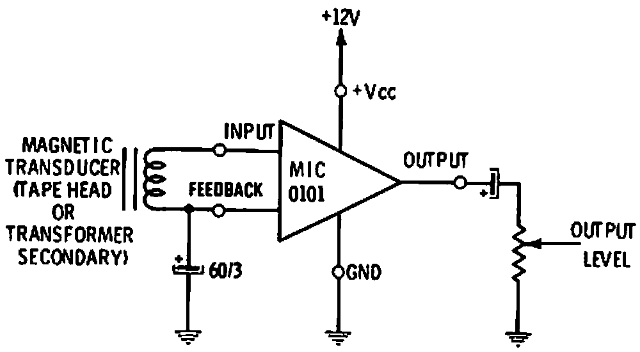

R10
12
+20 V
1
R1
2
R2
3
R3
4
R4
5
INPUT
COMMON
C1
R6
C2
6
7
R5
Q1
R7
C3
C4
9
R8
8
10
R9
R11
C6
Q2
R12
C5
R14
Q3
Q4
R15
13
C8
OUTPUT
14
R16
C7
11
COMMON
CR1
R13
R17
CR2

LINE AMPLIFIER WITH MIXER—Used to produce uniform audio levels required for high-quality tape recordings. Circuit also includes volume compression to prevent overload by loud passages of speech or music.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 72.

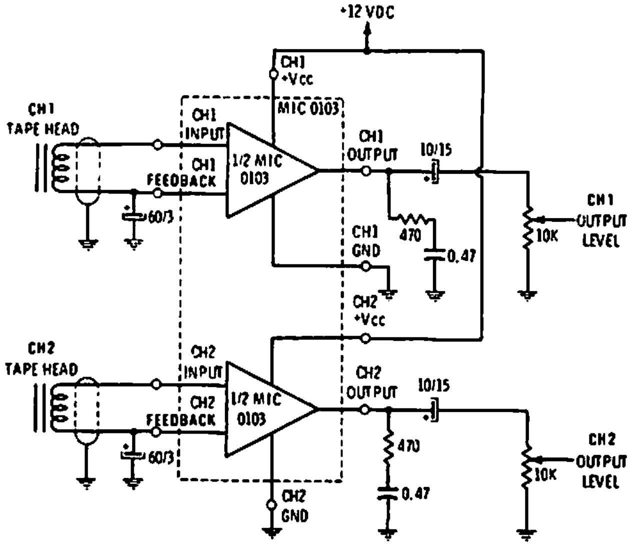
R_{14} = 1200 ohms, 1/2 watt, 10%
R_{15} = 100,000 ohms, 1/2 watt, 10%
R_{16} = 470 ohms, 1/2 watt, 10%
R_{17} = 2 megohms, 1/2 watt, 10%


-12v
20k
10k
0 v.d.c.
2N508A
-3.2 v.d.c.
2N508A
-3.4 v.d.c.
2N508A
4μf
PAPER
0 v.d.c.
2N109
100μf
6v
100k
100
1500
100μf
6v
2700
100μf
6v
4700
1500
150
L
CK1114
RAYSISTOR LAMP
82
R1
INPUT
RAYSISTOR
R2
A1
OUTPUT
L
R3
A2

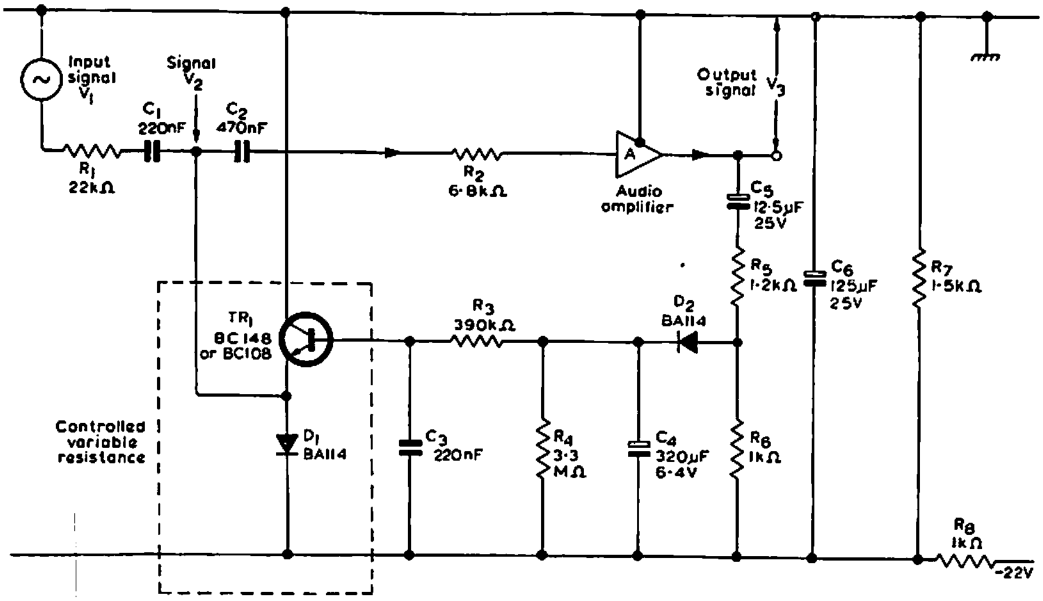
CLIPPING MOMENTARY STEREO PEAKS—Used in recording amateur performances on stereo magnetic tape, where dB output cannot always be accurately predicted in time for manual reduction of gain. Intended to catch only momentary peaks, rather than servo for automatic gain-riding. Requires separate limiter for each channel, but resulting wandering of stereo images is not as serious as momentary overloads that are prevented. Block diagram illustrates how input is taken from any convenient point following limiter in amplifier channel, for feeding side amplifier shown here which drives lamp in Raytheon Raysistor unit. Photocell of Raysistor varies shunt resistance across input of channel amplifier (A1) to give desired limiting.—J. Young and W. B. Denny, Solid State Limiter for Tape Recording, *Audio*, Sept. 1965.


+12V
+Vcc
MAGNETIC TRANSDUCER (TAPE HEAD OR TRANSFORMER SECONDARY)
INPUT
FEEDBACK
MIC 0101
OUTPUT
OUTPUT LEVEL
60/3
GND

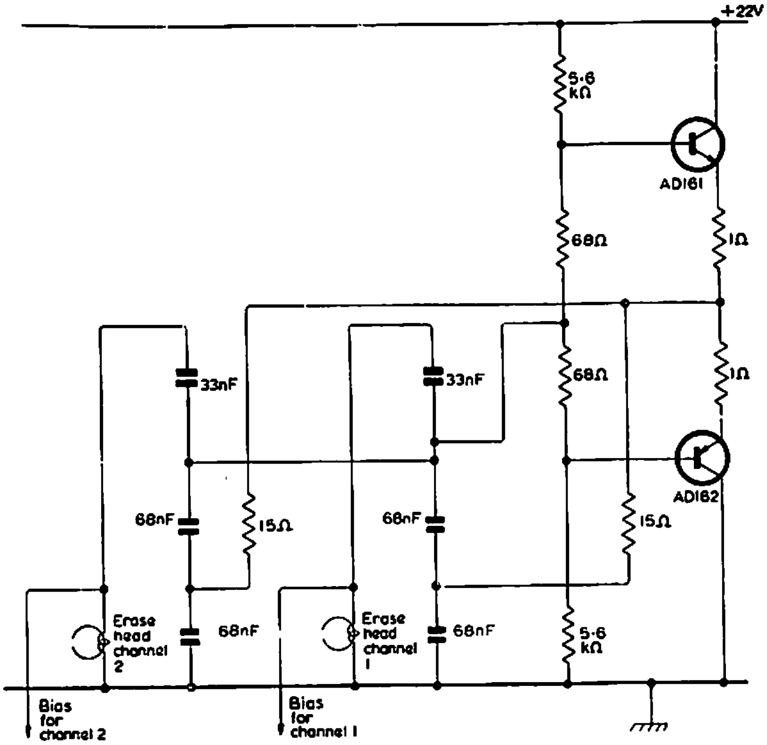
PLAYBACK PREAMP—Uses Mallory MIC0101 IC audio preamp with input terminals connected directly to tape playback head. Suitable for either audio or instrumentation applications. Uncompensated overall voltage gain of 57 to 63 dB can easily be obtained with 3-dB bandwidth of 10 Hz to 700 kHz and output of 3 V p-p with under 10% total harmonic distortion. —M. L. Deschler, Integrated Circuit Preamplifiers, Mallory, Indianapolis, Ind., APPN-2, 1968.


+12 VDC
CH1 +Vcc
MIC 0103
CH1 TAPE HEAD
CH1 INPUT
CH1 FEEDBACK
1/2 MIC 0103
60/3
CH1 OUTPUT
10/15
470
0.47
CH1 GND
10K
CH1 OUTPUT LEVEL
CH2 +Vcc
CH2 TAPE HEAD
CH2 INPUT
CH2 FEEDBACK
1/2 MIC 0103
60/3
CH2 OUTPUT
10/15
470
0.47
CH2 GND
10K
CH2 OUTPUT LEVEL

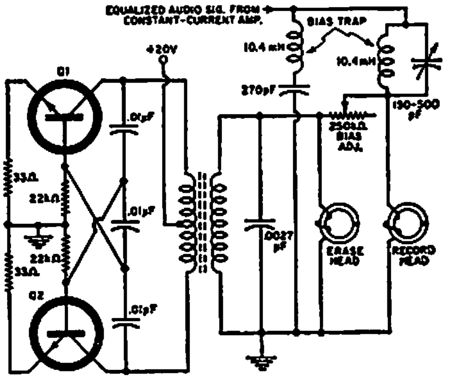
TAPE PLAYBACK PREAMP—Uses Mallory MIC-0103 dual-channel IC preamp with tape heads connected directly to IC inputs. Includes R-C compensation for magnetic tape response characteristic.—M. L. Deschler, Integrated Circuit Preamplifiers, Mallory, Indianapolis, Ind., APPN-2, 1968.


Input signal V_1
Signal V_2
C_1 220nF
C_2 470nF
R_1 22kΩ
R_2 6·8kΩ
A
Audio amplifier
Output signal V_3
C_5 12·5µF 25V
R_5 1·2kΩ
C_6 125µF 25V
R_7 1·5kΩ
TR_1 BC148 or BC108
R_3 390kΩ
D_2 BA114
Controlled variable resistance
D_1 BA114
C_3 220nF
R_4 3·3 MΩ
C_4 320µF 6·4V
R_6 1kΩ
R_8 1kΩ
-22V

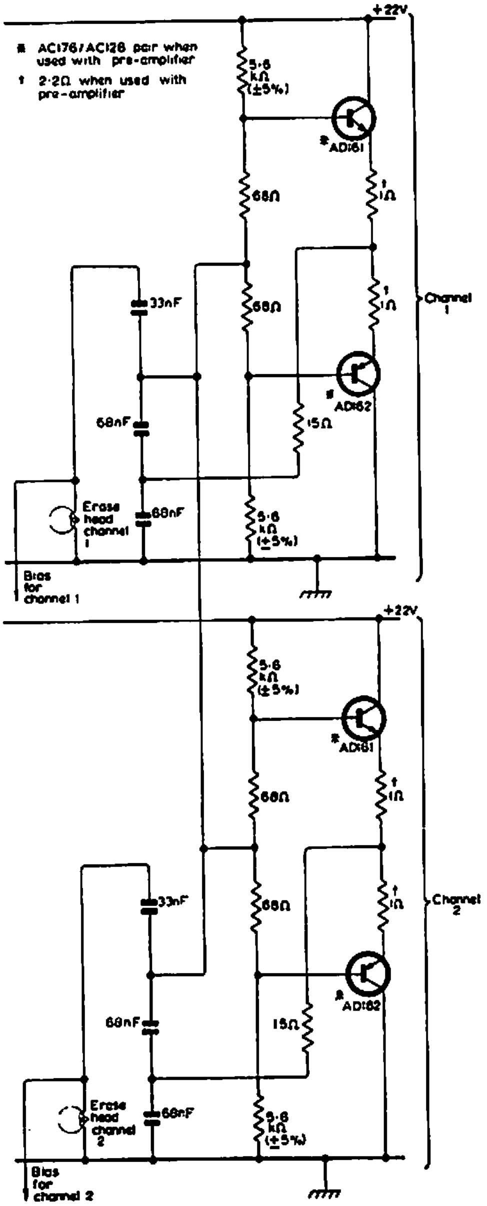
AGC FOR RECORDER—Automatically reduces gain of recording amplifier when optimum recording level is exceeded, to prevent severe distortion that occurs at tape saturation. Eliminates need for monitoring recording-head current with meter or magic eye and manually adjusting level. Circuit responds very rapidly to overload signal, producing attenuation of 40 dB within 50 ms, but has long recovery time to prevent volume compression wherein loud and soft musical passages would be recorded with equal loudness. Book describes operation of circuit in detail.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 80.


+22V
5·6 kΩ
AD161
68Ω
1Ω
33nF
33nF
68Ω
1Ω
AD162
68nF
15Ω
68nF
15Ω
Erase head channel 2
68nF
Erase head channel 1
68nF
5·6 kΩ
Bias for channel 2
Bias for channel 1

COMMON BIAS-ERASE OSCILLATOR FOR STEREO—Keeps bias and erase frequencies equal for stereo channels, to prevent production of audio beat frequencies. Tuned erase heads are connected in parallel to form load and feedback circuits for one of complementary pairs of transistors, but bias voltages for recording heads are still derived from erase voltages across individual erase heads. —"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 77.


EQUALIZED AUDIO SIG. FROM CONSTANT-CURRENT AMP.
BIAS TRAP
+20V
10.4 mH
10.4 mH
Q1
270pF
130-500 pF
.01μF
2500Ω BIAS ADJ.
33Ω
22kΩ
.01μF
22kΩ
33Ω
.0027 μF
ERASE HEAD
RECORD HEAD
Q2
.01μF

MAGNETIC TAPE BIAS OSCILLATOR—Basic transistor circuit for applying a-c bias uses common astable mvbr with center-tapped transformer, in place of normal collector resistors and capacitors, to complete parallel resonant circuit with transformer. This tuned circuit determines frequency of oscillation and makes signal sinusoidal. Transistors are not critical for bias frequency of 95 kHz. —J. G. McKnight, Biasing in Magnetic Tape Recording, *Electronics World*, Aug. 1967, p 34–36 and 75.


* AC176/AC128 pair when used with pre-amplifier

† 2·2Ω when used with pre-amplifier

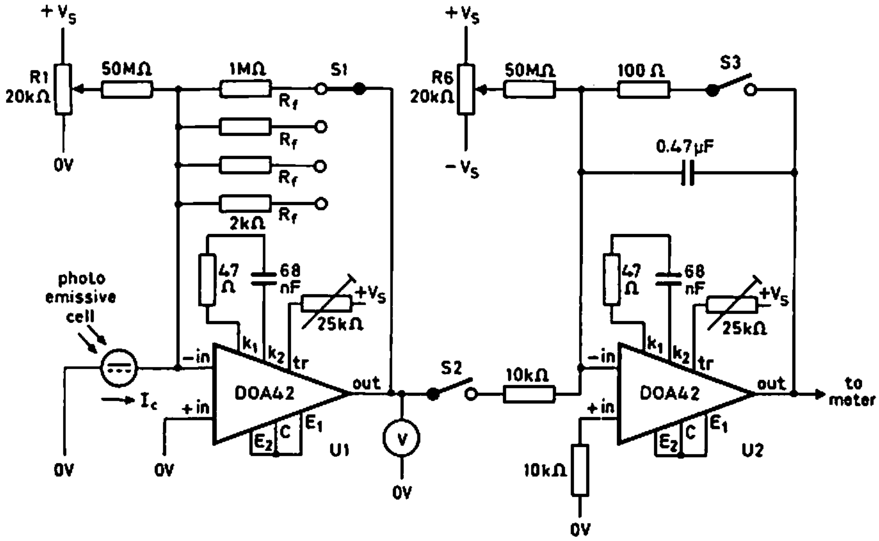
+22V
5·6 kΩ (±5%)
AD161
1Ω
68Ω
33nF
68Ω
1Ω
Channel 1
AD162
68nF
15Ω
Erase head channel 1
68nF
5·6 kΩ (±5%)
Bias for channel 1
+22V
5·6 kΩ (±5%)
AD161
68Ω
1Ω
33nF
68Ω
1Ω
Channel 2
AD162
68nF
15Ω
Erase head channel 2
68nF
5·6 kΩ (±5%)
Bias for channel 2

LOCKED BIAS-ERASE OSCILLATORS FOR STEREO—Feedback paths of individual oscillators are connected together to make bias and erase frequencies equal for both stereo channels, thereby preventing production of audio beat frequencies.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 78.

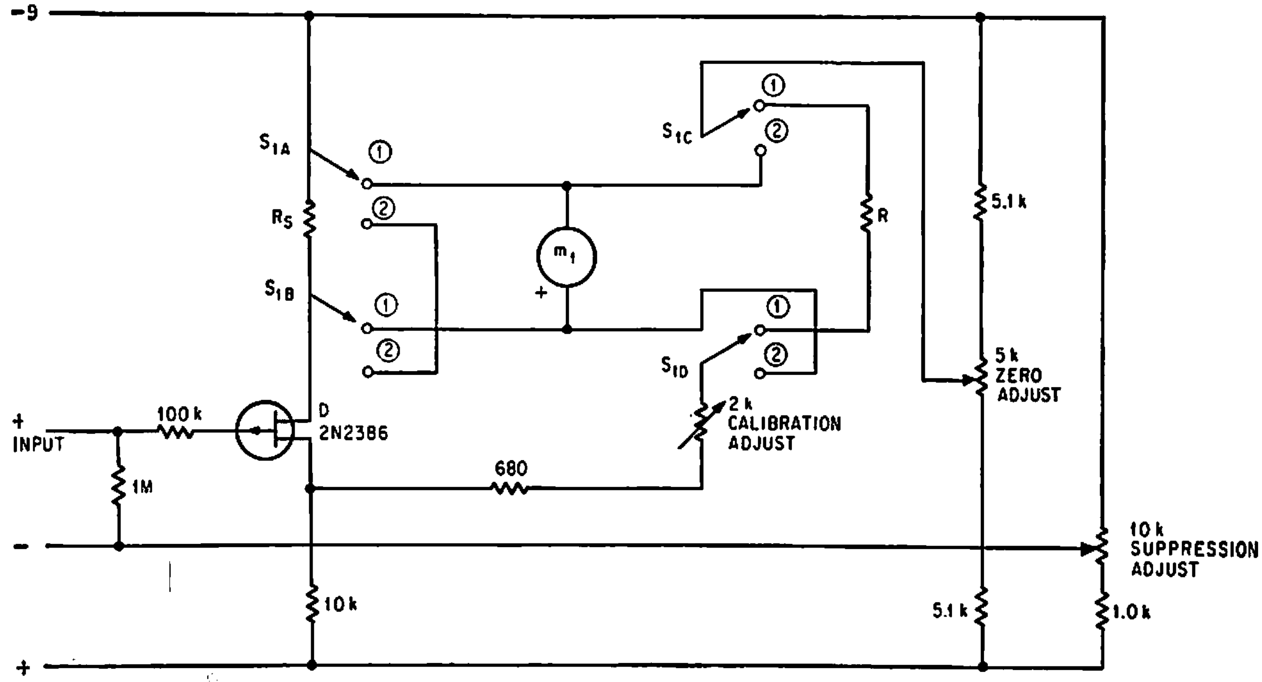
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 49
Measuring Circuits

MEASURING LIGHT INTENSITY—Uses high-gain opamp to hold voltage across photoemissive cell at almost zero voltage, to take advantage of linear relationship between current flow and light intensity at cell voltages below a few millivolts. Output voltage of opamp is then equal to product of cell current and feedback resistance Rf which is selected in steps by S1. Total light energy, as from flash lamps, can be measured by closing S2 and opening S3 to integrate output in second opamp.—J. Ph. Korthals Altes, Measurement of Light Intensity, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 85, 1970.

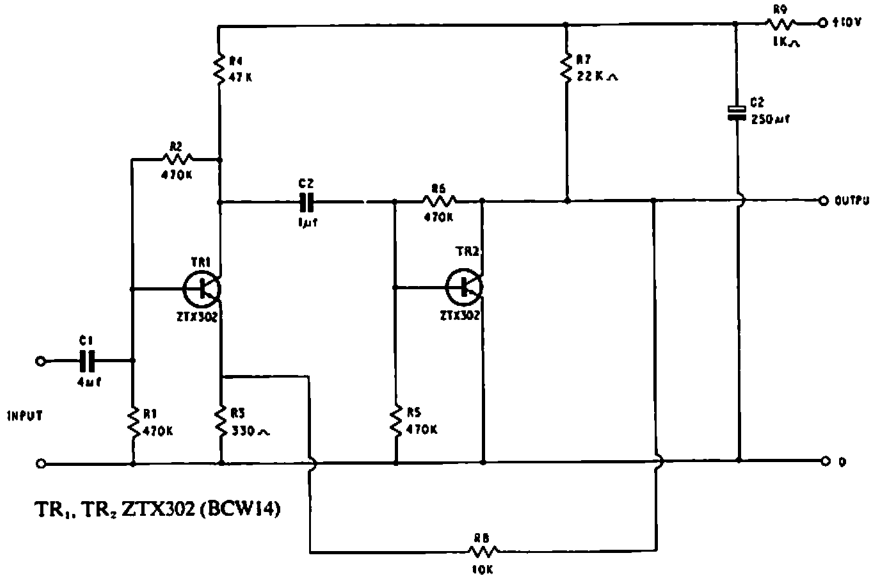


+V_S
R1 20kΩ
50MΩ
1MΩ
S1
R_f
R_f
R_f
2kΩ R_f
OV
47 Ω
68 nF
+V_S
25kΩ
photo emissive cell
I_c
-in
+in
k1
k2
tr
DOA42
out
E2
C
E1
U1
OV
OV
V
OV
+V_S
R6 20kΩ
-V_S
50MΩ
100 Ω
S3
0.47μF
S2
10kΩ
47 Ω
68 nF
+V_S
25kΩ
-in
+in
k1
k2
tr
DOA42
out
E2
C
E1
U2
10kΩ
OV
to meter



-9
S1A
①
②
RS
S1B
①
②
m1
+
S1C
①
②
R
5.1 k
S1D
①
②
5 k ZERO ADJUST
2 k CALIBRATION ADJUST
+ INPUT
100 k
D
2N2386
1M
680
-
10 k
5.1 k
10 k SUPPRESSION ADJUST
1.0 k
+

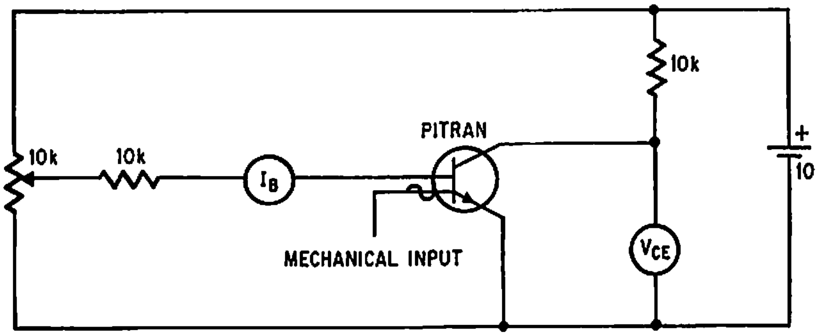
MOVABLE-RANGE D-C VOLTMETER—Full-scale range of 1 V may be positioned anywhere between 0 and 7 V d-c input, such as for reading 4 to 5 V. With switch at position 1, and input at low limit of voltage to be measured, drain current of fet is set at 350 μA with suppression-adjust pot. Switch is then moved to position 2, input voltage is increased 1 V above low limit, and calibration-adjust pot is set to give full-scale reading on 100-μA meter. Accuracy is 2%.—R. Traina, Multirange D-C Voltmeter, *Electronics*, Sept. 19, 1966, p 126.


R9
1KΩ
+10V
R4
47K
R7
22KΩ
C2
250μf
R2
470K
C2
1μf
R6
470K
OUTPUT
TR1
ZTX302
TR2
ZTX302
C1
4μf
INPUT
R1
470K
R3
330Ω
R5
470K
0
R8
10K

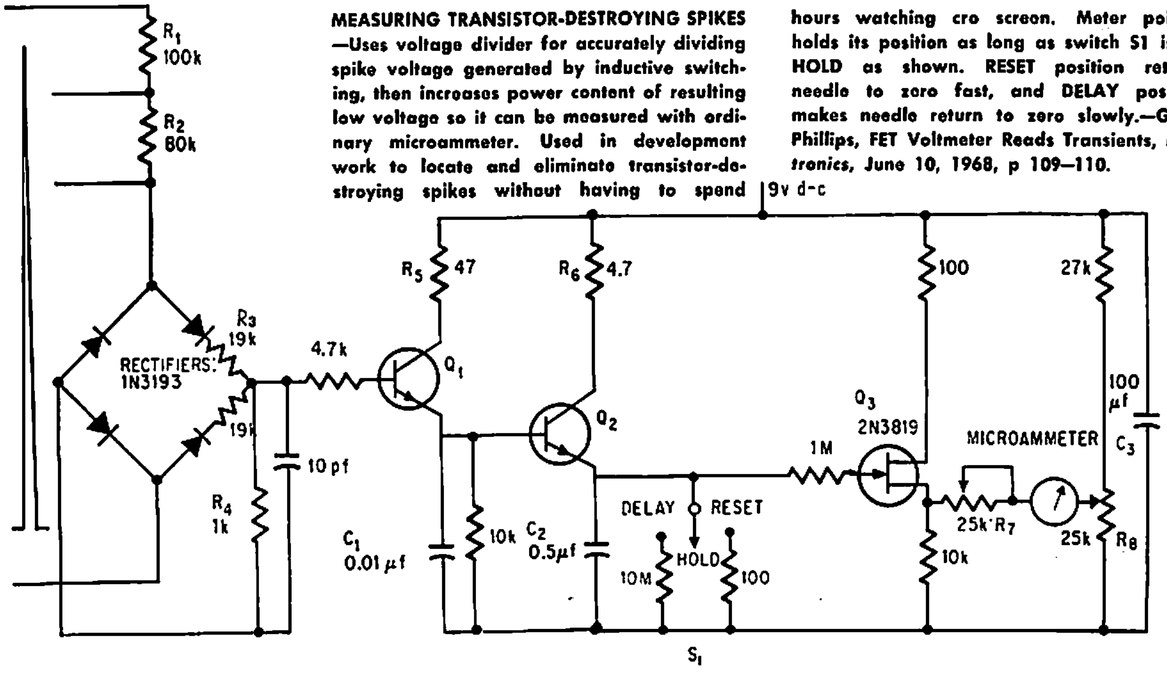
TR$_1$, TR$_2$ ZTX302 (BCW14)

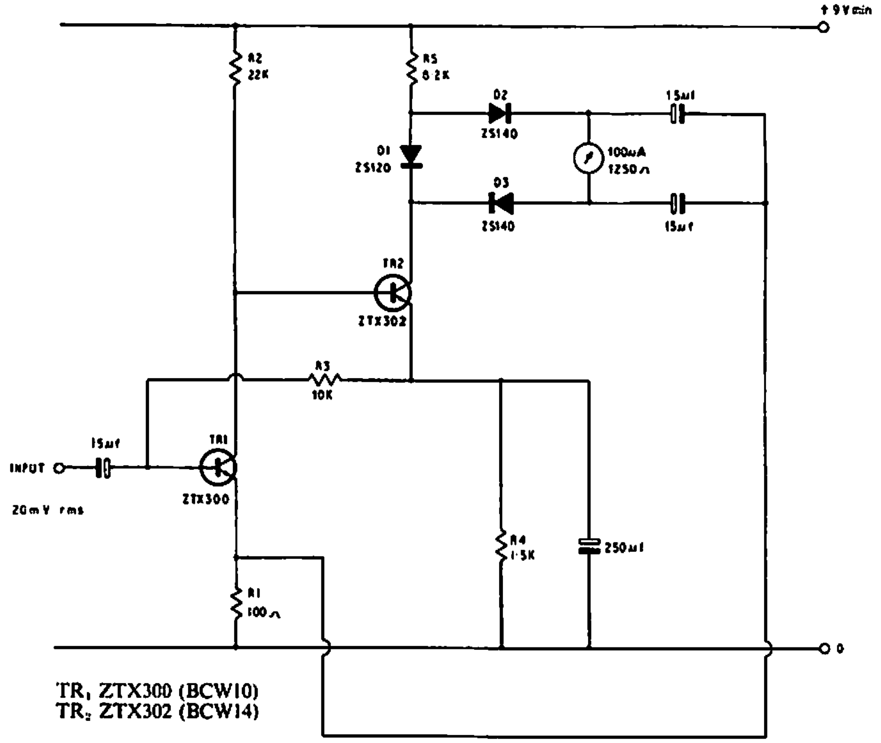
MILLIVOLTMETER PREAMP—Increases sensitivity of rectifier-type a-c millivoltmeter from 20 mV rms down to 1 mV rms for full-scale deflection. Bandwidth is 800 kHz, same as rectifier stage. Voltage gain is 22, and may be adjusted, while input impedance is 100K. Report gives design procedure.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 34.

TRANSISTOR STRAIN GAGE—Uses silicon npn planar piezoelectric transistor called Pitran (made by Stow Labs, Stow, Mass.), having emitter-base junction mechanically coupled to diaphragm in top of TO-46 can. Is sensitive enough to respond to feather touch. Voltage change per unit strain is over 10 times better than metal and other types of strain gages. Output is linearily proportional to mechanical input, and ranges up to 20% of d-c supply voltage.—R. M. Moore, Semiconductor Gages Make Sense in Most Transducer Applications, *Electronics*, March 18, 1968, p 109–116.


10k
PITRAN
10k
10k
I_B
MECHANICAL INPUT
V_{CE}
+
10v

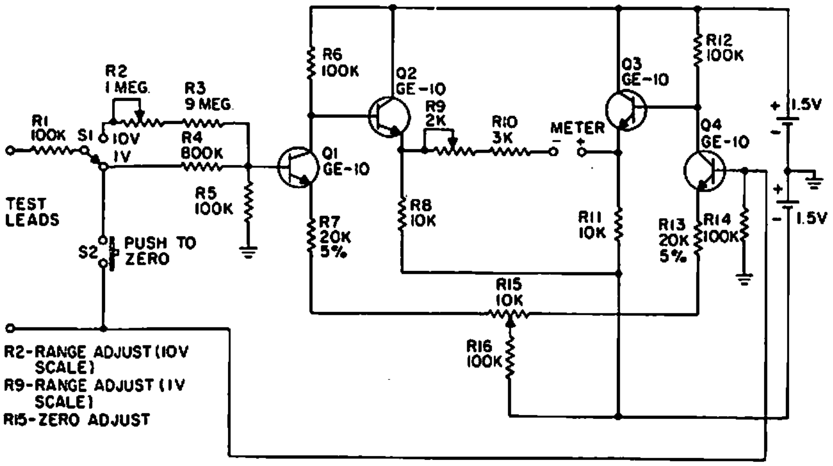
MEASURING TRANSISTOR-DESTROYING SPIKES—Uses voltage divider for accurately dividing spike voltage generated by inductive switching, then increases power content of resulting low voltage so it can be measured with ordinary microammeter. Used in development work to locate and eliminate transistor-destroying spikes without having to spend hours watching cro screen. Meter pointer holds its position as long as switch S1 is on HOLD as shown. RESET position returns needle to zero fast, and DELAY position makes needle return to zero slowly.—G. R. Phillips, FET Voltmeter Reads Transients, *Electronics*, June 10, 1968, p 109–110.


R_1
100k
R_2
80k
9v d-c
R_5 47
R_6 4.7
100
27k
R_3
19k
RECTIFIERS:
1N3193
19k
4.7k
Q_1
Q_2
Q_3
2N3819
100 μf
C_3
1M
MICROAMMETER
10 pf
R_4
1k
C_1
0.01 μf
10k
C_2
0.5μf
DELAY
RESET
HOLD
10M
100
10k
25k R_7
25k
R_8
S_1

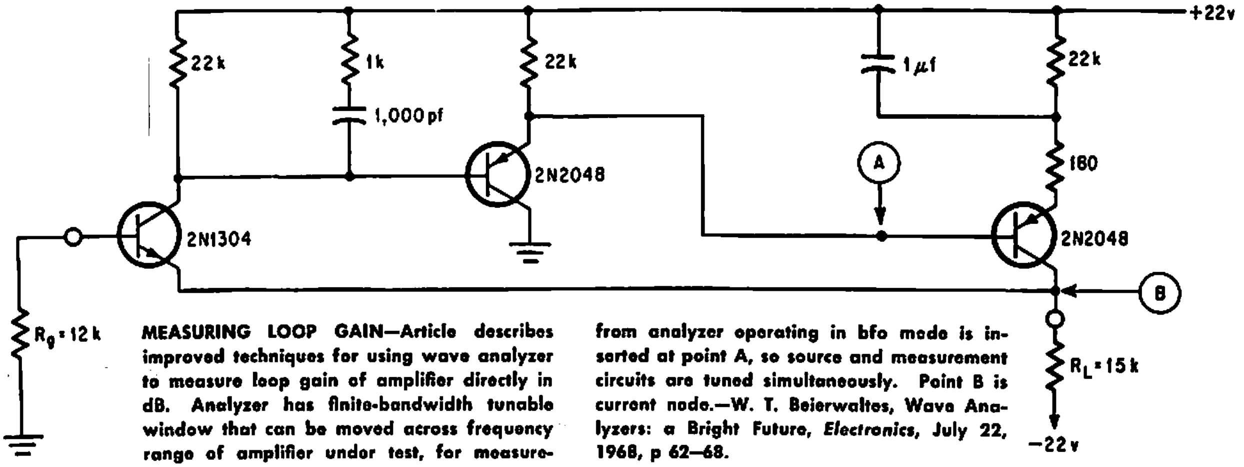

+9V min
R2
22K
R5
8.2K
D2
ZS140
15µf
D1
ZS120
100µA
1250Ω
D3
ZS140
15µf
TR2
ZTX302
R3
10K
INPUT
20mV rms
15µf
TR1
ZTX300
R4
1·5K
250µf
R1
100Ω
0
TR₁ ZTX300 (BCW10)
TR₂ ZTX302 (BCW14)

A-C MILLIVOLTMETER—Gives full-scale deflection on 100-µA linear-scale meter for input of about 20 mV rms over bandwidth of 800 kHz. Input impedance is 10K. Report gives design procedure.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 33.

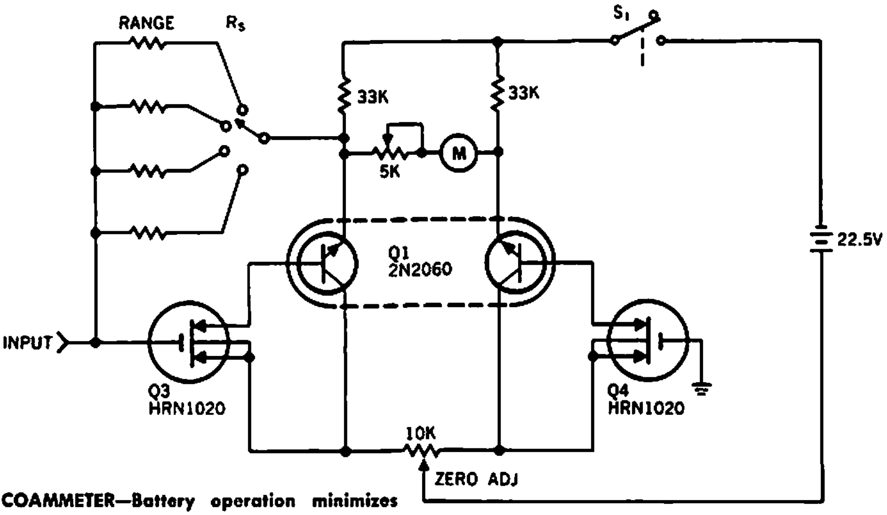
VTVM ADAPTER FOR MULTIMETER—Uses only typical 60 to 100 µA meter of multimeter, for making low-voltage d-c measurements (1-V and 10-V scales) at high impedance. Adapter draws only 1 µA from measured circuit at full-scale deflection, which is equivalent to sensitivity of 1 meg per V. Uses silicon transistors in two-stage differential amplifier. Has no warm-up zero drift. Since standby battery drain is only fraction of µA, no on-off switch is required. Set multimeter to 60 (or 100) µA position and plug test leads of adapter into corresponding jack. Does not interfere with normal use of multimeter.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 170.


R6
100K
R12
100K
Q2
GE-10
Q3
GE-10
R2
1 MEG.
R3
9 MEG.
R9
2K
R10
3K
METER
+
R1
100K
S1
10V
1V
R4
800K
Q1
GE-10
Q4
GE-10
+
1.5V
TEST LEADS
R5
100K
R7
20K
5%
R8
10K
R11
10K
R13
20K
5%
R14
100K
1.5V
S2
PUSH TO ZERO
R15
10K
R16
100K

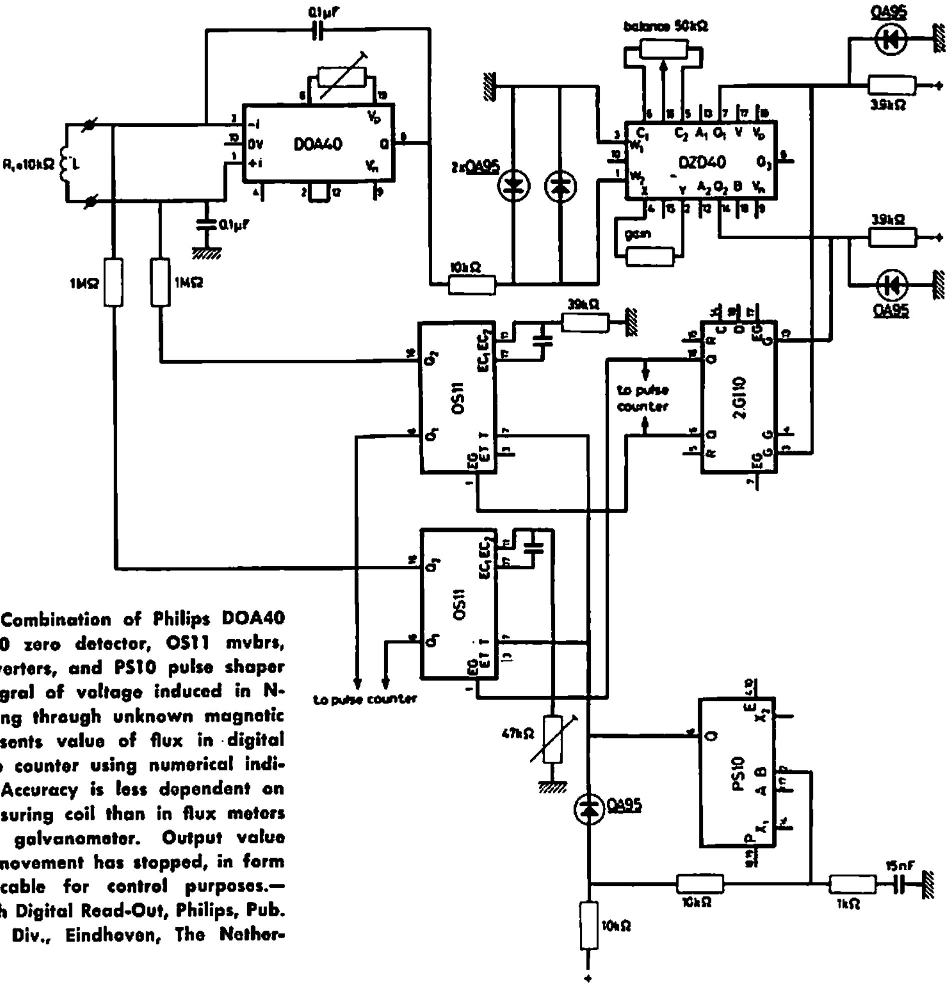
R2-RANGE ADJUST (10V SCALE)
R9-RANGE ADJUST (1V SCALE)
R15-ZERO ADJUST


+22v
22k
1k
1,000pf
22k
1µf
22k
2N2048
A
180
2N1304
2N2048
B
R_g=12k
R_L=15k
−22v

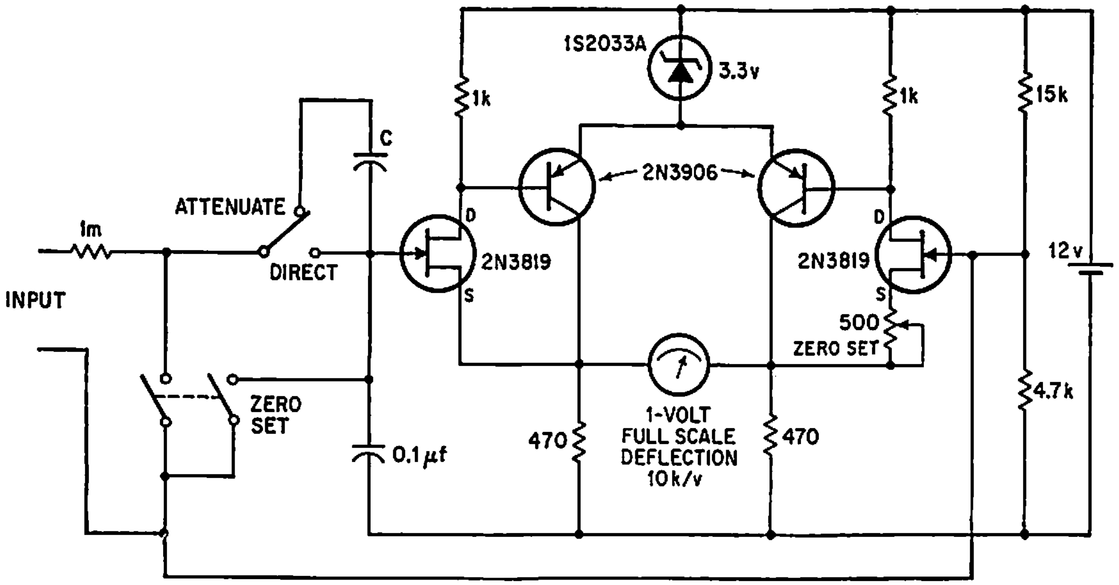
MEASURING LOOP GAIN—Article describes improved techniques for using wave analyzer to measure loop gain of amplifier directly in dB. Analyzer has finite-bandwidth tunable window that can be moved across frequency range of amplifier under test, for measurement of signals framed by window. Signal from analyzer operating in bfo mode is inserted at point A, so source and measurement circuits are tuned simultaneously. Point B is current node.—W. T. Beierwaltes, Wave Analyzers: a Bright Future, *Electronics*, July 22, 1968, p 62–68.


RANGE
R_S
S_1
33K
33K
5K
M
Q1
2N2060
22.5V
INPUT
Q3
HRN1020
Q4
HRN1020
10K
ZERO ADJ

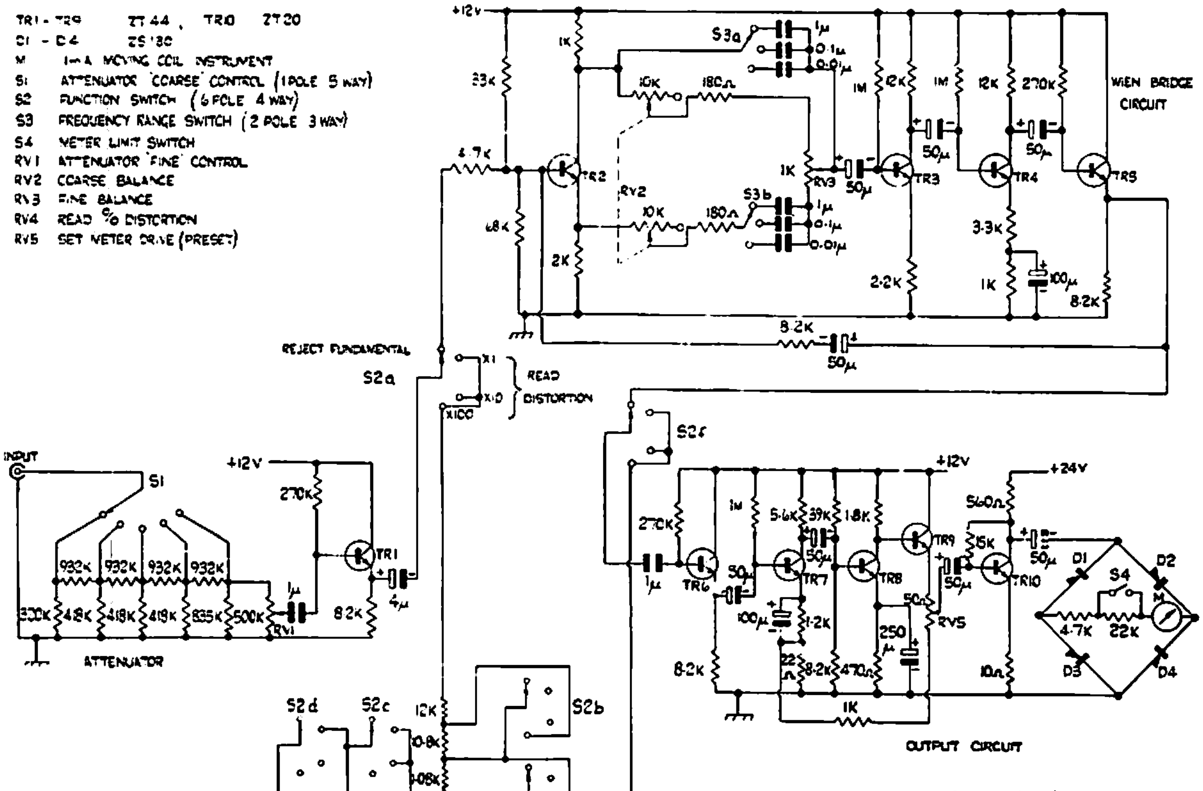
PICOAMMETER—Battery operation minimizes noise and allows excellent isolation between input and meter. Mosfet Q3 provides high impedance to minimize effect on circuit being measured. Q4 provides reference for balancing meter when input is short-circuited for calibration. Dual transistors are connected as emitter-followers to drive low-impedance meter movement. Will measure low d-c voltages as well as picoamperes.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 19.


0.1μF
balance 50kΩ
OA95
39kΩ
DOA40
DZD40
2xOA95
R_s=10kΩ
L
0.1μF
gain
39kΩ
OA95
1MΩ
1MΩ
10kΩ
39kΩ
OS11
2.GI10
to pulse counter
OS11
to pulse counter
47kΩ
PS10
OA95
10kΩ
1kΩ
15nF
10kΩ

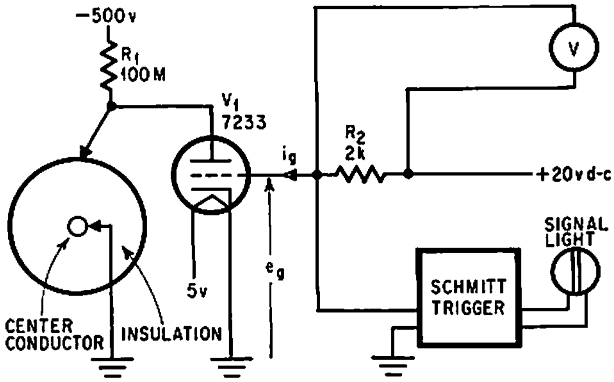
FLUX METER—Combination of Philips DOA40 opamp, DZD40 zero detector, OS11 mvbrs, GI10 gate inverters, and PS10 pulse shaper evaluates integral of voltage induced in N-turn coil moving through unknown magnetic flux, and presents value of flux in digital form on pulse counter using numerical indicator tubes. Accuracy is less dependent on speed of measuring coil than in flux meters using ballistic galvanometer. Output value is held after movement has stopped, in form directly applicable for control purposes.—Fluxmeter With Digital Read-Out, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands.


1S2033A
3.3v
1k
1k
15k
C
2N3906
ATTENUATE
1m
DIRECT
INPUT
D
S
2N3819
2N3819
D
S
12v
500
ZERO SET
ZERO SET
4.7k
470
1-VOLT FULL SCALE DEFLECTION 10k/v
470
0.1μf

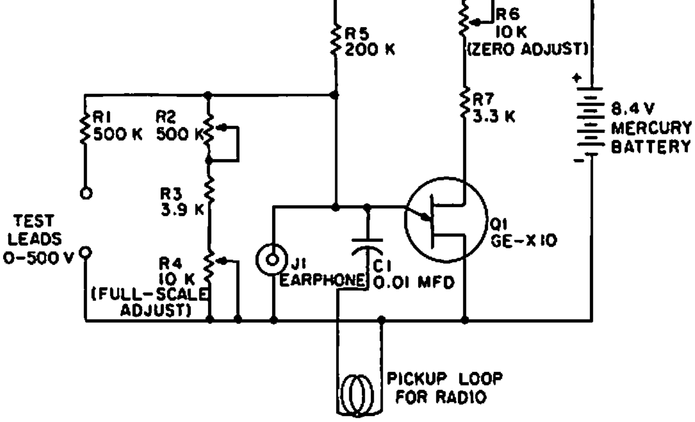
DRIFT-BALANCING VTVM—High-impedance voltmeter has current-measuring sensitivity of 1 nA. Two source-followers are connected to meter for cancellation of drift caused by temperature changes. Output to meter is 1 V at 100 μA. When current to be measured is sent through 1,000-meg shunt across input terminals, meter will read 1 nA full scale. Value of C depends on voltage range desired. —D. F. Wadsworth, Pair of Source Followers Keep a Voltmeter Steady, *Electronics*, June 23, 1969, p 103.


TR1 - TR9 ZT44, TR10 ZT20
D1 - D4 ZS130
M 1mA MOVING COIL INSTRUMENT
S1 ATTENUATOR 'COARSE' CONTROL (1 POLE 5 WAY)
S2 FUNCTION SWITCH (6 POLE 4 WAY)
S3 FREQUENCY RANGE SWITCH (2 POLE 3 WAY)
S4 METER LIMIT SWITCH
RV1 ATTENUATOR 'FINE' CONTROL
RV2 COARSE BALANCE
RV3 FINE BALANCE
RV4 READ % DISTORTION
RV5 SET METER DRIVE (PRESET)
+12V
WIEN BRIDGE CIRCUIT
S3a
S3b
TR2
TR3
TR4
TR5
RV2
RV3
REJECT FUNDAMENTAL
S2a
READ DISTORTION
X1
X10
X100
S2f
INPUT
S1
+12V
TR1
932K
932K
932K
932K
300K
4.8K
41.8K
419K
835K
500K
RV1
82K
ATTENUATOR
+12V
+24V
TR6
TR7
TR8
TR9
TR10
RV5
D1
D2
D3
D4
S4
M
4.7K
22K
OUTPUT CIRCUIT
S2d
S2c
S2b
S2e
133Ω
1.33K
22K
25K
RV4
12K
10.8K
1.08K
CALIBRATED POTENTIOMETER

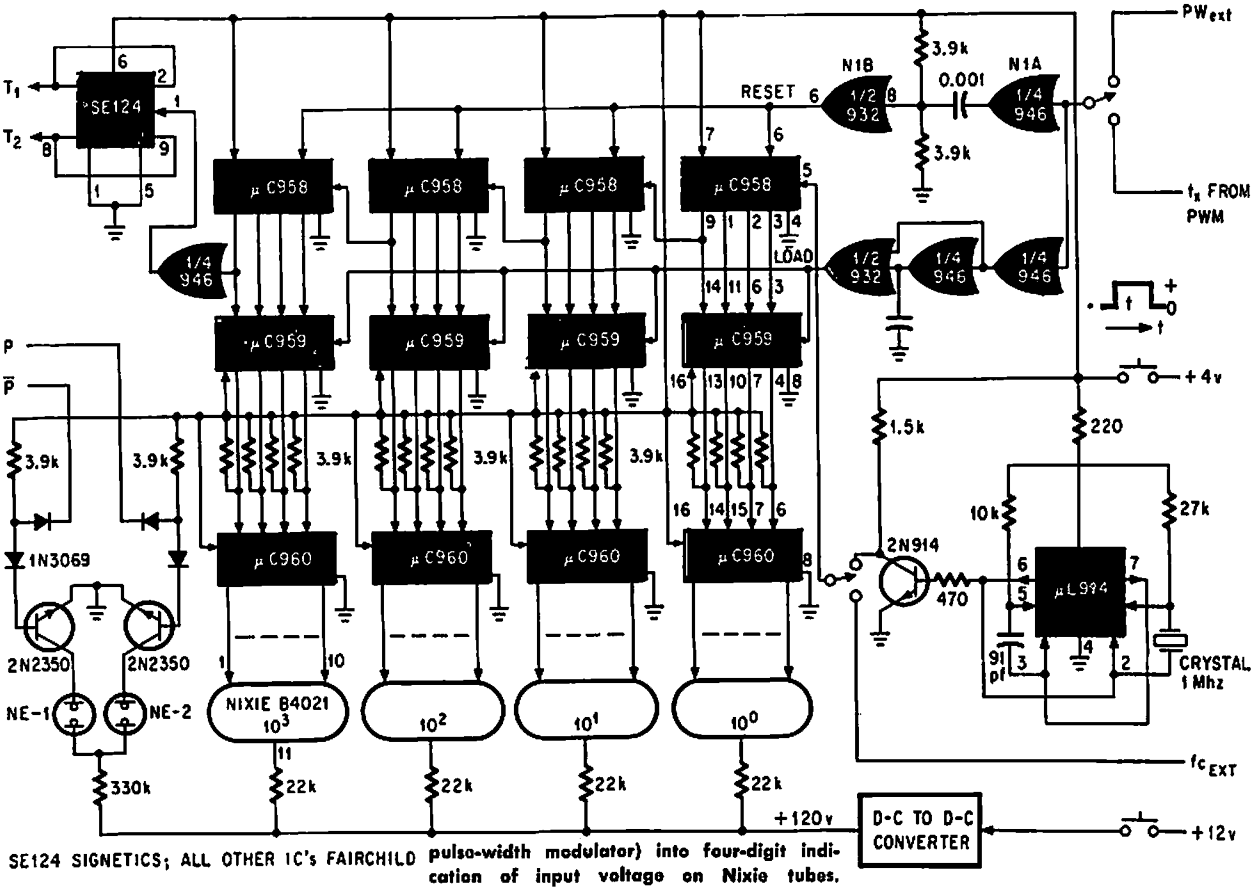
DISTORTION METER—Measures total distortion of audio signal in fundamental frequency range of 15 Hz to 20 kHz, including harmonic components up to fifth. Signal levels measured can range from 150 mV to 75 V rms, with sensitivity sufficient to measure 0.1% distortion at lowest level. Technique involves suppressing fundamental frequency component of signal, then comparing residual voltage with total signal voltage by means of full-wave rectifier meter.—Silicon Transistor A. F. Distortion Meter, Ferranti Ltd., Oldham, Lancs., England, No. 17, 1965.


−500v
R1 100M
V1 7233
R2 2k
ig
+20v d-c
V
eg
5v
SIGNAL LIGHT
SCHMITT TRIGGER
CENTER CONDUCTOR
INSULATION

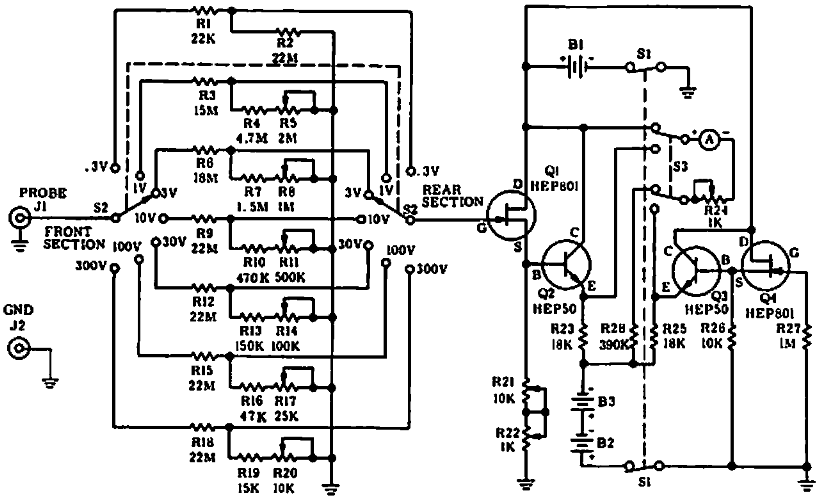
INFINITE-Z VOLTMETER—Used for measuring insulation on high-voltage conductors. Anode of triode is made negative with respect to cathode, to give infinite impedance. Insulation leak makes anode voltage drop, and resulting change in grid voltage turns on Schmitt trigger and signal light used as level detector. Voltage limit of tube is 600 V.—R. A. Parks, Reversed-Polarity Triode Measures Insulation, *Electronics*, Feb. 5, 1968, p 87–88.


S1
R5 200 K
R6 10 K (ZERO ADJUST)
R7 3.3 K
8.4 V MERCURY BATTERY
R1 500 K
R2 500 K
R3 3.9 K
TEST LEADS 0-500 V
R4 10 K (FULL-SCALE ADJUST)
J1 EARPHONE
C1 0.01 MFD
Q1 GE-X10
PICKUP LOOP FOR RADIO

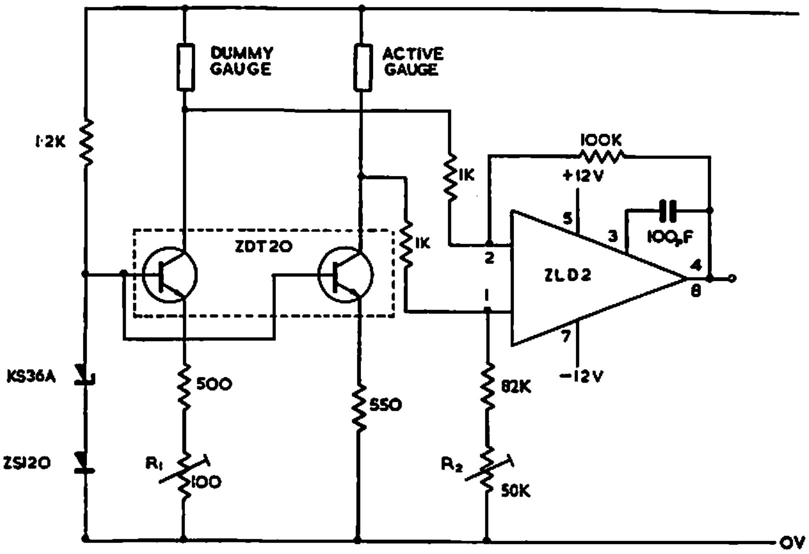
METERLESS D-C VOLTMETER—Covers range of 0–500 V d-c, with 0.5-meg input impedance minimizing risk of damage to components in tested circuit. With test leads in position for measurement, turn on voltmeter and rotate R2 until audio tone is just heard; dial then indicates d-c voltage, either in earphone or in nearby radio tuned to quiet spot at low-frequency end of a-m broadcast band. Loop should be close to antenna of radio. Radio picks up high-frequency harmonics of audio tone generated by ujt. Book gives calibration procedure.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 178.


T1
T2
SE124
1/4 946
P
P̄
3.9k
1N3069
2N2350
NE-1
NE-2
330k
μC958
μC959
μC960
NIXIE B4021 10^3
10^2
10^1
10^0
22k
+120v
RESET
LOAD
N1B 1/2 932
N1A 1/4 946
0.001
PWext
tx FROM PWM
+4v
1.5k
220
2N914
470
10k
27k
μL914
91 pf
CRYSTAL 1 Mhz
fcEXT
D-C TO D-C CONVERTER
+12v
SE124 SIGNETICS; ALL OTHER IC's FAIRCHILD

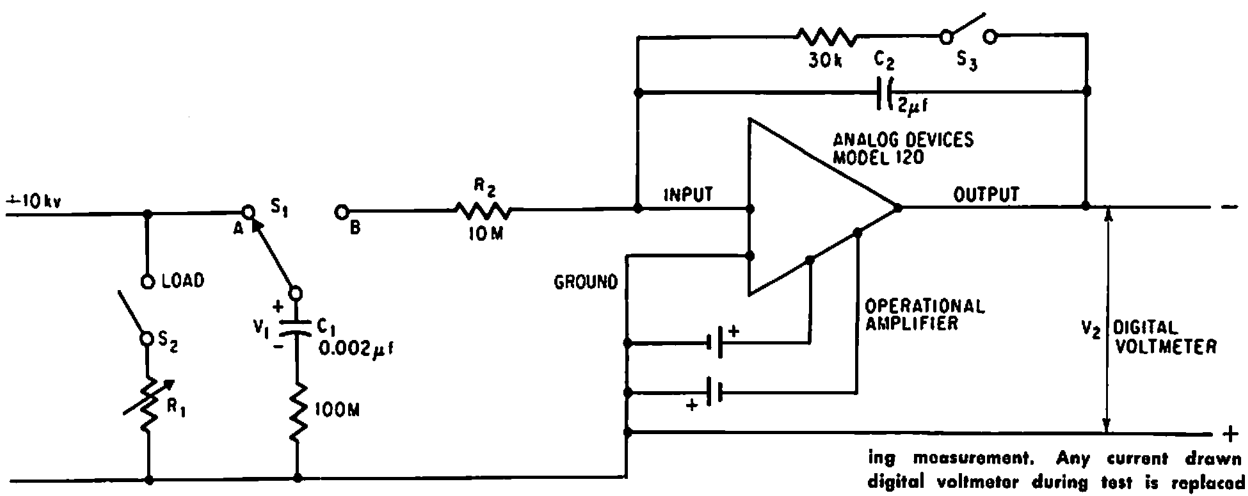
IC DIGITAL VOLTMETER—Counter section of meter converts pulse width (obtained from pulse-width modulator) into four-digit indication of input voltage on Nixie tubes. Crystal oscillator using Fairchild μL914 IC generates accurate 1-MHz clock frequency for counter.—H. Schmid, Digital Meters for Under $100, *Electronics*, Nov. 28, 1966, p 88–94.


R1 22K
R2 22M
R3 15M
R4 4.7M
R5 2M
R6 18M
R7 1.5M
R8 1M
R9 22M
R10 470K
R11 500K
R12 22M
R13 150K
R14 100K
R15 22M
R16 47K
R17 25K
R18 22M
R19 15K
R20 10K
PROBE J1
GND J2
S2
FRONT SECTION
REAR SECTION
.3V
1V
3V
10V
30V
100V
300V
Q1 HEP801
Q2 HEP50
Q3 HEP50
Q4 HEP801
B1
B2
B3
S1
S3
R21 10K
R22 1K
R23 18K
R24 1K
R25 18K
R26 10K
R27 1M
R28 390K
D
G
S
B
C
E

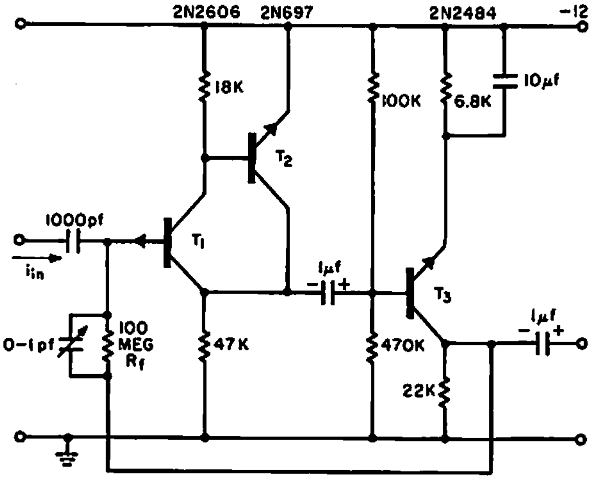
FET D-C VOLTMETER—Compact, inexpensive, and accurate meter features 22-meg input impedance on seven ranges, using three 9-V batteries for power. Article gives construction details.—"Field Effect Transistor Projects," Motorola, Phoenix, Ariz., 1966, p 75–90.


DUMMY GAUGE
ACTIVE GAUGE
1·2K
1K
1K
100K
+12V
−12V
ZDT20
ZLD2
100μF
5
3
2
1
4
8
7
KS36A
ZS120
500
550
82K
R1
100
R2
50K
OV

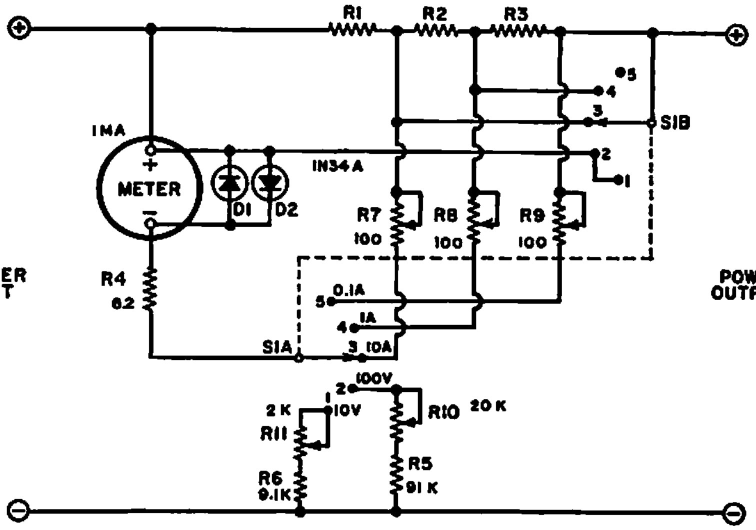
IC STRAIN-GAGE AMPLIFIER—Uses two constant-current generators feeding about 10 mA into active and dummy silicon strain gages. Differential output of gages is fed into Ferranti ZLD2 IC differential amplifier. R1 is adjusted until output of ZLD2 is zero, and R2 is adjusted for maximum common mode rejection of ZLD2.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 5/67, p 18.


+10 kV
LOAD
S2
R1
S1
A
B
V1
C1
0.002μf
100M
R2
10M
30k
C2
S3
2μf
ANALOG DEVICES MODEL 120
INPUT
OUTPUT
GROUND
OPERATIONAL AMPLIFIER
V2
DIGITAL VOLTMETER
−
+

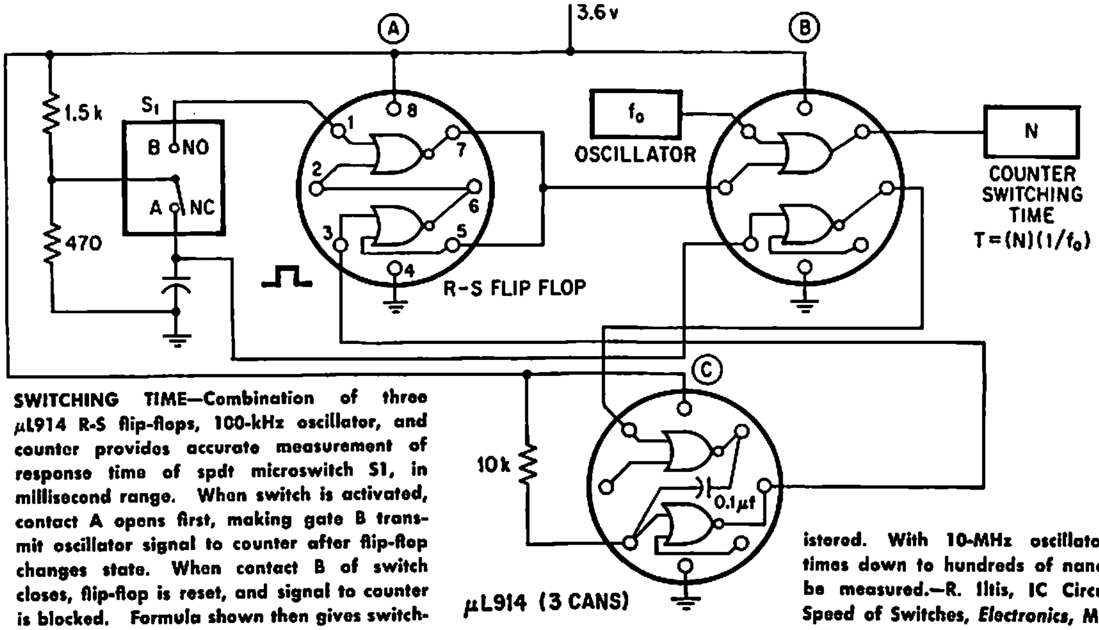
HIGH-ACCURACY ELECTROSTATIC VOLTMETER—Charge transfer circuit used with IC opamp ahead of digital voltmeter permits measuring voltages up to 10 kV to accuracy of 0.5%, as compared to 2% accuracy of conventional electrostatic voltmeter. Circuit precisely divides high voltage being measured and protects divided voltage from current drain during measurement. Any current drawn by digital voltmeter during test is replaced by opamp. Article gives measuring procedure.—T. P. Kohler and E. H. Hudspeth, Operational Amplifier Overcomes Voltmeter Loading, *Electronics*, Dec. 25, 1967, p 67–68.


2N2606
2N697
2N2484
-12
18K
T2
100K
6.8K
10µf
1000pf
T1
iin
1µf
T3
1µf
0-1pf
100 MEG Rf
47K
470K
22K

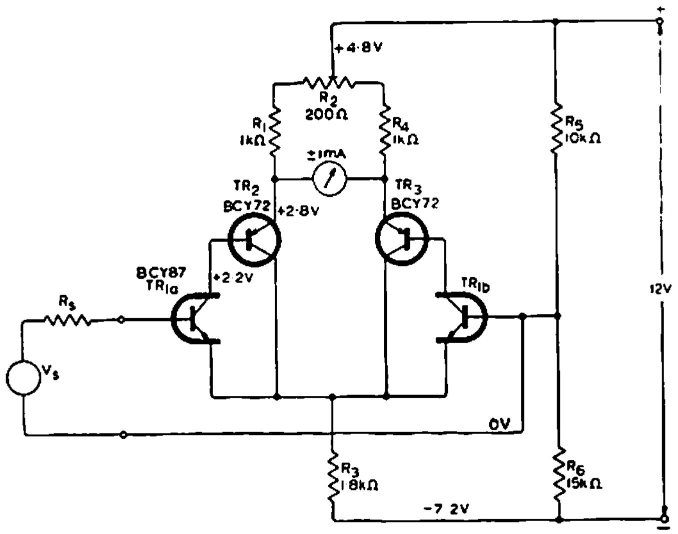
FET ELECTROMETER AMPLIFIER—Low-noise characteristic of fet T1 makes it possible to measure currents as low as 100 femtoamperes at room temperature in audio range, over 1-Hz bandwidth. Article gives design equations. Transistor types are given at top of diagram.—R. Munoz, Put FETs to Work in Electrometers, *Electronic Design*, May 11, 1964, p 56–61.


R1
R2
R3
5
4
3
S1B
2
1
1MA
METER
IN34A
D1
D2
R7 100
R8 100
R9 100
POWER INPUT
POWER OUTPUT
R4 62
5 0.1A
4 1A
S1A
3 10A
2 100V
1 10V
2K R11
R10 20K
R6 9.1K
R5 91K

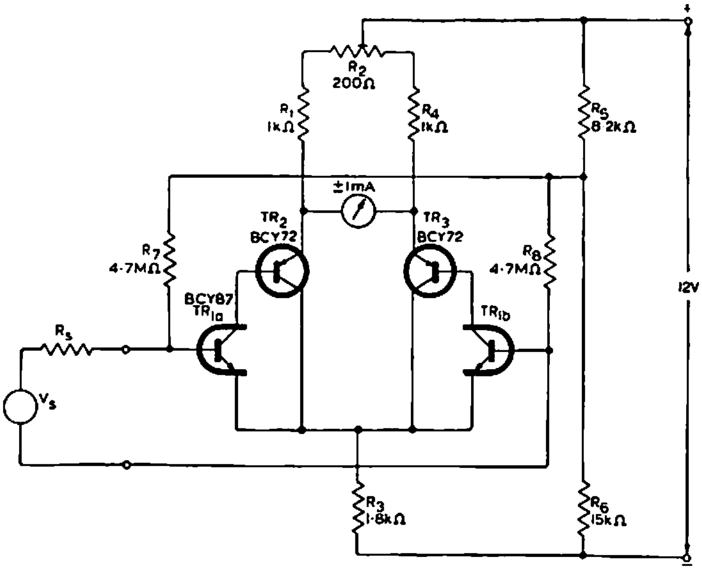
D-C VOLT-AMMETER—Design of current-range selection circuit minimizes effect of variations in range switch contact resistance. Accuracy is better than 3%, yet total cost of parts is under $30. Current ranges are 0.1, 1, and 10 A, and voltage ranges are 10 and 100 V. Article gives detailed construction and calibration procedures. R1 is 18" of No. 16 enameled wire, R2 is 20" of No. 26, and R3 is 48" of No. 32, all wound on 2-W fixed resistors used as coil forms.—M. Chan and R. Brock, Shunt Switching Method Reduces Meter Errors, *Electronics World*, Oct. 1968, p 76–77.


3.6v
Ⓐ
Ⓑ
1.5k
S1
B NO
A NC
470
1
8
7
2
6
3
5
4
R-S FLIP FLOP
f0
OSCILLATOR
N
COUNTER SWITCHING TIME
T=(N)(1/f0)
Ⓒ
10k
0.1µf
µL914 (3 CANS)

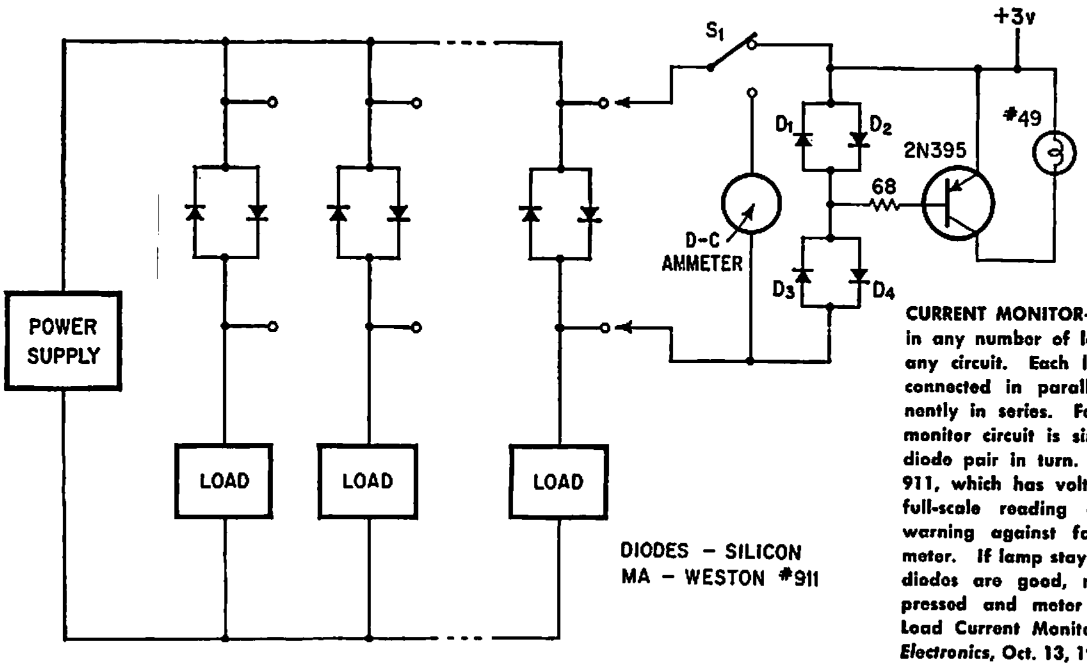
SWITCHING TIME—Combination of three µL914 R-S flip-flops, 100-kHz oscillator, and counter provides accurate measurement of response time of spdt microswitch S1, in millisecond range. When switch is activated, contact A opens first, making gate B transmit oscillator signal to counter after flip-flop changes state. When contact B of switch closes, flip-flop is reset, and signal to counter is blocked. Formula shown then gives switching time, where N is number of counts registered. With 10-MHz oscillator, switching times down to hundreds of nanoseconds can be measured.—R. Iltis, IC Circuit Measures Speed of Switches, *Electronics*, May 12, 1969, p 108.


+
+4·8V
R2
200Ω
R1
1kΩ
R4
1kΩ
±1mA
TR2
BCY72
+2·8V
TR3
BCY72
BCY87
TR1a
+2·2V
TR1b
Rs
Vs
R5
10kΩ
12V
0V
R3
1·8kΩ
-7·2V
R6
15kΩ
-

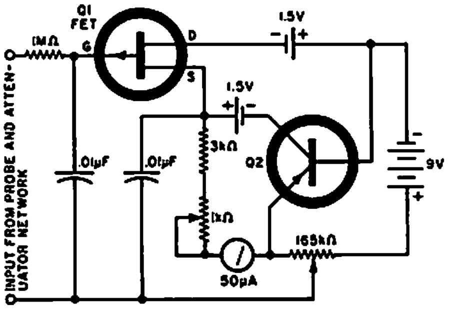
GALVANOMETER AMPLIFIER—Amplifies small direct current sufficiently to drive rugged zero-center 1-mA meter. Consists of long-tailed pair directly coupled to two emitter-followers connected to output meter. R2 permits adjusting meter current to zero for zero input voltage. With 10-ohm meter, 30-mV input gives full-scale deflection. Corresponding input value is 34 mV for 220-ohm meter. Input current for zero output is typically 65 nA, and 90 nA for full-scale deflection.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 15.


+
R2
200Ω
R1
1kΩ
R4
1kΩ
R5
8·2kΩ
±1mA
TR2
BCY72
TR3
BCY72
R7
4·7MΩ
R8
4·7MΩ
BCY87
TR1a
TR1b
Rs
Vs
12V
R3
1·8kΩ
R6
15kΩ
-

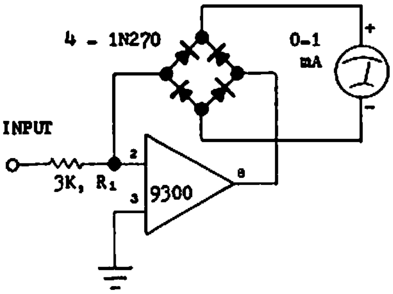
GALVANOMETER AMPLIFIER—Gives full-scale deflection of rugged zero-center 1-mA meter for input current of 35 nA. Maximum differential voltage drift is 7.5 μV per deg C, which is 2.5 times maximum voltage drift. Uses bias arrangement in which half the difference between input transistor base currents passes through signal source.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 16.


S1
+3V
#49
D1
D2
2N395
68
D-C
AMMETER
D3
D4
POWER
SUPPLY
LOAD
LOAD
LOAD
DIODES - SILICON
MA - WESTON #911

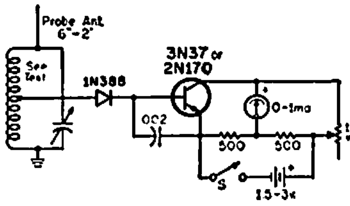
CURRENT MONITOR—Permits checking current in any number of loads without interrupting any circuit. Each load has pair of diodes, connected in parallel front-to-back, permanently in series. For checking load current, monitor circuit is simply placed across each diode pair in turn. Meter is Weston Model 911, which has voltage drop of 100 mV at full-scale reading of 10 A. Lamp gives warning against faulty diodes, to protect meter. If lamp stays off, indicating that both diodes are good, momentary switch S1 is pressed and meter is read.—F. H. Horan, Load Current Monitor Doesn't Break Circuit, *Electronics*, Oct. 13, 1969, p 93.


INPUT FROM PROBE AND ATTEN-UATOR NETWORK
1MΩ
Q1 FET
G
D
S
1.5V
1.5V
.01μF
.01μF
3kΩ
Q2
9V
1kΩ
165kΩ
50μA

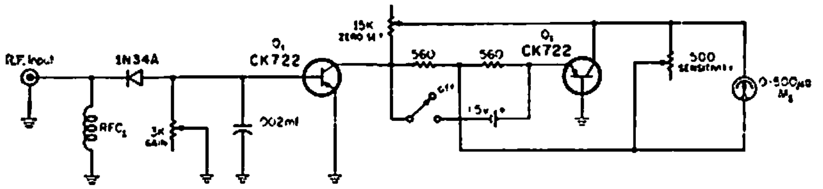
TRANSISTORIZED MULTIMETER—Use of fet with its high input impedance, in cascade with conventional transistor Q2 having low output impedance, gives advantages of vtvm. Circuit shown is simplified; complete circuit with transistor types and switching network is given in Triplett Model 600 service manual.—Triplett Model 600 Transistorized V.O.M., *Electronics World*, Aug. 1967, p 74.


4 - 1N270
0-1 mA
INPUT
3K, R1
2
3
8
9300

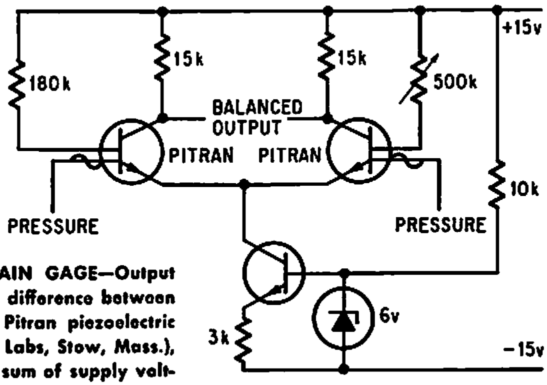
WIDEBAND METER DRIVER—OEI 9300 opamp with bridge rectifier in feedback path responds to average value of input regardless of whether it is d-c, sinusoidal, or any other waveform at frequencies up to 1 MHz. Serves as voltmeter.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


Probe Ant. 6"-2'
See text
1N388
3N37 or 2N170
.002
0-1ma
500
500
15K
S
1.5-3v

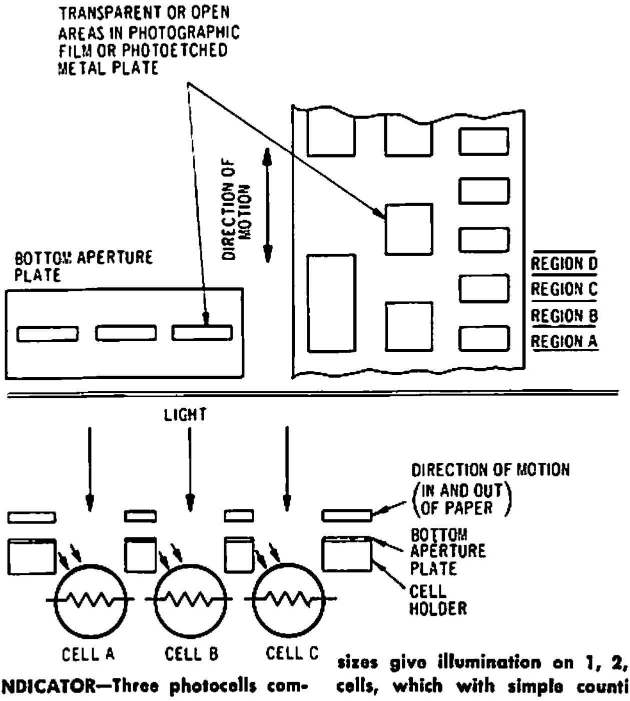
FIELD STRENGTH METER—Simple single-transistor circuit can be used for transmitter tune-up, adjustment of beam antennas, or as monitor if phones are connected in series with meter and collector of transistor. Use coil and tuning capacitor that will resonate at desired frequency; for 10 or 20 meters, coil can be six turns of No. 22 enamel spaced slightly on 1-inch form and tapped two turns from ground end. Any good npn transistor may be used.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 81.


R.F. Input
1N34A
Q1 CK722
15K
560
560
Q2 CK722
500
0-500μa
RFC1
3K
.002mf
1.5v

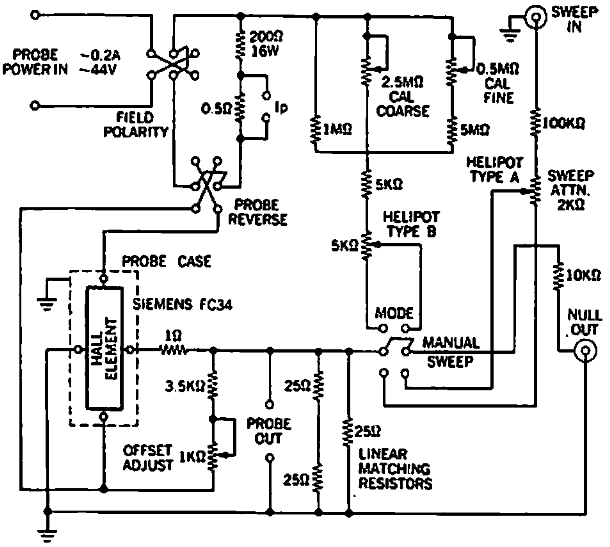
UNTUNED FIELD STRENGTH METER—Untuned choke input for diode eliminates need for tuning and plug-in coils, and high-gain two-transistor d-c amplifier provides required sensitivity. Any other high-gain transistors may be used.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 82.


+15v
180k
15k
15k
500k
BALANCED OUTPUT
PITRAN
PITRAN
10k
PRESSURE
PRESSURE
6v
3k
-15v

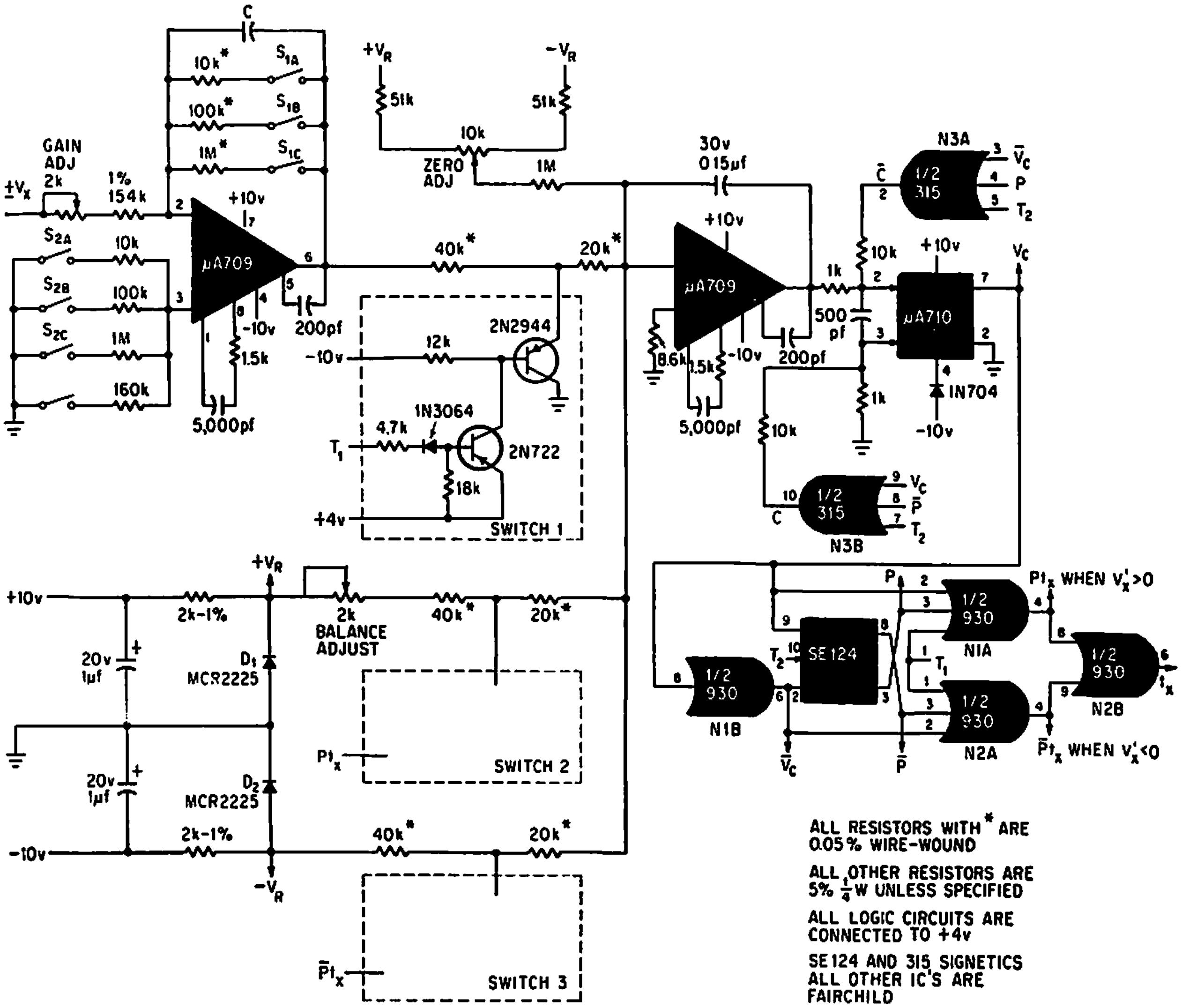
DIFFERENTIAL-PITRAN STRAIN GAGE—Output is linearily proportional to difference between pressures applied to two Pitran piezoelectric transistors (made by Stow Labs, Stow, Mass.), and can be up to 20% of sum of supply voltages. Applications discussed in article include seismic exploration, accelerometers, and wind-tunnel research. Transistor type is not critical. Pulse width modulation output for telemetry can be obtained by adding simple mvbr.—R. M. Moore, Semiconductor Gages Make Sense in Most Transducer Applications, *Electronics*, March 18, 1968, p 109–116.


TRANSPARENT OR OPEN AREAS IN PHOTOGRAPHIC FILM OR PHOTOETCHED METAL PLATE
DIRECTION OF MOTION
BOTTOM APERTURE PLATE
REGION D
REGION C
REGION B
REGION A
LIGHT
DIRECTION OF MOTION (IN AND OUT OF PAPER)
BOTTOM APERTURE PLATE
CELL HOLDER
CELL A
CELL B
CELL C

POSITION INDICATOR—Three photocells combined with fixed and moving aperture plates can be arranged to measure either linear or angular position with high degree of accuracy. Combinations of different aperture sizes give illumination on 1, 2, or 3 photocells, which with simple counting logic circuits can be converted into total number of smallest units of displacement.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 25.


PROBE POWER IN ~0.2A ~44V
FIELD POLARITY
200Ω 16W
0.5Ω
Ip
PROBE REVERSE
1MΩ
2.5MΩ CAL COARSE
0.5MΩ CAL FINE
5MΩ
SWEEP IN
100KΩ
HELIPOT TYPE A
SWEEP ATTN. 2KΩ
5KΩ
HELIPOT TYPE B
5KΩ
PROBE CASE
SIEMENS FC34
HALL ELEMENT
1Ω
3.5KΩ
25Ω
PROBE OUT
OFFSET ADJUST 1KΩ
25Ω
25Ω LINEAR MATCHING RESISTORS
MODE
MANUAL
SWEEP
10KΩ
NULL OUT

HALL PROBE FIELD CONTROL—Probe consists of Siemens FC-34 Hall element and circuitry needed to adjust for Hall arm offset, plus loading resistors for linearizing probe response. Output of Hall element is about 20 mV per kilogauss for input current of 0.2 A. Used in measuring transverse dHS effect in bismuth at liquid helium temperatures.—R. D. Brown III, New Methods for De Haas-Shubnikov Measurements, *IBM Journal*, Nov. 1966, p 462–471.


C
10k* S1A
100k* S1B
1M* S1C
GAIN ADJ 2k
±Vx
1% 154k
S2A 10k
S2B 100k
S2C 1M
160k
μA709
+10v
-10v
1.5k
5,000pf
200pf
+VR
-VR
51k
51k
10k
ZERO ADJ
1M
40k*
20k*
12k
2N2944
-10v
1N3064
4.7k
T1
2N722
18k
+4v
SWITCH 1
30v 0.15μf
+10v
μA709
8.6k
1.5k
-10v
200pf
5,000pf
10k
1k
500 pf
10k
1k
μA710
+10v
1N704
-10v
N3A
1/2 315
C̄
Vc
P
T2
N3B
1/2 315
C
V̄c
P̄
T2
+10v
2k-1%
+VR
2k BALANCE ADJUST
40k*
20k*
20v 1μf
D1 MCR2225
D2 MCR2225
20v 1μf
Ptx
SWITCH 2
-10v
2k-1%
-VR
40k*
20k*
P̄tx
SWITCH 3
SE124
T2
T1
1/2 930 N1A
1/2 930 N2A
1/2 930 N1B
1/2 930 N2B
Ptx WHEN V'x>0
P̄tx WHEN V'x<0
tx
Vc
P̄

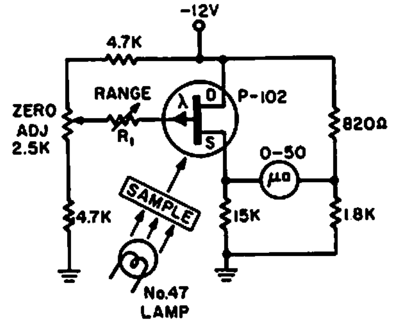
ALL RESISTORS WITH * ARE 0.05% WIRE-WOUND

ALL OTHER RESISTORS ARE 5% $\frac{1}{4}$W UNLESS SPECIFIED

ALL LOGIC CIRCUITS ARE CONNECTED TO +4v

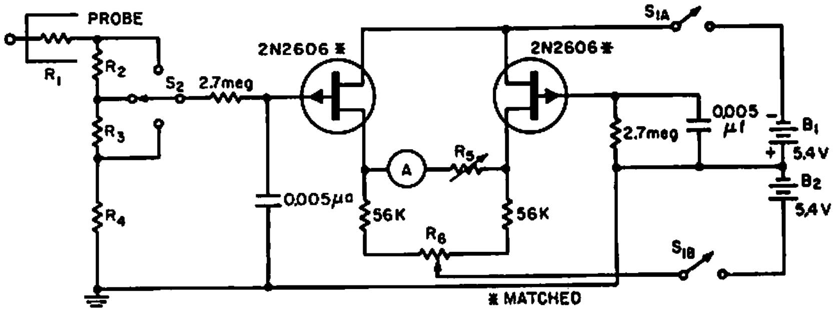
SE124 AND 315 SIGNETICS
ALL OTHER IC'S ARE FAIRCHILD

IC DIGITAL VOLTMETER—Use of low-cost IC linear amplifiers and IC logic chips minimizes cost of instrument comparable in performance to conventional four-digit voltmeters costing over $1,000. Uses up-down modulation to convert unknown analog voltage to digital pulse-width signal that is converted from bcd value in counter to decimal value for reading on Nixie tubes. Circuit shown is analog portion, for pulse-width modulator, which includes range selection, integrator, comparator, three solid-state shunt switches, output logic, and reference voltage.—H. Schmid, Digital Meters for Under $100, *Electronics*, Nov. 28, 1966, p 88–94.

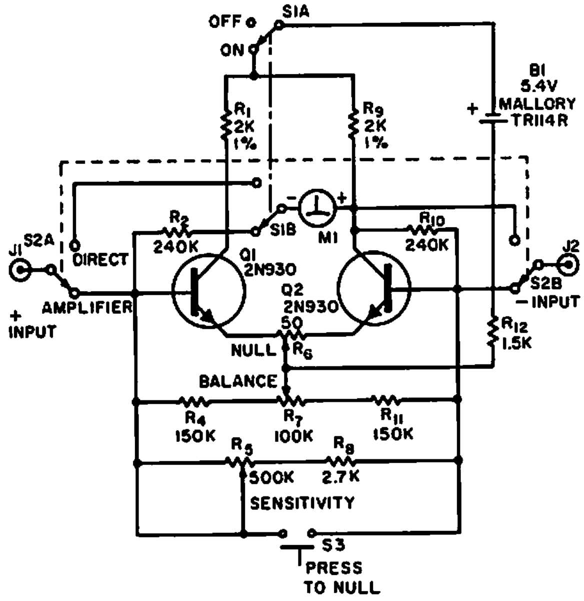

-12V
4.7K
RANGE
ZERO ADJ 2.5K
R1
D
P-102
S
820Ω
0-50 μa
SAMPLE
4.7K
15K
1.8K
No.47 LAMP

R1 RANGE RESISTOR VALUE	FULL-SCALE OPTICAL DENSITY CALIBRATION
10K	0.0 (100% TRANS)
100K	1.0 (10% TRANS)
1MEG	2.0 (1% TRANS)
10MEG	3.0 (0.1% TRANS)
100MEG	4.0 (0.01% TRANS)

PHOTOMETER—Used to measure changes in optical density of translucent materials. Setting of R1 determines full-scale range. Minimum full-scale range, for 0.01% transmission or density of 4.0, is obtained with 100 meg.—M. Shipley, Using Photo Field-Effect Transistors, *Electronic Design*, Aug. 31, 1964, p 76.

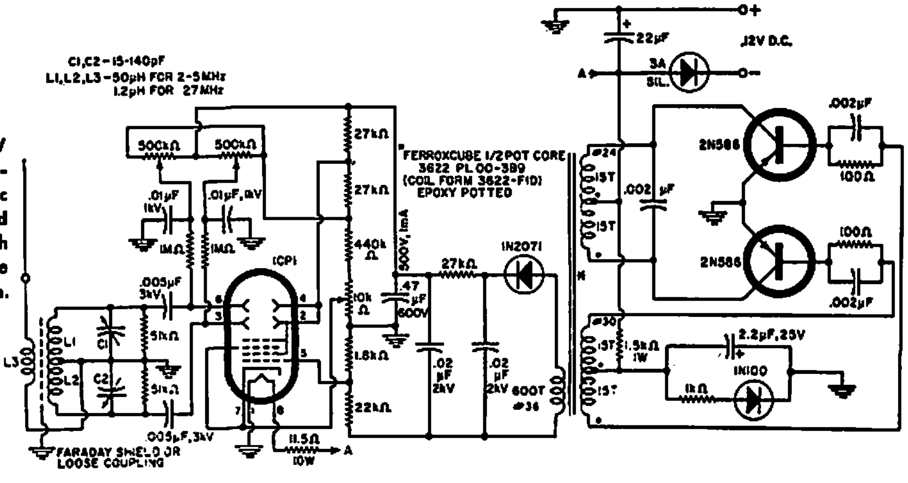

PROBE
R1
R2
S2
2.7meg
R3
R4
2N2606 *
2N2606 *
A
R5
0.005μa
56K
56K
R6
S1A
0.005 μf
2.7meg
B1 5.4V
B2 5.4V
S1B
* MATCHED

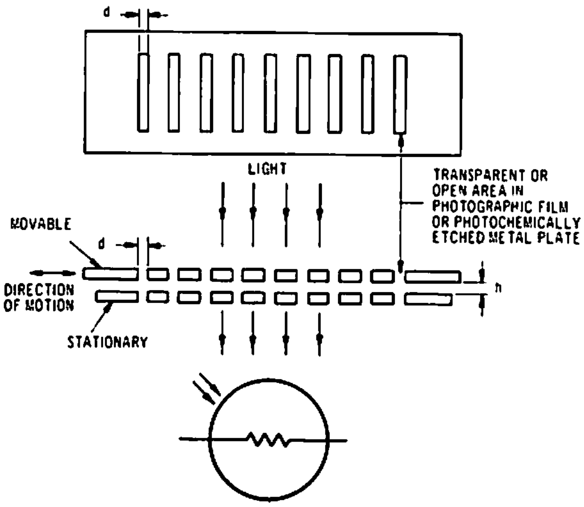
FET VTVM—Can be mounted directly on small meter. Input impedance is 30 meg. Ranges are 2, 10, and 20 V. Resistor values are: R1 15 meg; R2 12 meg; R3 1.5 meg; R4 1.5 meg; R5 10,000; R6 5,000.—Field Effect Voltmeter, *Electronic Design*, Jan. 6, 1964, p 78.


OFF
ON
S1A
B1 5.4V MALLORY TR114R
R1 2K 1%
R9 2K 1%
M1
S1B
R2 240K
R10 240K
J1
S2A
DIRECT
AMPLIFIER
+ INPUT
Q1 2N930
Q2 2N930
J2
S2B
- INPUT
50
NULL R6
R12 1.5K
BALANCE
R4 150K
R7 100K
R11 150K
R5 500K
R8 2.7K
SENSITIVITY
S3
PRESS TO NULL

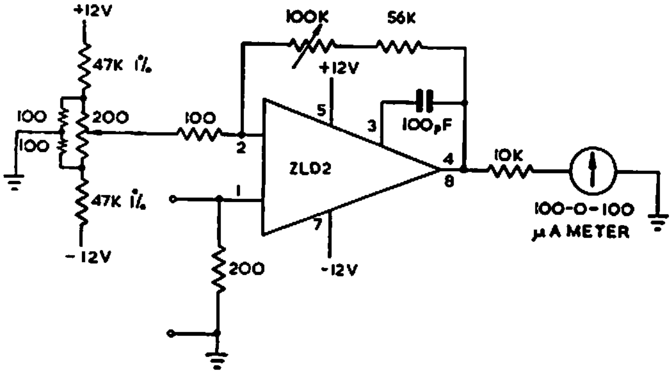
DIFFERENTIAL MICROAMMETER AMPLIFIER—Differential amplifier, using degenerative biasing and collector feed to 100-μA meter, gives excellent null stability and 2-μA instrument sensitivity.—J. P. Graham, Galvanometer Amplifier Has Greater Sensitivity, *Electronic Design*, Feb. 17, 1964, p 90–91.

% MODULATION ON CRT—Operates off 12-V battery for measuring percentage of amplitude modulation of transmitter when no a-c power is available. Percentage is indicated as ratio of radii of two circles on 1-inch cathode-ray tube.—D. Stephani, Amplitude Modulation Tester, *Electronics World*, Jan. 1968, p 51.

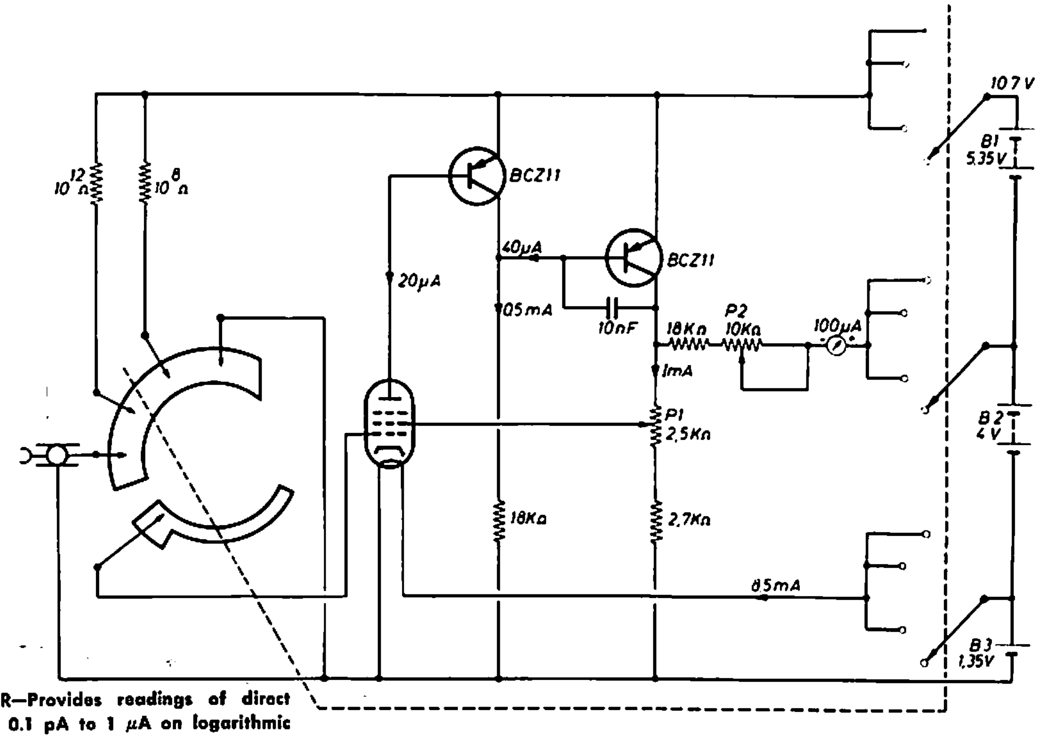

C1,C2-15-140pF
L1,L2,L3-50μH FOR 2-5MHz
1.2μH FOR 27MHz
500kΩ
500kΩ
.01μF 1kV
.01μF, 1kV
1MΩ
1MΩ
1CP1
.005μF 3kV
L1
C1
5kΩ
L3
L2
C2
5kΩ
.005μF, 3kV
FARADAY SHIELD OR LOOSE COUPLING
11.5Ω 10W
A
27kΩ
27kΩ
440kΩ
10kΩ
1.8kΩ
22kΩ
500V, 1mA
.47 μF 600V
*FERROXCUBE 1/2POT CORE 3622 PL00-3B9 (COIL FORM 3622-F1D) EPOXY POTTED
27kΩ
1N2071
.02 μF 2kV
.02 μF 2kV
600T #36
+
22μF
12V D.C.
3A SIL.
#24
15T
15T
.002 μF
2N586
2N586
.002μF
100Ω
100Ω
.002μF
#30
15T
15T
1.5kΩ 1W
2.2μF, 25V
1N100
1kΩ


d
LIGHT
TRANSPARENT OR OPEN AREA IN PHOTOGRAPHIC FILM OR PHOTOCHEMICALLY ETCHED METAL PLATE
MOVABLE
d
DIRECTION OF MOTION
h
STATIONARY

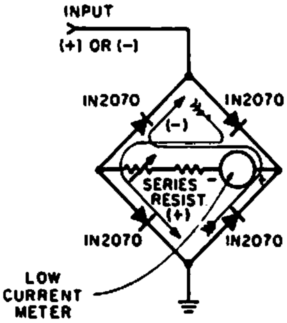
DISPLACEMENT DETECTOR—Object being monitored is attached to movable top plate, which may be photographic film or etched metal having apertures only a few thousandths of an inch wide. Movement equal to aperture width changes light on photocell from maximum to zero. Resulting change in photocell current or impedance is then measured with conventional meter-driving circuit that can be calibrated to read displacement. "Solid State Photosensitive Devices," RCA, Harrison, N.J., p 25.


+12V
47K 1%
100
100
200
100
2
100K
56K
+12V
5
3
100pF
ZLD2
4
8
1
7
10K
100-0-100
μA METER
47K 1%
-12V
200
-12V

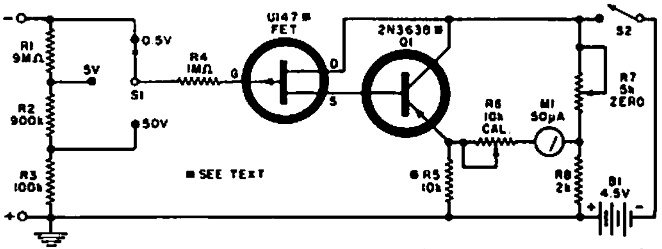
EXTENDING RANGE OF D-C MICROAMMETER—Uses Ferranti ZLD2 IC differential amplifier as d-c amplifier for converting 100-0-100 μA meter to rugged 10-μA meter. Offset of IC is eliminated by adjusting 200-ohm pot until output is zero for zero input. For calibration, apply known input current and adjust 100K pot until correct output reading is obtained. For 1% meter accuracy, temperature should be held within 3 C of calibration temperature.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 19.


10¹²Ω
10⁸Ω
BCZ11
40μA
BCZ11
20μA
05mA
10nF
18KΩ
P2
10KΩ
100μA
1mA
P1
2,5KΩ
18KΩ
2,7KΩ
85mA
107V
B1
5.35V
B2
4V
B3
1.35V

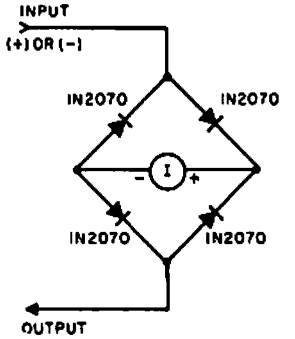
ELECTROMETER—Provides readings of direct currents from 0.1 pA to 1 μA on logarithmic scale, using Philips type 4068 electrometer tube. Report deals with measuring techniques and precautions for achieving maximum accuracy.—Electrometer Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 11, 1965, p 6.


INPUT
(+) OR (-)
IN2070
IN2070
(-)
SERIES RESIST (+)
IN2070
IN2070
LOW CURRENT METER

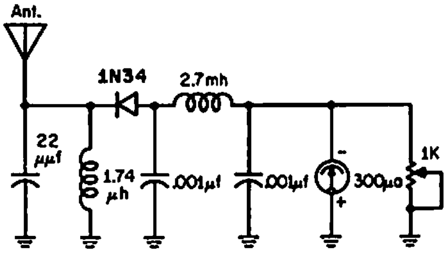
AUTOMATIC REVERSAL OF VOLTMETER—Low-loss diodes in bridge provide automatic reversal of polarity, without switching, when testing both npn and pnp transistors. Diodes are inexpensive and often cheaper than reversing switch, and do not introduce more than 10% error when measuring voltages above 5 V.—R. M. Mann, Low-Loss Diodes Reverse Meter Polarity, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 152.


-
R1 9MΩ
R2 900k
R3 100k
+
5V
0.5V
S1
50V
R4 1MΩ
U147 ■ FET
G
D
S
2N3638 ■ Q1
■ SEE TEXT
● R5 10k
R6 10k CAL.
M1 50μA
R7 5k ZERO
R8 2k
B1 4.5V
+
-
S2

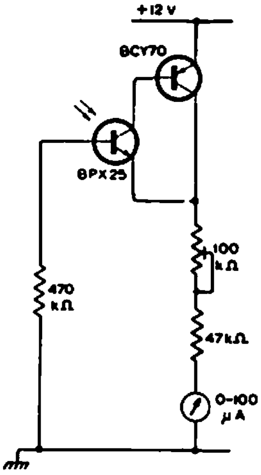
VTVM—Simple transistorized version of popular vacuum-tube voltmeter circuit uses inexpensive fet to give input impedance of 10 meg. Linear response permits using scale markings of meter. Battery drain is only 1 mA. Changing R7 to 2,500 ohms will give better resolution. (Changes are described in reader letter on p 12 of Nov. 1967 *Electronics World.*)—J. Randall, FET Voltmeter, *Electronics World*, Feb. 1967, p 63–64.


INPUT
(+) OR (-)
IN2070
IN2070
-
I
+
IN2070
IN2070
OUTPUT

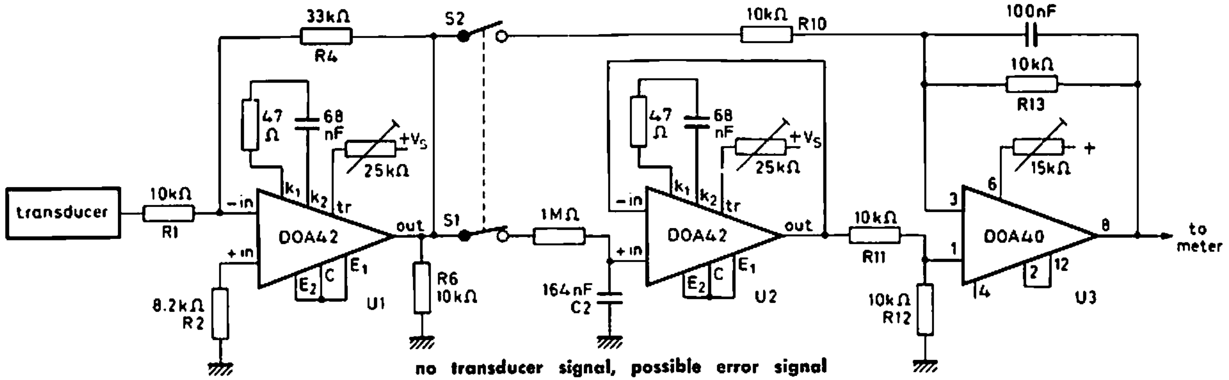
AUTOMATIC REVERSAL OF AMMETER—Low-loss diodes in bridge provide automatic reversal of polarity, without switching, when making current measurements in npn and pnp transistor test circuits. Error due to bridge is negligible except at extremely small currents, because leakage in diodes shunting meter is extremely low.—R. M. Mann, Low-Loss Diodes Reverse Meter Polarity, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 152.


Ant.
1N34
2.7mh
22 μμf
1.74 μh
.001μf
.001μf
-
+
300μa
1K

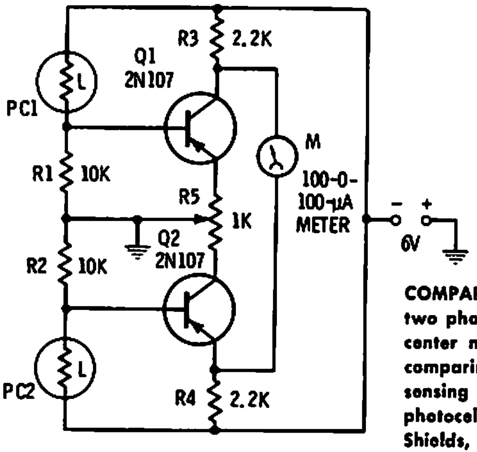
DIODE METER—Though low in sensitivity, will provide satisfactory indication of relative signal strength of transmitter in same room. Antenna is short length of insulated wire.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 89.


+12 V
BCY70
BPX25
470 kΩ
100 kΩ
47kΩ
0-100 μA

LINEAR LIGHT METER—Feedback across emitter resistor of BCY70 transistor stabilizes gain of BPX25 phototransistor. With values shown, 1,000 lux gives full-scale deflection of meter. May be calibrated either against standard light source or with another luxmeter.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.

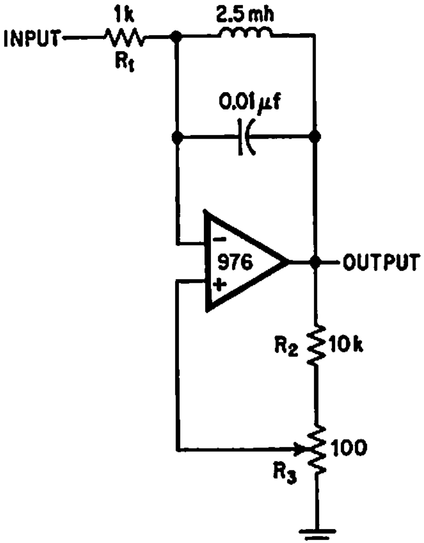

33kΩ
R4
S2
10kΩ R10
100nF
10kΩ
R13
47 Ω
68 nF
+Vs
25kΩ
k1
k2
tr
-in
+in
DOA42
out
E1
E2
C
U1
transducer
10kΩ
R1
8.2kΩ
R2
S1
R6 10kΩ
1MΩ
164nF
C2
47 Ω
68 nF
+Vs
25kΩ
-in
+in
k1
k2
tr
DOA42
out
E1
E2
C
U2
10kΩ
R11
10kΩ
R12
15kΩ
+
3
6
1
DOA40
8
4
2
12
U3
to meter

TRANSDUCER DRIFT COMPENSATION—Used to eliminate or greatly reduce zero error caused by drift in transducer and preamplifier of measuring circuit. Requires +15 V and −15 V supplies. With S1 closed (S2 open) and no transducer signal, possible error signal from transducer is amplified by opamp U1 and applied to opamp U2 connected as hold circuit feeding differential amplifier U3. After about 1 s, S2 is closed and transducer activated. Stored signal then cancels zero error, so measured value appears without error at output of U3.—P. Havas, Compensation of Transducer Zero Error, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 78.

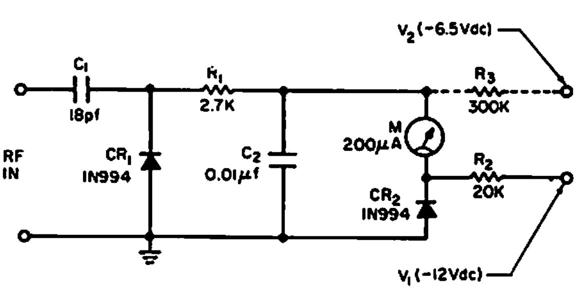

PC1
R1 10K
R2 10K
PC2
L
L
Q1
2N107
R3 2.2K
R5
1K
Q2
2N107
R4 2.2K
M
100-0-100-µA
METER
- +
6V

PC1, PC2 • LAFAYETTE #99-H-6309

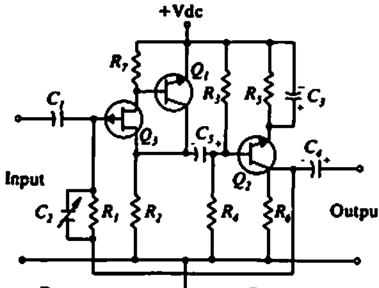
COMPARATOR—Circuit determines which of two photocells is illuminated and drives zero-center meter accordingly. May be used for comparing brilliance of two light sources, sensing position of vane moving between photocells, and comparing colors.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 80.


INPUT
1k
R1
2.5mh
0.01µf
976
-
+
OUTPUT
R2
10k
100
R3

Q MULTIPLIER—Simple opamp circuit provides means for varying Q of tuned circuit with single pot. Developed for low-level measurements in communication receivers and active filters. Will operate up to 3 MHz. Values shown are for resonant frequency of 33 kHz. —R. C. Gordos, Q-Multiplier Circuit Uses Op Amp With LC Feedback, *Electronics*, May 26, 1969, p 92.


C1
18pf
RF IN
CR1
IN994
R1
2.7K
C2
0.01µf
M
200µA
CR2
IN994
V2(-6.5Vdc)
R3
300K
R2
20K
V1(-12Vdc)

PEAK-READING VOLTMETER WITH DIODE—Addition of diode CR2 in series with meter of conventional peak-reading voltmeter improves its sensitivity, temperature characteristic, and low-level sensitivity and linearity. Extra diode also protects meter from current overload by opening above upper meter current limit as determined by R2 and V1. Performance is good up to 250 MHz, for input voltages below 0.4 V.—H. T. McAleer, Diode Improves Voltmeter's Linearity and Stability, *Electronic Design*, Nov. 22, 1965, p 65–67.


+Vdc
C1
Input
C2
R1
R2
Q2
R7
Q1
R3
R5
C3
C5
Q3
C4
R4
R6
Output

R_1	100 MΩ	R_7	18K
R_2	47K	C_1	1000 pF
R_3	100K	C_2	0–1 pF
R_4	470K	C_3	10 µF
R_5	6.8K	C_4	1 µF
R_6	22K	C_5	1 µF

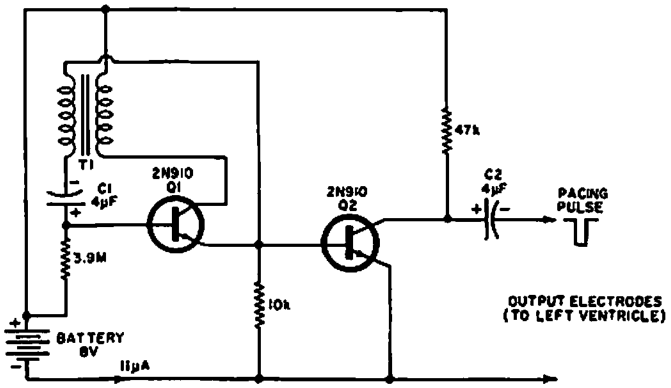
ELECTROMETER AMPLIFIER—Uses fet to measure currents as small as 0.1 pA at room temperature with 1 Hz bandwidth and approaching theoretical noise limit. Should be used with external filter that limits bandwidth, for optimum noise performance. Q1 is 2N697, Q2 is 2N2484, Q3 is 2N2606, and supply is 12 V.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 3.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

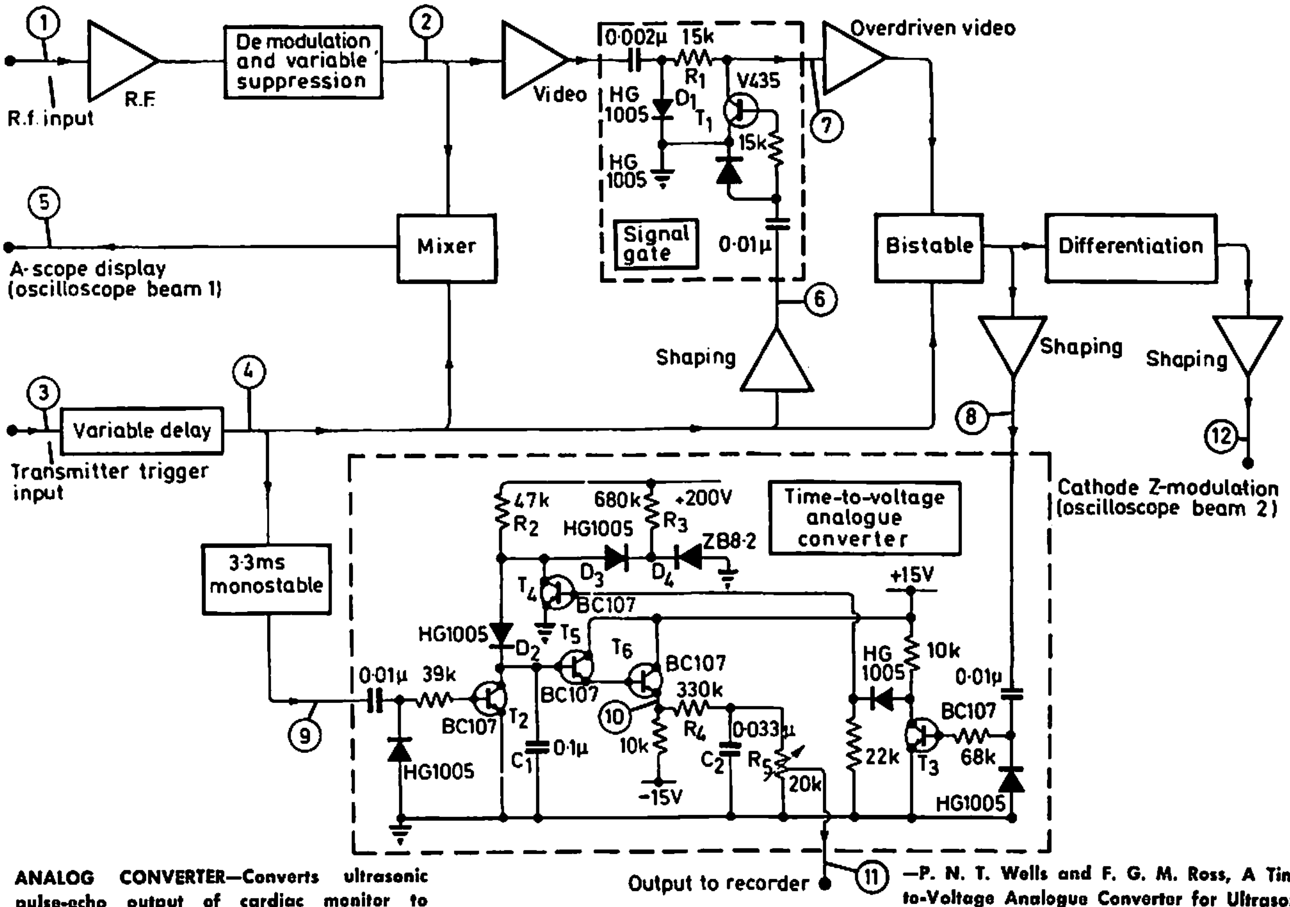
CHAPTER 50

Medical Circuits

PACEMAKER—Tv-type blocking oscillator Q1 generates fixed pacing pulse at rate determined before implantation and connection to heart. Oscillator generates very low-power pulse for triggering Q2, which then makes C2 deliver 1-ms pulse to heart.—J. T. Prentice, Electronic Implants, *Electronics World*, June 1968, p 46–48.

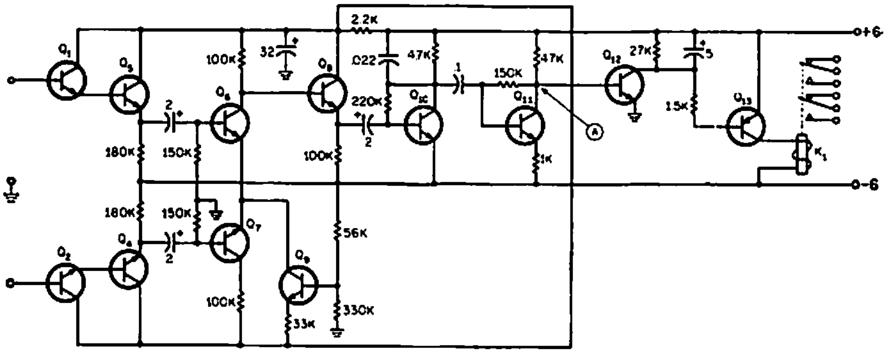


T1
C1
4μF
3.9M
2N910
Q1
2N910
Q2
47k
10k
C2
4μF
PACING
PULSE
OUTPUT ELECTRODES
(TO LEFT VENTRICLE)
BATTERY
8V
11μA



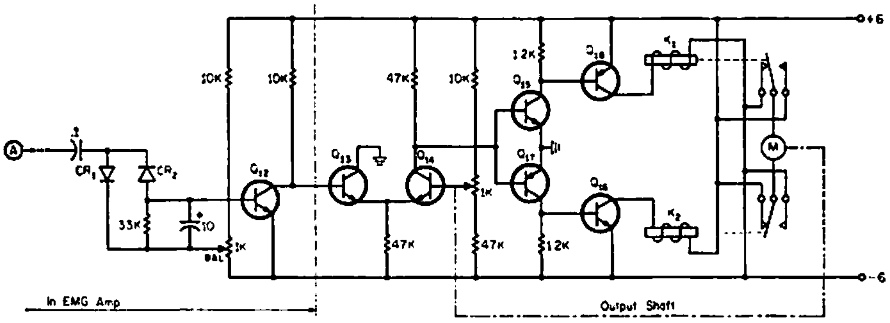
①
R.F
R.f. input
De modulation and variable suppression
②
Video
0·002μ
15k
R1
V435
HG 1005
D1
T1
15k
HG 1005
Signal gate
0·01μ
⑦
Overdriven video
⑤
A-scope display (oscilloscope beam 1)
Mixer
Bistable
Differentiation
⑥
Shaping
Shaping
Shaping
⑧
⑫
③
Variable delay
④
Transmitter trigger input
Cathode Z-modulation (oscilloscope beam 2)
3·3ms monostable
47k
R2
680k
R3
+200V
HG1005
ZB8·2
D3
D4
Time-to-voltage analogue converter
+15V
T4
BC107
HG1005
D2
T5
T6
BC107
0·01μ
39k
BC107
T2
BC107
330k
R4
0·033μ
HG 1005
10k
0·01μ
BC107
⑨
HG1005
C1
0·1μ
⑩
10k
C2
R5
20k
-15V
22k
T3
68k
HG1005
Output to recorder
⑪

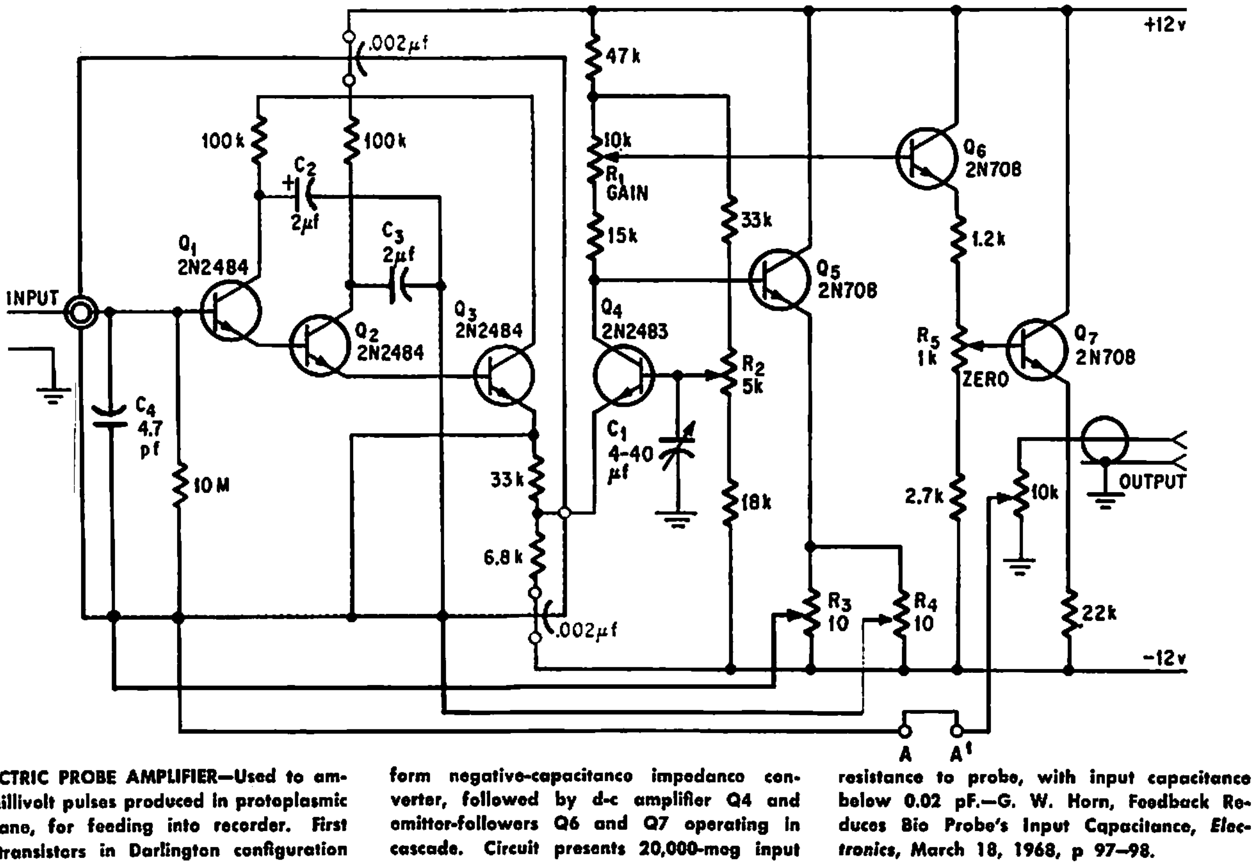
ANALOG CONVERTER—Converts ultrasonic pulse-echo output of cardiac monitor to square-wave pulses suitable for recording with high-speed ink-jet strip-chart recorders. Article describes operation of circuit in detail and gives examples of recordings obtained. —P. N. T. Wells and F. G. M. Ross, A Time-to-Voltage Analogue Convertor for Ultrasonic Cardiology, *Ultrasonics*, July 1969, p 171–176.


Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
2.2K
100K
32
.022
47K
.1
150K
47K
27K
5
220K
2
15K
K1
180K
150K
100K
1K
A
+6
-6
56K
330K
33K
2

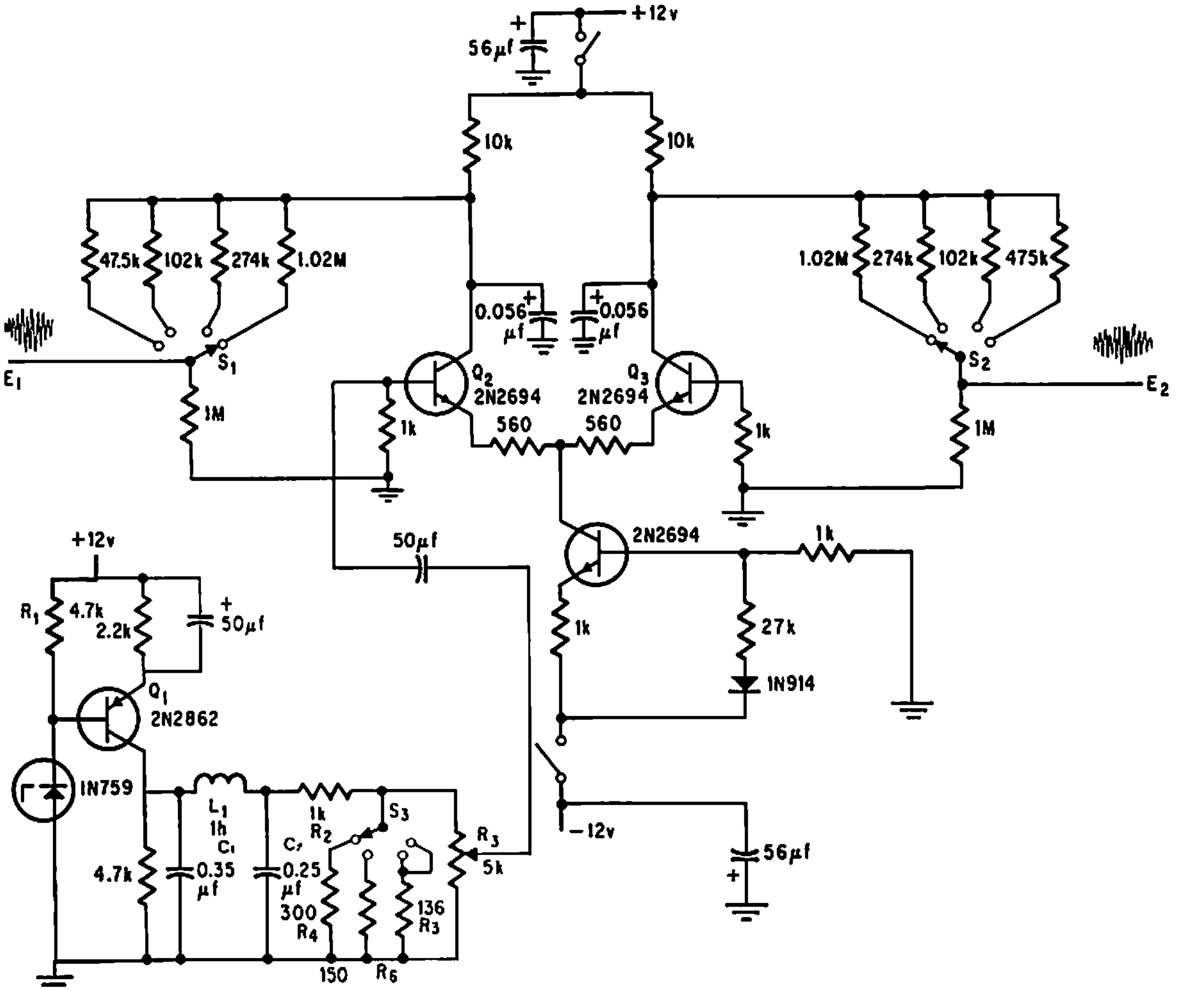
EMG KEYER—Electromyograph pulses picked up by silver electrodes held against stump muscle of amputee are fed to low-noise differential amplifier through impedance transformer. Output goes through conventional two-stage high-gain amplifier, detector, and d-c amplifier operating output relay used for keying amateur radio transmitter. Operator merely thinks of moving missing or paralyzed arm, to make relay operate. Bandwidth of amplifier is 50–500 Hz, corresponding to range of emg signals being picked up. Q13 is 2N-398 and other transistors are 2N708. Relay is Sigma SIL2500 or equivalent.—G. W. Horn, The Third Hand—An Aid for the Handicapped Operator, CQ, Feb. 1966, p 54–57.

EMG SERVO—Used with electromyograph amplifier to convert amplified muscle potential (taken ahead of detector) to appropriate input for position servo providing continuous control of angular position of tuning knob for amateur radio transmitter or receiver. Position of output motor shaft is proportional at any instant to mental effort exerted by amputee on stump muscle. Relaxing muscle makes shaft return to zero position, because decreasing signal voltage pulls in other output relay and reverses motor. Q16 is BFY-56, Q17 2N398, Q18 BFY64, and others 2N-708.—G. W. Horn, The Third Hand—An Aid for the Handicapped Operator, CQ, Feb. 1966, p 54–57.

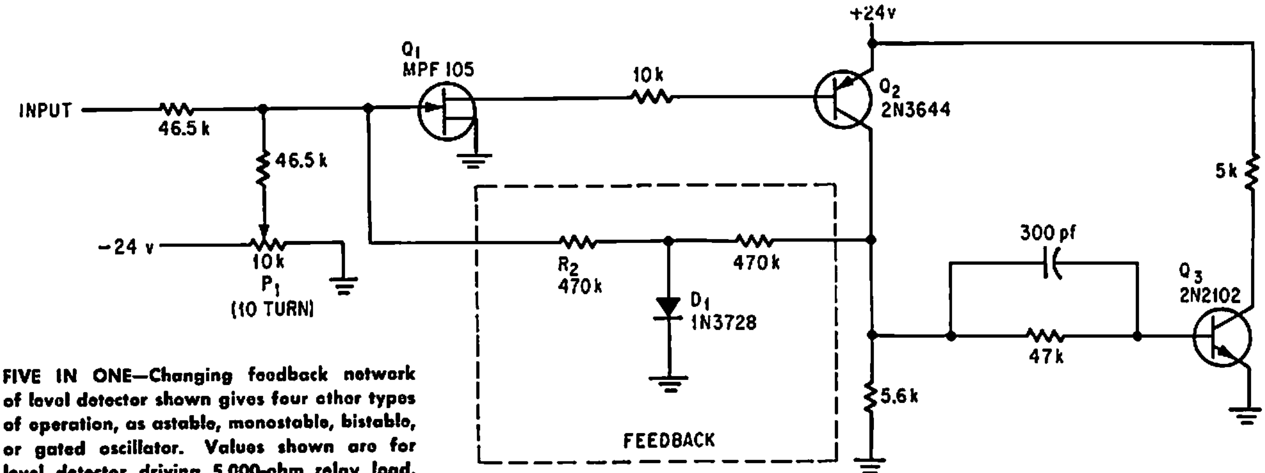

A
.1
CR1
CR2
33K
10
1K
BAL
10K
10K
Q12
Q13
Q14
47K
10K
1K
47K
47K
12K
12K
Q15
Q16
Q17
Q18
K1
K2
M
+6
-6
In EMG Amp
Output Shaft


.002μf
47k
+12v
100k
100k
C2
2μf
10k
R1
GAIN
Q6
2N708
33k
15k
1.2k
C3
2μf
Q1
2N2484
Q5
2N708
INPUT
Q2
2N2484
Q3
2N2484
Q4
2N2483
R5
1k
ZERO
Q7
2N708
R2
5k
C1
4-40
μf
C4
4.7
pf
10M
33k
18k
2.7k
10k
OUTPUT
6.8k
.002μf
R3
10
R4
10
22k
-12v
A
A'

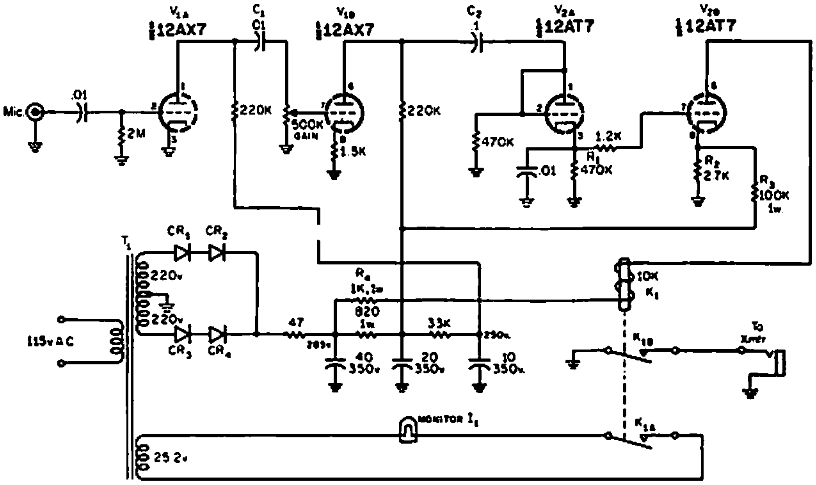
BIOELECTRIC PROBE AMPLIFIER—Used to amplify millivolt pulses produced in protoplasmic membrane, for feeding into recorder. First three transistors in Darlington configuration form negative-capacitance impedance converter, followed by d-c amplifier Q4 and emitter-followers Q6 and Q7 operating in cascade. Circuit presents 20,000-meg input resistance to probe, with input capacitance below 0.02 pF.—G. W. Horn, Feedback Reduces Bio Probe's Input Capacitance, *Electronics*, March 18, 1968, p 97–98.


+12v
56μf
10k
10k
47.5k
102k
274k
1.02M
1.02M
274k
102k
475k
0.056 μf
0.056 μf
E1
S1
1M
Q2
2N2694
Q3
2N2694
560
560
1k
1k
S2
E2
1M
+12v
50μf
2N2694
1k
R1
4.7k
2.2k
50μf
1k
27k
1N914
Q1
2N2862
1N759
L1
1h
C1
1k
R2
S3
R3
5k
−12v
56μf
4.7k
0.35 μf
C2
0.25 μf
300
R4
136
R5
150
R6

MUSCLE SIGNAL SIMULATOR—Simulates white noise generated in flexed muscle, for use in developing amplifiers and servomechanisms for controlling artificial limbs. Output of zener, serving as broad-spectrum noise generator, is amplified and filtered to give required 1-kHz bandwidth of noise.—W. Paisner, D. Antonelli, and W. Waring, Zener Simulates Muscle Signals, *Electronics*, June 10, 1968, p 111–112.

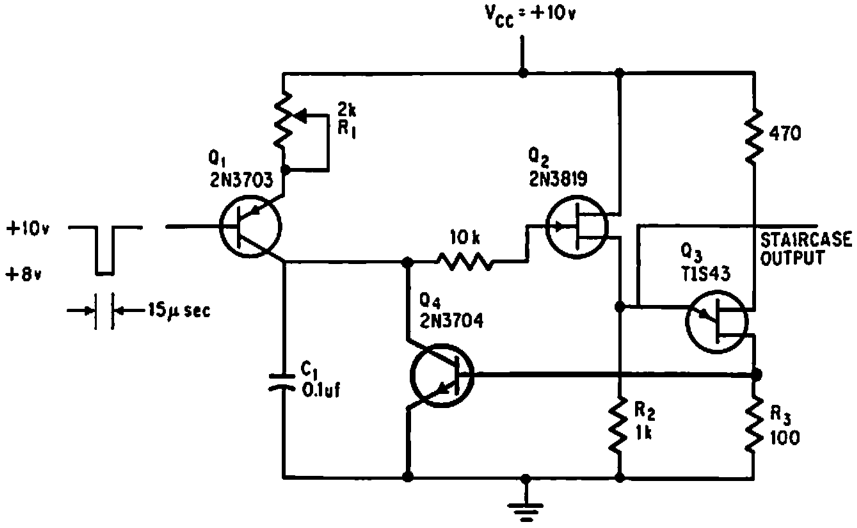

+24v
Q1
MPF 105
10k
Q2
2N3644
INPUT
46.5k
46.5k
5k
−24 v
10k
P1
(10 TURN)
R2
470k
470k
D1
1N3728
300 pf
Q3
2N2102
47k
5.6k
FEEDBACK

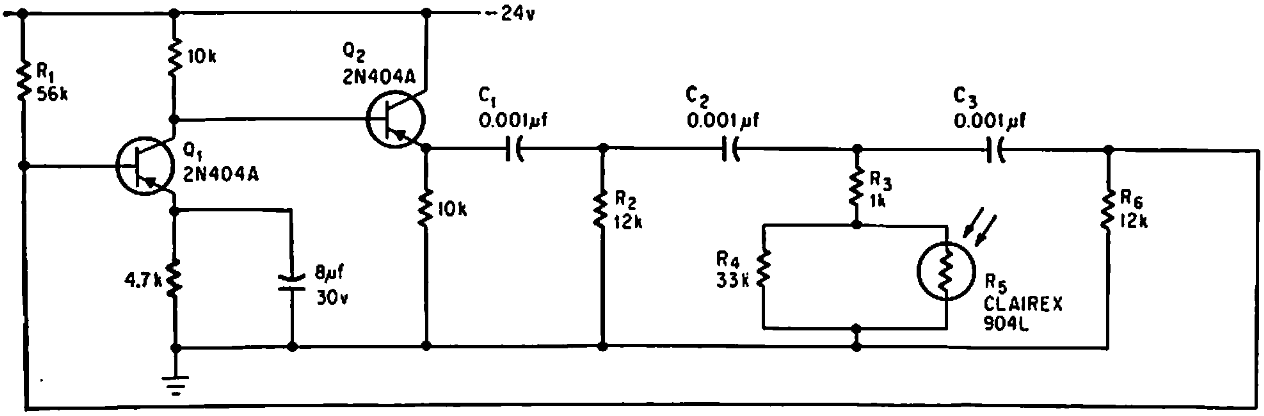
FIVE IN ONE—Changing feedback network of level detector shown gives four other types of operation, as astable, monostable, bistable, or gated oscillator. Values shown are for level detector driving 5,000-ohm relay load, used to analyze electroencephalographs. Input can be 0 to 20 V. Article tells how to change network for other types of operation. —G. Silverman, Five Valuable Circuits From Changes In Feedback, *Electronics*, Oct. 2, 1967, p 95–96.


V_{1A} ½12AX7
C_1 .01
V_{1B} ½12AX7
C_2 .1
V_{2A} ½12AT7
V_{2B} ½12AT7
Mic.
.01
2M
220K
500K GAIN
1.5K
220K
470K
.01
1.2K
R_1 470K
R_2 2.7K
R_3 100K 1w
T_1
CR_1 CR_2
220v
220v
CR_3 CR_4
115v AC
47
285v
R_4 1K, 1w
820 1w
33K
250v
40 350v
20 350v
10 350v
10K
K_1
K_{1B}
To Xmtr
MONITOR I_1
K_{1A}
25.2v

VOICE-OPERATED KEY—Developed for c-w amateur radio operators lacking full use of hands. Duration of sound at mike determines whether keying relay K1 produces dot or dash. Clearly spoken dah-dit-dah-dit dah-dah-dit-dah will give acceptable CQ in code after very little practice. Whistling also works. Other applications include keying of transmitter from magnetic tape recorder for on-the-air code classes.—A. Horst, The Vox Key, CQ, Jan. 1965, p 29–30.

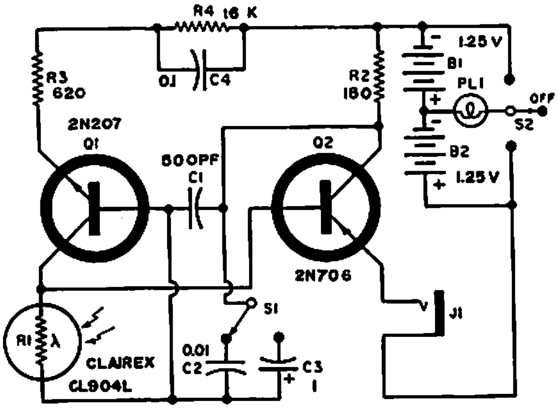
FET FLATTENS STEPS—Fet Q2 isolates waveforming capacitor from ujt of staircase generator, to prevent exponential decay or droop of staircase step voltage. Used as pulse counter, for accurately monitoring uterine contractions, heart beat, and respiration rate. —K. J. Bray, FET Keeps Long Staircase Steps Flat, *Electronics*, March 18, 1968, p 94.

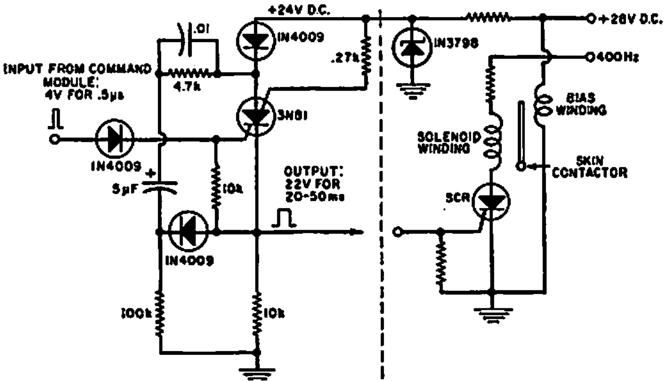

V_{CC} = +10v
2k R_1
Q_1 2N3703
Q_2 2N3819
470
+10v
+8v
15µ sec
10k
Q_3 T1S43
STAIRCASE OUTPUT
Q_4 2N3704
C_1 0.1uf
R_2 1k
R_3 100


–24v
R_1 56k
10k
Q_2 2N404A
Q_1 2N404A
C_1 0.001µf
C_2 0.001µf
C_3 0.001µf
10k
R_2 12k
R_3 1k
R_6 12k
4.7k
8µf 30v
R_4 33k
R_5 CLAIREX 904L

LIGHT-CONTROLLED OSCILLATOR—Addition of emitter-follower Q2 to phase-shift oscillator Q1 boosts output frequency 1.4 times, and gives greater frequency sensitivity to changes in light-sensitive resistor R5. One application is as psychological testing device that measures ability of subject to follow moving light source. For other applications, potentiometer in place of R5 will control frequency. —G. Silverman, Emitter Follower Enhances Oscillator's Frequency Variation, *Electronics*, Dec. 26, 1966, p 73–74.

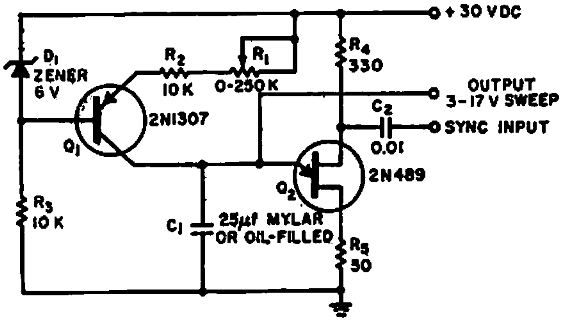
MOVEMENT SENSOR FOR BLIND—Used with interchangeable lenses to detect movements at various distances up to infinity, in science labs for blind students. Photoresistor R1 (Clairex CL904L or equivalent) produces frequency change in two-transistor RC feedback audio oscillator having small magnetic earphone in its output. PL1 is 1.25-V grain-of-wheat lamp used for cell illumination, as required for reading thermometer and sensing position of meter pointer.—Light Probe for the Blind, *Electronics World*, Nov. 1967, p 77.


R4 16 K
.01
C4
R3
620
R2
180
1.25V
B1
PL1
OFF
S2
B2
1.25V
2N207
Q1
500PF
C1
Q2
2N706
S1
J1
R1
λ
CLAIREX
CL904L
0.01
C2
C3
1

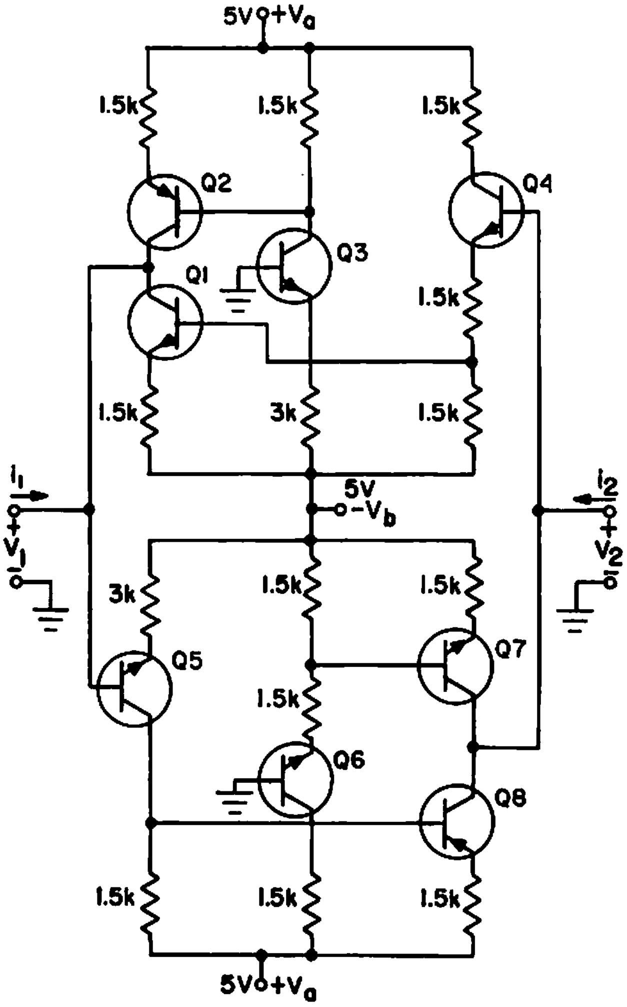

+24V D.C.
.01
1N4009
.27k
1N3798
+28V D.C.
400Hz
INPUT FROM COMMAND MODULE: 4V FOR .5μs
4.7k
3N81
BIAS WINDING
1N4009
5μF
10k
OUTPUT: 22V FOR 20-50ms
SOLENOID WINDING
SKIN CONTACTOR
SCR
1N4009
100k
10k

(A) PULSE STRETCHER (B) VIBROTACTOR

VIBROTACTOR—Developed for transmitting emergency signals to astronauts without using voice communication. Tiny vibrator, with solenoid winding, is attached to skin and actuated by pulses from communication link. Since taps on skin shorter than 0.5 μs cannot be felt by man, four-transistor pulse stretcher is used ahead of vibrator stage.—L. G. Lawrence, Communications Via Touch, *Electronics World*, May 1968, p 32–34 and 80.

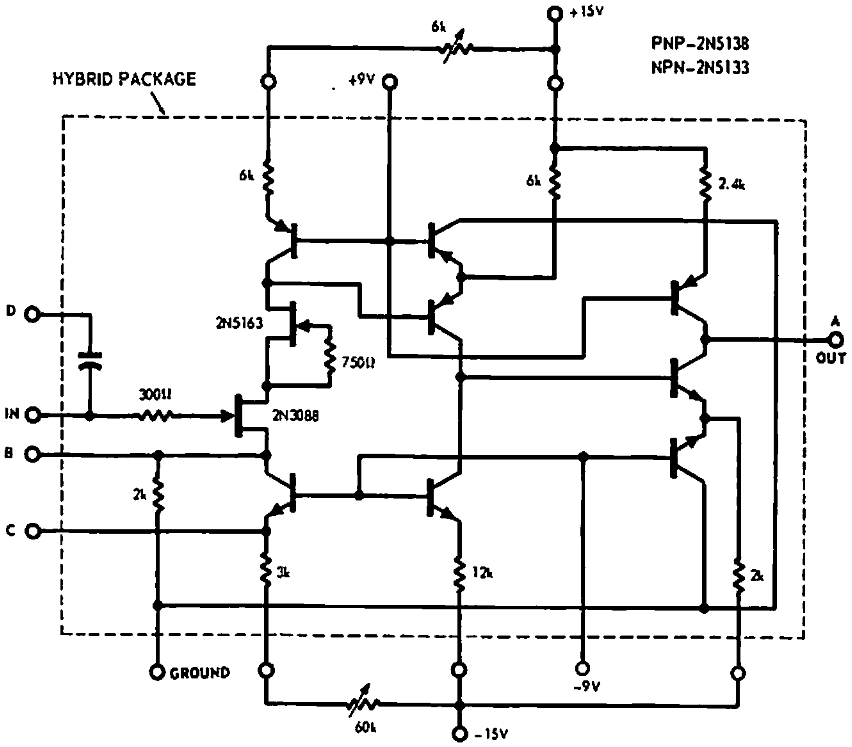

+30 VDC
D1
ZENER
6 V
R2
10 K
R1
0-250 K
R4
330
OUTPUT
3-17 V SWEEP
C2
SYNC INPUT
0.01
2N1307
Q1
Q2
2N489
R3
10 K
C1
25μf MYLAR OR OIL-FILLED
R5
50

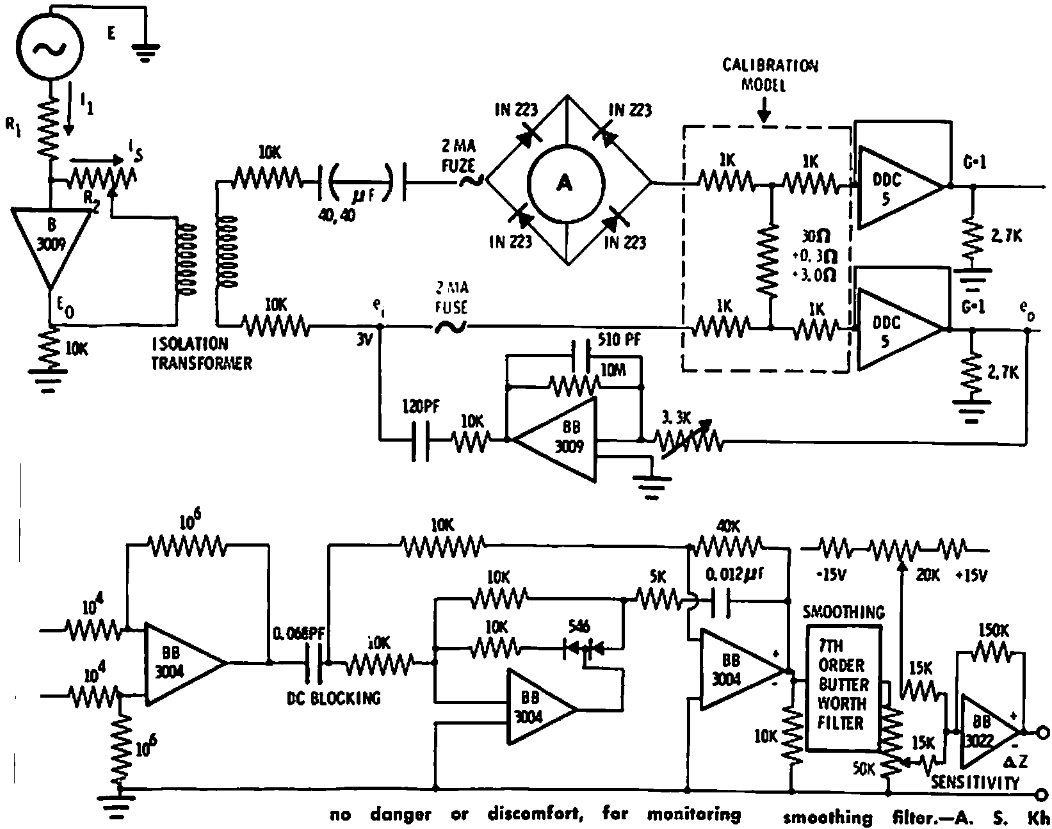
SLOW SWEEP FOR CARDIAC MONITOR—Slow linear sweep, adjustable by R1 from 1 to 30 s can be used for monitoring cardiac waveforms. Voltage ramp produced has less than 1% displacement error from linearity.—J. L. Aker, Unijunction Oscillator Gives 30-Sec Sweep, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 189.


5V +Va
1.5k
1.5k
1.5k
Q2
Q4
Q3
Q1
1.5k
1.5k
3k
1.5k
i1
+
V1
5V
-Vb
i2
+
V2
3k
1.5k
1.5k
Q5
Q7
1.5k
Q6
Q8
1.5k
1.5k
1.5k
5V +Va

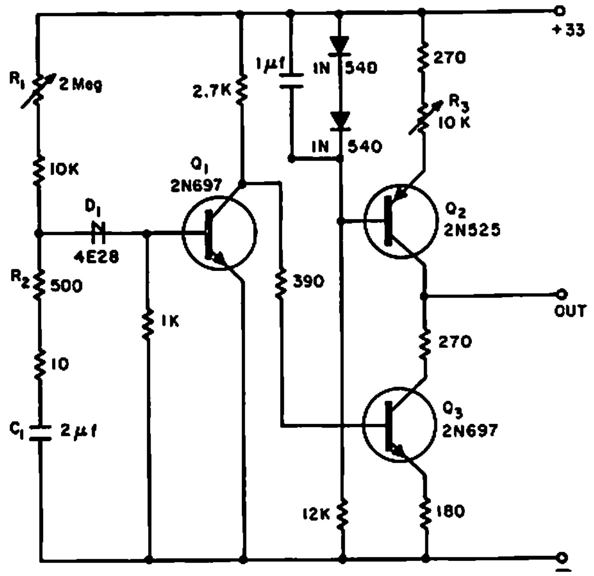
GYRATOR—Consists of two voltage-to-current negative-impedance convertors, connected to produce output current proportional to input voltage. In addition, reverse transconductance makes input current proportional to output voltage. Serves as active filter for very low frequencies used in oceanography, seismology, and medical electronics. Article gives application circuits for specific frequencies.—J. L. Hogin, Active Filters, *Electronics World*, April 1969, p 58–60.

NERVE AMPLIFIER—Low-noise hybrid IC amplifier substitutes for electrometer tube in amplifying nerve and muscle-fiber impulses picked up by electrodes attached to body. Circuit has high input resistance and good linearity.—J. Y. Lettvin, Low-Noise Electrometer Amplifier, *EDN*, Sept. 1, 1969, p 69–70.

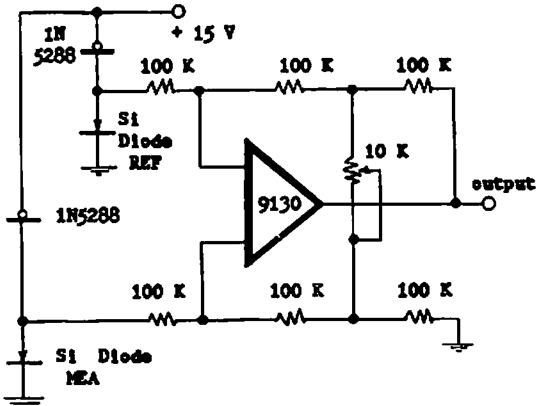

+15V
6k
PNP-2N5138
NPN-2N5133
HYBRID PACKAGE
+9V
6k
6k
2.4k
D
2N5163
750Ω
300Ω
IN
2N3088
B
2k
C
3k
12k
2k
A
OUT
GROUND
-9V
60k
-15V


E
I1
R1
IS
R2
B 3009
E0
10K
ISOLATION TRANSFORMER
10K
μF
40,40
2 MA FUZE
IN 223
IN 223
IN 223
IN 223
A
CALIBRATION MODEL
1K
1K
30Ω
+0.3Ω
+3.0Ω
1K
1K
DDC 5
DDC 5
G-1
G-1
2.7K
2.7K
e0
10K
e1
3V
2 MA FUSE
510 PF
10M
120PF
10K
BB 3009
3.3K
10^6
10^4
10^4
10^6
BB 3004
0.068PF
DC BLOCKING
10K
10K
10K
10K
546
BB 3004
5K
40K
0.012μf
BB 3004
10K
-15V
20K
+15V
SMOOTHING
7TH ORDER BUTTER WORTH FILTER
15K
15K
50K
150K
BB 3022
ΔZ
SENSITIVITY

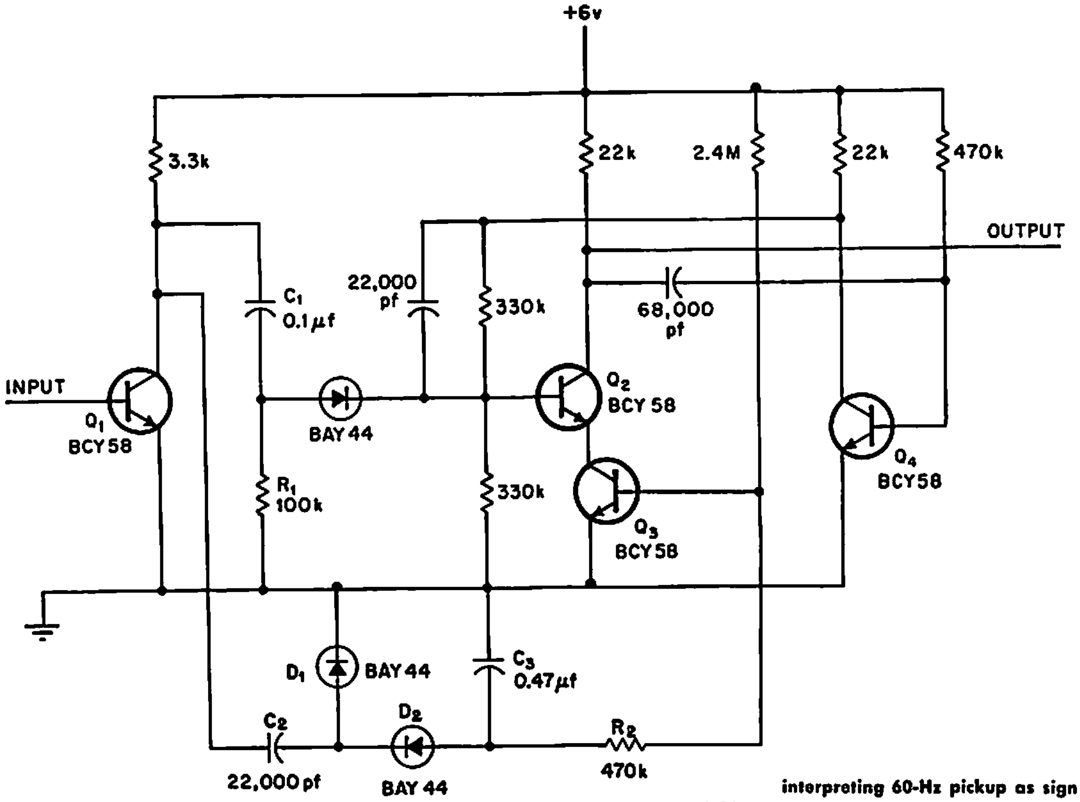
PLETHYSMOGRAPH—Low-frequency impedance plethysmograph provides current of 1 mA at frequencies as low as 10 Hz to subjects with no danger or discomfort, for monitoring impedance changes in 37 normal subjects under various conditions of lung ventilation. Output of BB3022 voltage comparator drives strip chart recorder through smoothing filter.—A. S. Khalafalla, S. P. Stackhouse, and O. H. Schmitt, Thoracic Impedance Gradient with Respect to Breathing, *IEEE Transactions on Bio-Medical Engineering*, July 1970, p 191–197.


+33
R1
2 Meg
10K
D1
4E28
R2
500
10
C1
2 µf
1K
2.7K
Q1
2N697
1µf
IN 540
IN 540
390
12K
270
R3
10 K
Q2
2N525
OUT
270
Q3
2N697
180

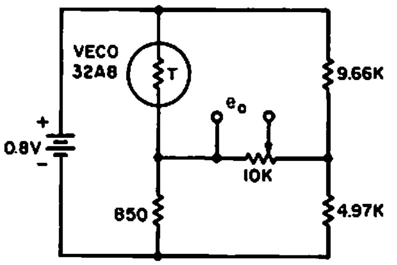
CONSTANT-CURRENT PULSES—Provides constant current within 3%, adjustable from 200 µA to 10 mA for pulses that are variable in frequency and duty cycle, with rise and fall times under 1 µs. Circuit is ideal for neurophysiological testing, pulse beta testing, and as driver for some types of sensors. Capacitor loading of output gives sawtooth with fast fall time and good linearity.—R. Dobkin, Pulse Generator Delivers a Constant Current, *Electronic Design*, March 15, 1965, p 63–64.


1N 5288
+ 15 V
100 K
100 K
100 K
Si Diode REF
1N5288
9130
10 K
output
100 K
100 K
100 K
Si Diode MEA

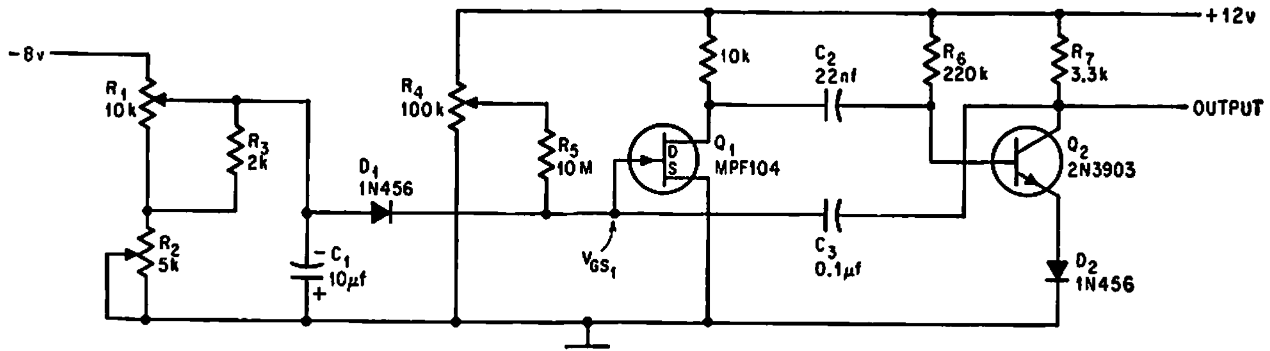
MEDICAL THERMOMETER—Uses one diode to establish reference temperature, and silicon diode to sense temperature being compared. If sensed temperature is lower than reference, output will go positive, and vice-versa. Output drives panel meter.—Two Electronic Thermometers for Medical/Industrial Use, Optical Electronics, Tucson, Ariz., No. 10075.


+6v
3.3k
22k
2.4M
22k
470k
OUTPUT
C1
0.1µf
22,000 pf
330k
68,000 pf
INPUT
Q1
BCY58
BAY44
Q2
BCY 58
Q4
BCY58
R1
100k
330k
Q3
BCY58
D1
BAY44
C3
0.47µf
C2
D2
R2
22,000pf
BAY 44
470k

PACEMAKER CONTROL—Prevents false triggering by 60-Hz pickup from faulty system grounding leads, by suppressing input pulses above normal heart limit of 150 beats per minute or 2.5 Hz. Mono Q2-Q4 inhibits cardiac pacemaker when heart is operating on its own. Q3 and associated diode frequency-voltage convertor prevent mono from interpreting 60-Hz pickup as sign of heart action and turning off pacemaker when it is actually needed.—V. Bicik, Monostable Protected Against 60-Hertz Pickup, *Electronics*, May 11, 1970, p 101.


VECO
32A8
T
9.66K
e_o
+
0.8V
−
10K
850
4.97K

RECTAL TEMPERATURE MONITOR—Catheter-type thermistor probe in Wheatstone bridge circuit covers range of 30–50 C for studying temperature responses of dogs to various physical stimuli. Provides signal for driving standard d-c millivolt recorder. Source is 0.8 V.—M. Sapoff and R. M. Oppenheim, A Blanket Approach to a Linear Thermistor Network, *Electronic Design*, April 12, 1965, p 36 and 38–40.

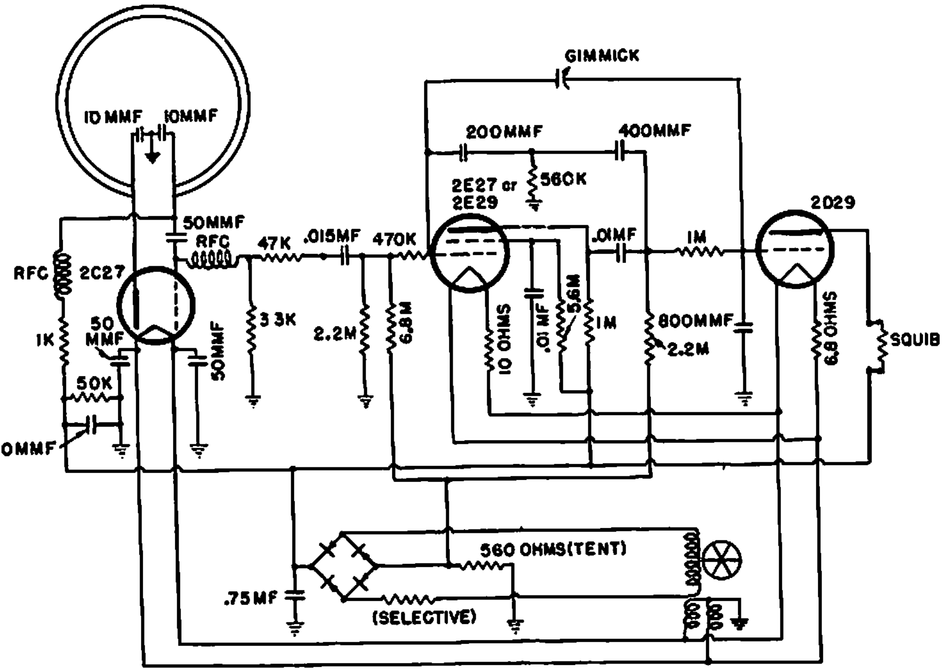

−8v
R_1
10k
R_3
2k
R_2
5k
C_1
10μf
D_1
1N456
R_4
100k
R_5
10M
V_{GS_1}
D
S
Q_1
MPF104
10k
C_2
22nf
C_3
0.1μf
R_6
220k
R_7
3.3k
Q_2
2N3903
D_2
1N456
+12v
OUTPUT

ON-OFF RATIOS FROM 20 TO 300—Developed for biomedical application requiring 3-ms pulses at repetition rates adjustable from 1 to 15 pps. Use of fet Q1 eliminates need for large electrolytics otherwise required for such widely spaced pulses. R1 adjusts prr, R4 establishes lowest frequency, and R2 establishes highest frequency.—E. A. Pfeiffer, Multivibrator Provides Short Pulses, Wide Spacing, *Electronics*, April 3, 1967, p 98–99.

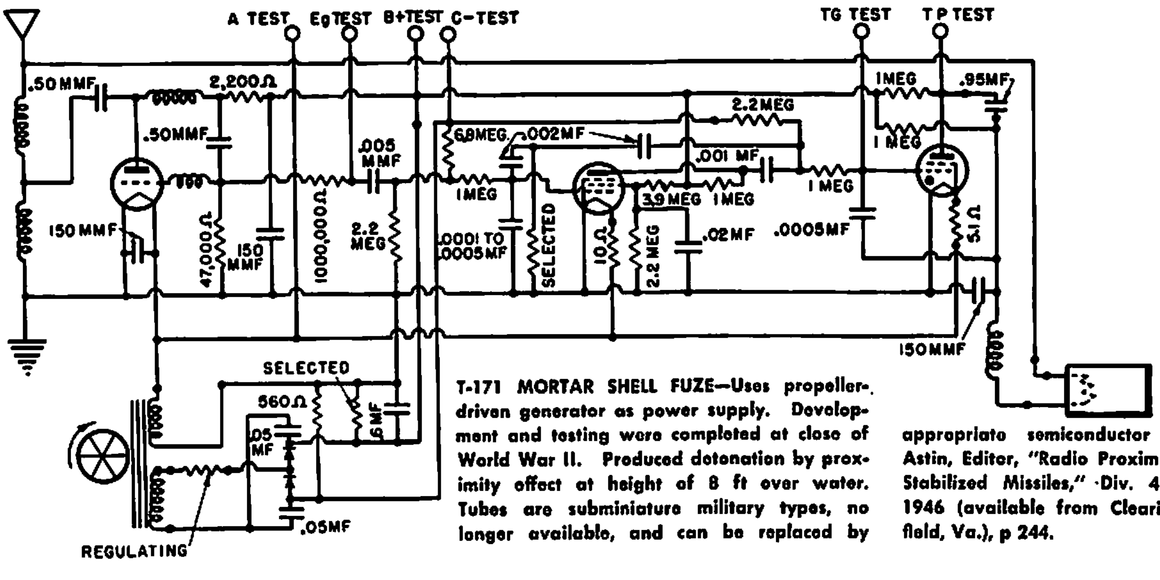
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 51

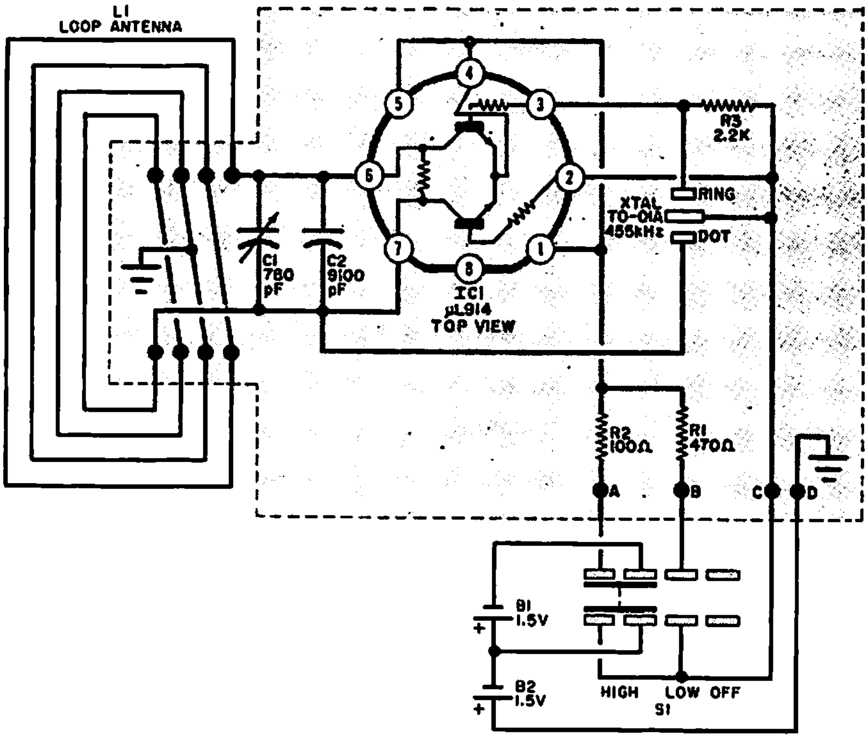
Metal Detector Circuits


GIMMICK
10 MMF
10MMF
200MMF
400MMF
560K
2E27 or 2E29
2029
50MMF
RFC
47K
.015MF
470K
.01MF
1M
RFC
2C27
1K
50 MMF
3.3K
2.2M
6.8M
50MMF
10 OHMS
.01 MF
5.6M
1M
800MMF
2.2M
6.8 OHMS
SQUIB
50K
150MMF
560 OHMS(TENT)
.75MF
(SELECTIVE)

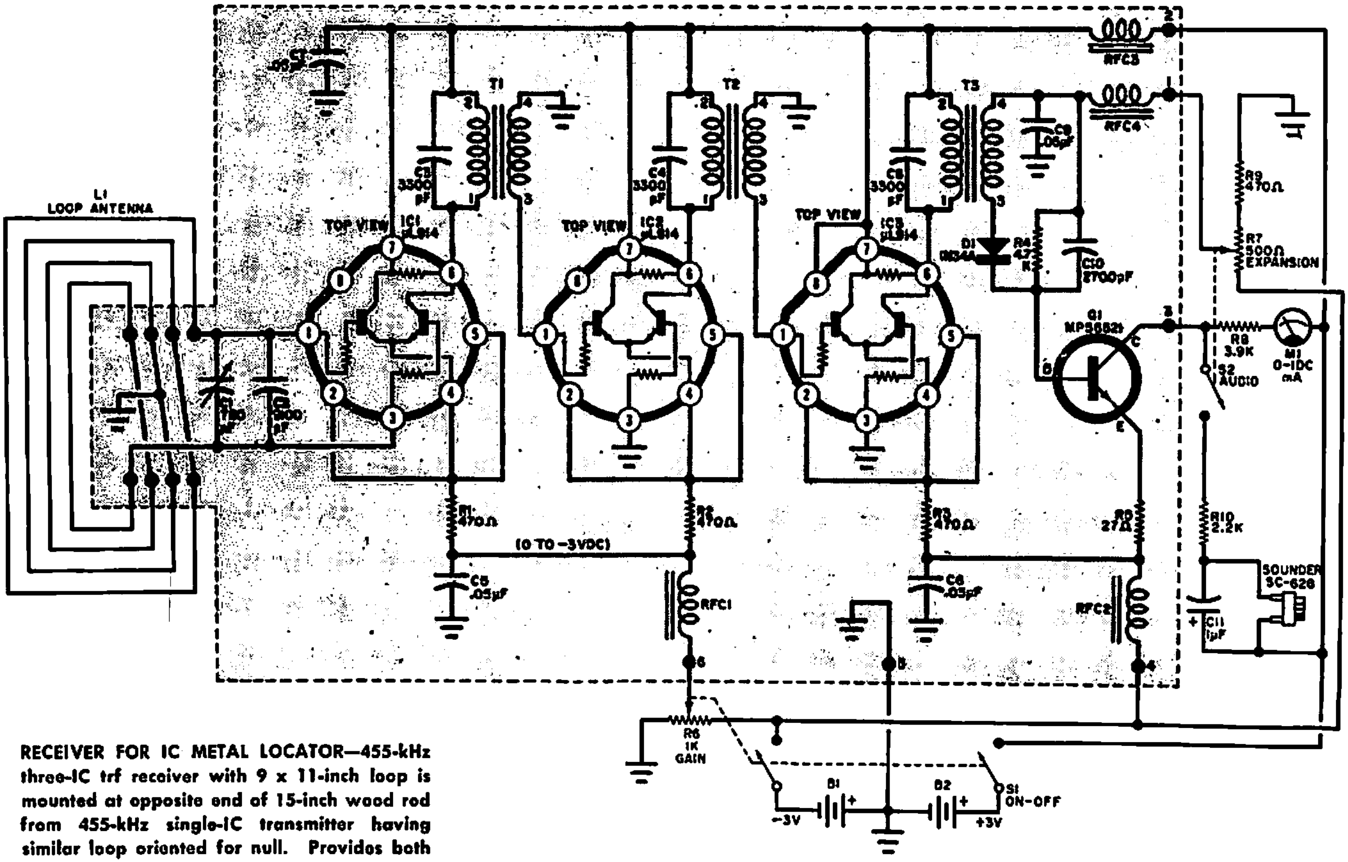
T-172 MORTAR SHELL FUZE—Major innovation in this proximity fuze circuit is loop antenna. Burst height over water was 23 ft. Uses reaction-grid-detector circuit.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 244.


A TEST
Eg TEST
B+TEST
C-TEST
TG TEST
TP TEST
.50MMF
2,200Ω
.50MMF
150 MMF
47,000Ω
150 MMF
.005 MMF
1000,000Ω
2.2 MEG
6.8MEG
.002MF
IMEG
.0001 TO .0005MF
SELECTED
10Ω
2.2 MEG
3.9 MEG
IMEG
.001 MF
.02MF
2.2MEG
IMEG
.95MF
I MEG
I MEG
.0005MF
5.1Ω
150MMF
SELECTED
560Ω
.05 MF
.6MF
.05MF
REGULATING

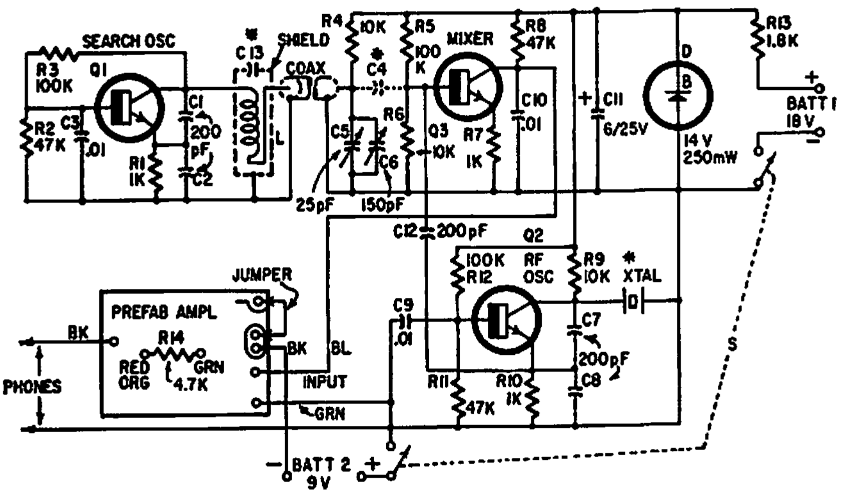
T-171 MORTAR SHELL FUZE—Uses propeller-driven generator as power supply. Development and testing were completed at close of World War II. Produced detonation by proximity effect at height of 8 ft over water. Tubes are subminiature military types, no longer available, and can be replaced by appropriate semiconductor devices.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 244.


L1
LOOP ANTENNA
C1
780
pF
C2
9100
pF
IC1
µL914
TOP VIEW
R3
2.2K
RING
XTAL
TO-01A
455kHz
DOT
R2
100Ω
R1
470Ω
A
B
C
D
B1
1.5V
B2
1.5V
HIGH
LOW
OFF
S1

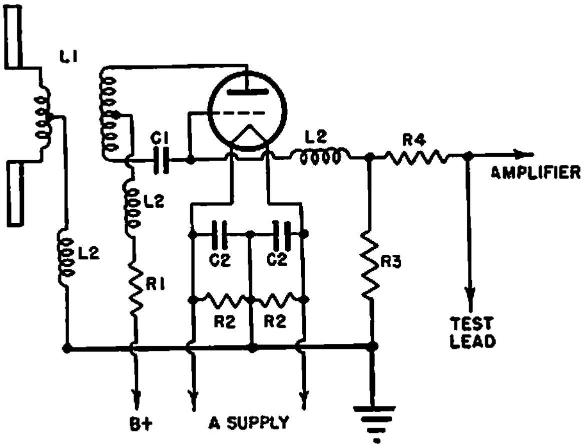
TRANSMITTER FOR IC METAL LOCATOR—Will locate pipes and valves buried as deep as 7 ft, and smaller objects at lesser depths if larger than coffee cans. Not intended for locating coins. Transmitter is 455-kHz IC oscillator controlled by ceramic Transfilter (XTAL), with single turn of four-conductor flat cable forming 9 x 11-inch loop, mounted at one end of 50-inch wood carrying rod. Receiver at other end of rod has similar loop feeding high-gain three-IC trf circuit tuned to 455 kHz, with loop oriented for null. Article gives construction details and sources for required parts.—D. Lancaster, Build IC-67 Metal Locator, *Popular Electronics*, Jan. 1967, p 41–48, 94, 96, 98, and 99.


L1
LOOP ANTENNA
C7
.05µF
T1
T2
T3
C3
3300
pF
C4
3300
pF
C8
3300
pF
TOP VIEW
IC1
µL914
IC2
µL914
IC3
µL914
C1
780
pF
C2
9100
pF
R1
470Ω
R2
470Ω
R3
470Ω
(0 TO −3VDC)
C5
.05µF
C6
.05µF
RFC1
RFC2
RFC3
RFC4
C9
.05µF
D1
1N34A
R4
4.7
K
C10
2700pF
Q1
MPS6521
B
C
E
R5
27Ω
R9
470Ω
R7
500Ω
EXPANSION
R8
3.9K
M1
0–1DC
mA
S2
AUDIO
R10
2.2K
SOUNDER
SC-626
C11
1µF
R6
1K
GAIN
B1
B2
−3V
+3V
S1
ON-OFF

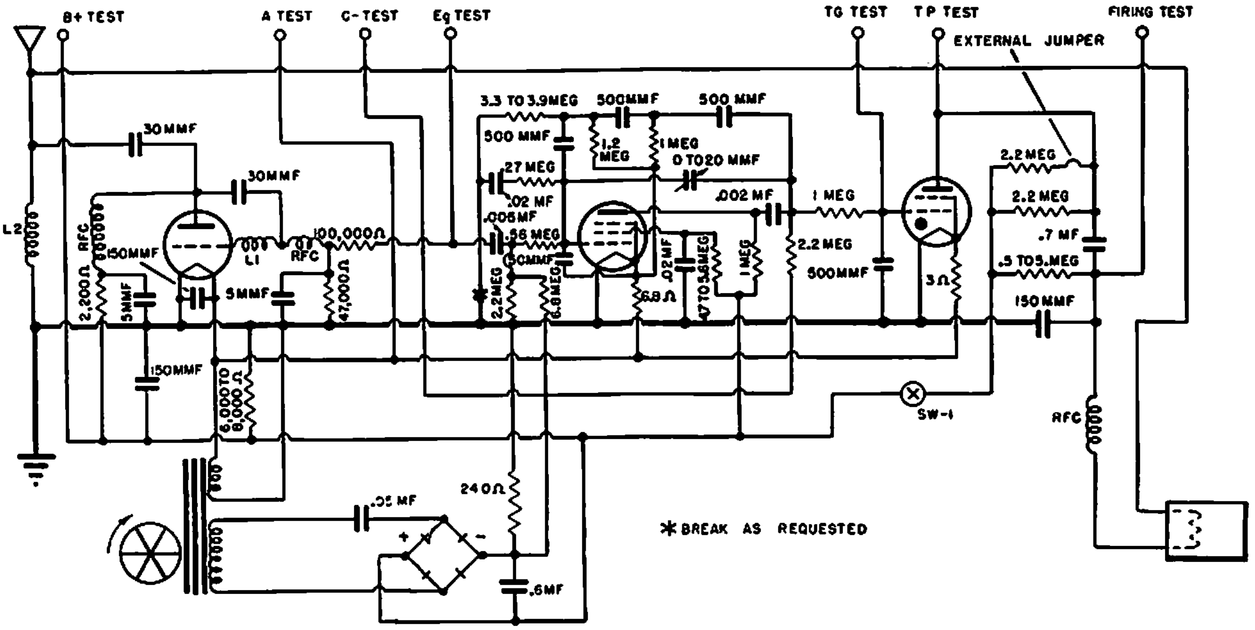
RECEIVER FOR IC METAL LOCATOR—455-kHz three-IC trf receiver with 9 x 11-inch loop is mounted at opposite end of 15-inch wood rod from 455-kHz single-IC transmitter having similar loop oriented for null. Provides both meter and audible indication for large buried metal objects. Article gives construction details and sources for required parts.—D. Lancaster, Build IC-67 Metal Locator, *Popular Electronics*, Jan. 1967, p 41–48, 94, 96, 98, and 99.


SEARCH OSC
R3 100K
Q1
R2 47K
C3 .01
C1 200 pF
C2
R1 1K
C13
SHIELD
COAX
L
R4 10K
R5 100 K
C4
MIXER
R8 47K
C10 .01
C11 6/25V
D
B
14 V 250mW
R13 1.8K
BATT 1 18 V
C5
C6
R6
Q3
R7 1K
10K
25pF
150pF
C12 200pF
Q2
100K R12
RF OSC
R9 10K
XTAL
C7
200pF
C8
C9 .01
R11 47K
R10 1K
JUMPER
PREFAB AMPL
BK
R14
RED ORG
GRN 4.7K
BL
INPUT
GRN
PHONES
BATT 2 9V
S

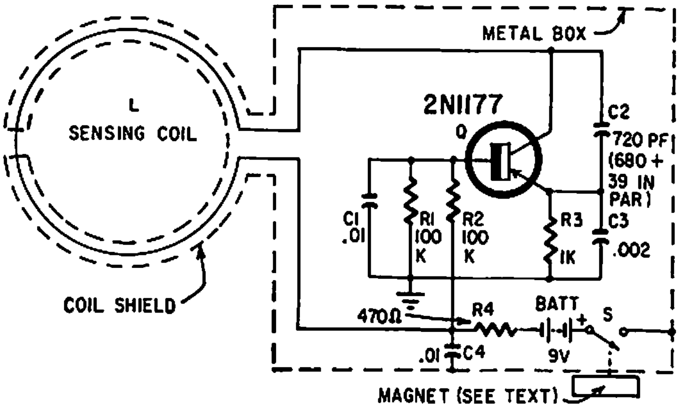
COIN-FINDER—Will detect dimes 4 inches from loop and gold or silver rings up to 5 inches away in dry or slightly damp ground. Uses 2,100-kHz surplus military crystal, but 160-meter amateur crystal will work if coil turns are adjusted. Search coil L is 8 turns of No. 24 plastic-covered hookup wire threaded through 3/8th-inch copper tubing bent into split ring 10½ inches in diameter. Article gives construction details. Transistors are npn with minimum beta of 30 and alpha cutoff above 3 MHz, such as 2N334, 2N1090, or 2N2926. IC audio amplifier is Lafayette 99R9039 or equivalent. Audio beat note in phone changes in frequency when search coil is near metal.—G. H. Gill, Summer Fun With a Sensitive Metal-Finder, *Radio-Electronics*, July 1966, p 55–57.


L1
L2
C1
L2
R4
AMPLIFIER
C2
C2
R3
R1
R2
R2
TEST LEAD
B+
A SUPPLY

VT BOMB FUZE DETECTOR—Reaction-grid-detector circuit shown was used in M-166 bar-type bomb fuzes to initiate detonation at 50 to 100 feet above ground when dropped from aircraft. Antenna is nose of fuze. Coil values are adjusted to obtain required frequency and sensitivity. Values are: R1 1K; R2 3; R3 33K; R4 47K; C1 25 pF; C2 50 pF; Triode NR3A. Oscillator and antenna coils for L1 are wound on same core. L2 is r-f choke.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 225–226.


B+ TEST
A TEST
C-TEST
Eq TEST
TG TEST
TP TEST
FIRING TEST
EXTERNAL JUMPER
30MMF
30MMF
L2
RFC
150MMF
2,200Ω
5MMF
5MMF
L1
RFC
100,000Ω
47,000Ω
150MMF
6,000 TO 8,000Ω
3.3 TO 3.9MEG
500MMF
500 MMF
500 MMF
1.2 MEG
1 MEG
0 TO 20 MMF
27 MEG
.02 MF
.005MF
.58 MEG
30MMF
2.2MEG
6.8MEG
6.8Ω
.02MF
470 TO 5.6MEG
1MEG
.002 MF
1 MEG
2.2 MEG
500MMF
2.2MEG
2.2 MEG
.7 MF
.5 TO 5.MEG
3Ω
150MMF
SW-1
RFC
240Ω
.05 MF
.6MF
+
-
*BREAK AS REQUESTED

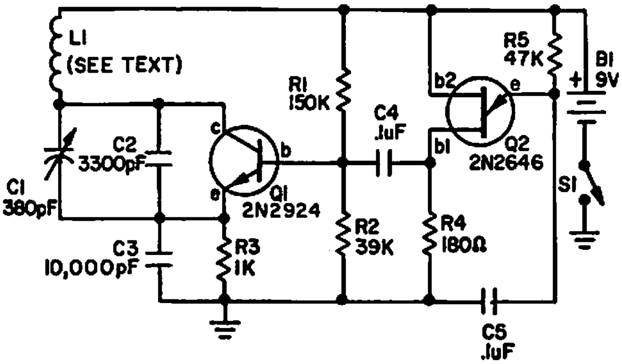
VT ROCKET FUZE—Developed just before end of World War II, as T-2005 rocket fuze. Intended for shipboard defense against attacking enemy aircraft. Fuze initiated detonation automatically when missile was within kill distance of aircraft. Tubes are subminiature military types, no longer available; modern versions undoubtedly use semiconductor devices.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 241–242.



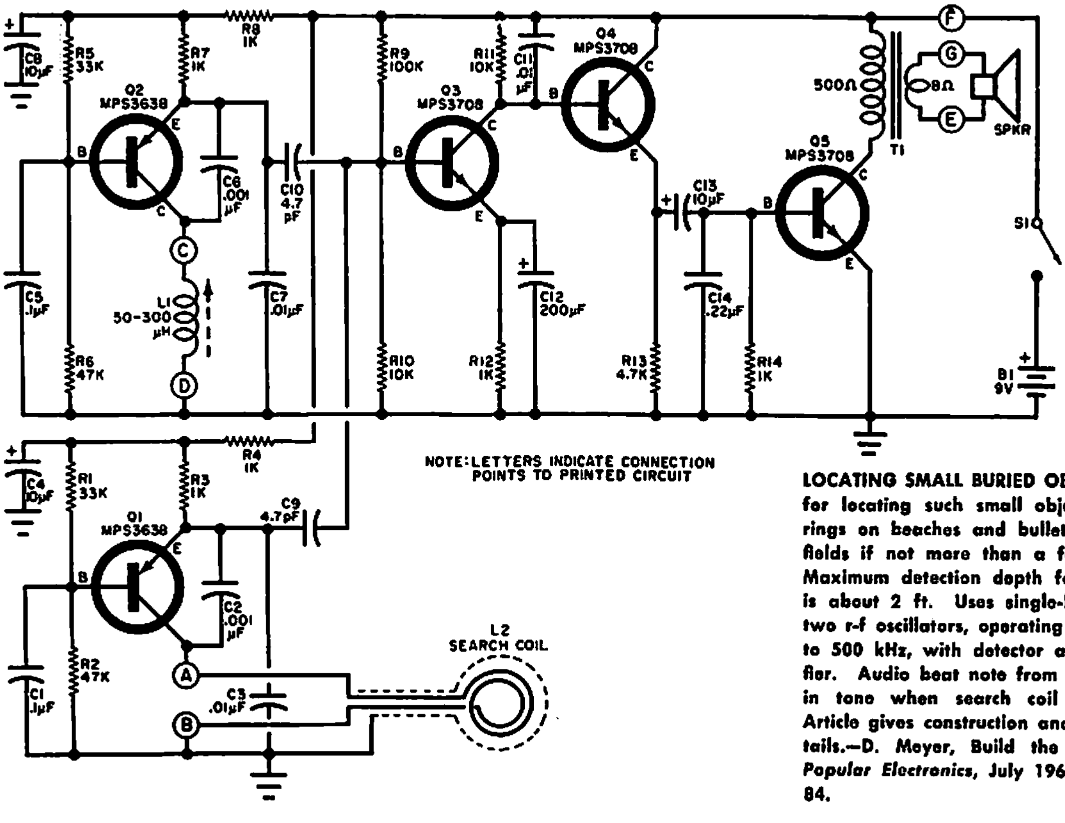
METAL BOX
L
SENSING COIL
COIL SHIELD
2N1177
Q
C1
.01
R1
100
K
R2
100
K
R3
1K
C2
720 PF
(680 + 39 IN PAR)
C3
.002
470Ω
R4
BATT
9V
S
.01
C4
MAGNET (SEE TEXT)

WATERPROOF ANCHOR-FINDER—Solder-sealed single-transistor transmitter suspended from boat is used with ordinary transistor radio in boat for locating lost outboard motors, anchors, or other relatively large metal objects under water. Beat-frequency oscillator should be added to radio, or coupling should be introduced between two i-f stages to make oscillating i-f serving same purpose. Transmitter operates at about 600 kHz. In depths greater than 30 ft, connect insulated antenna wire to receiver and run it parallel with transmitter suspension rope. Article gives construction details for search coil which is 4 turns of insulated wire threaded through 23-inch-diameter split ring of ½-inch copper tubing. Permanent magnet outside housing holds improvised magnetic-blade switch open; remove magnet to turn on transmitter.—O. Klippberg, Underwater Metal Hunting for Fun or Profit, *Radio-Electronics*, June 1966, p 38–39.

AUDIO-MODULATED 180-KHZ TRANSMITTER—Ujt relaxation oscillator Q2 produces low-frequency audio tone for modulating transistor r-f oscillator Q1 which radiates search signal from L1 (34 turns No. 22 enamel wound around 6.8 x 5.3-inch plastic case of transmitter). Receiver is mounted at other end of 30-inch support rod, with its loop at right angles to that of transmitter. Operating frequency is around 180 kHz. Intended for locating buried objects larger than pie pans, such as metal pails filled with gold coins. Article gives construction details.—C. D. Rakes, Treasure Witcher, *Science & Electronics*, April/May 1970, p 39–44 and 80.



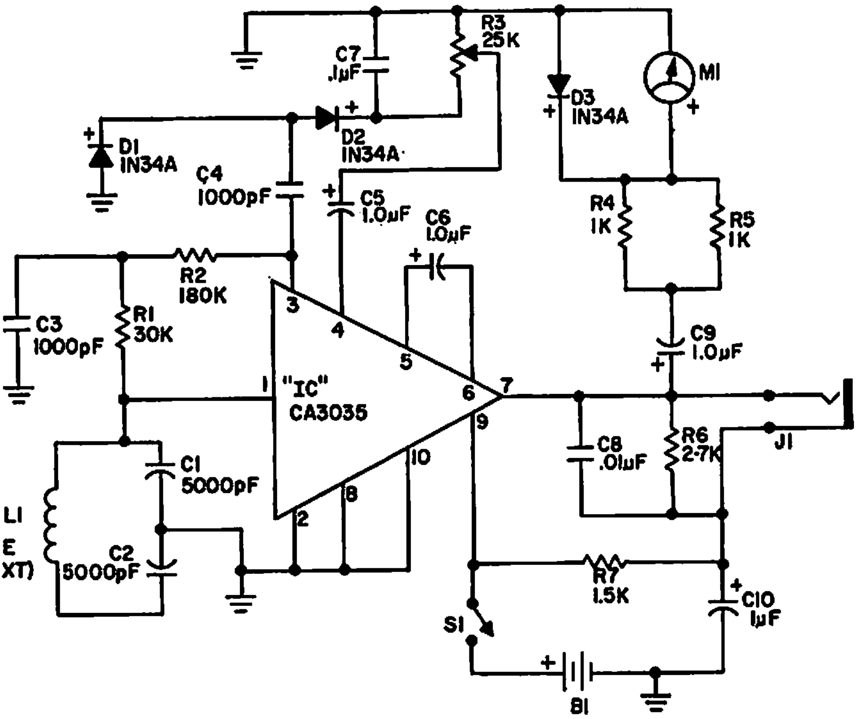
L1
(SEE TEXT)
C1
380pF
C2
3300pF
C3
10,000pF
c
b
e
Q1
2N2924
R1
150K
R2
39K
R3
1K
C4
.1uF
b2
e
b1
Q2
2N2646
R5
47K
R4
180Ω
C5
.1uF
B1
9V
S1



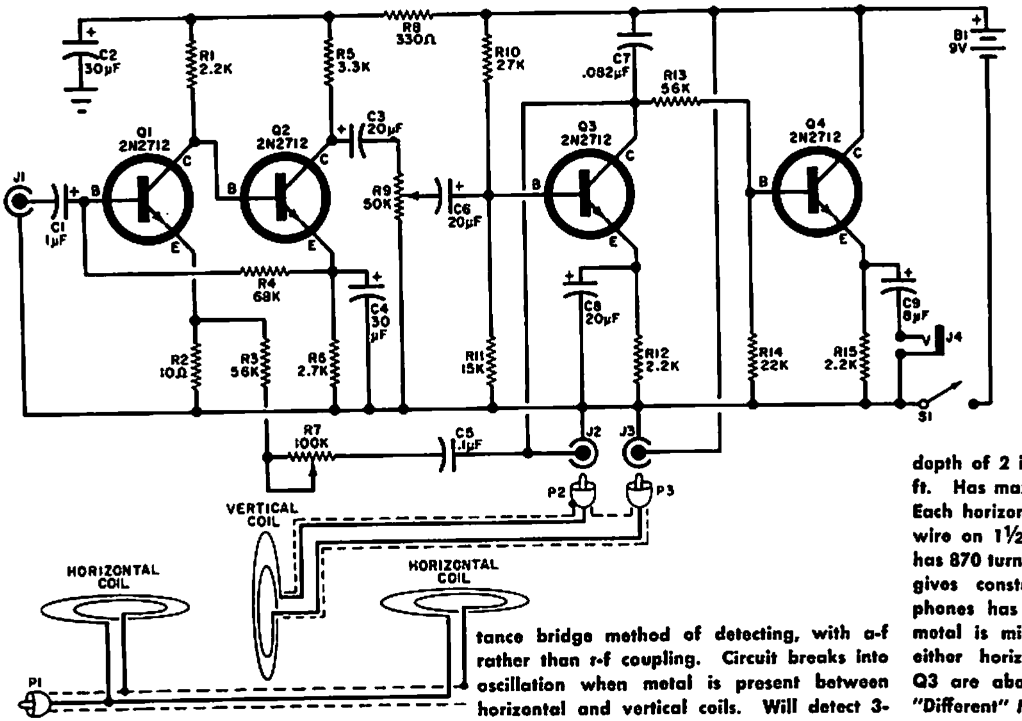
C8
10µF
R5
33K
R7
1K
R8
1K
Q2
MPS3638
B
E
C
C6
.001
µF
C10
4.7
pF
C
L1
50-300
µH
D
C5
.1µF
R6
47K
C7
.01µF
R9
100K
R11
10K
C11
.01
µF
Q3
MPS3708
B
C
E
Q4
MPS3708
B
C
E
C12
200µF
R10
10K
R12
1K
R13
4.7K
C13
10µF
C14
.22µF
R14
1K
Q5
MPS3708
B
C
E
500Ω
T1
F
G
E
8Ω
SPKR
S1
B1
9V
C4
10µF
R1
33K
R3
1K
R4
1K
Q1
MPS3638
B
E
C9
4.7pF
C2
.001
µF
C1
.1µF
R2
47K
A
B
C3
.01µF
L2
SEARCH COIL

NOTE: LETTERS INDICATE CONNECTION POINTS TO PRINTED CIRCUIT

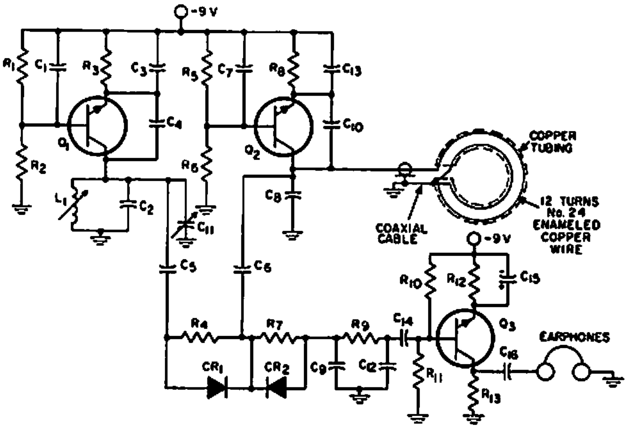
LOCATING SMALL BURIED OBJECTS—Designed for locating such small objects as coins or rings on beaches and bullets on old battlefields if not more than a few inches deep. Maximum detection depth for larger objects is about 2 ft. Uses single-loop circuit with two r-f oscillators, operating in range of 400 to 500 kHz, with detector and audio amplifier. Audio beat note from speaker changes in tone when search coil is near metal. Article gives construction and adjustment details.—D. Meyer, Build the "Beachcomber," *Popular Electronics*, July 1967, p 27–32 and 84.


R3
25K
C7
.1μF
MI
D1
IN34A
D2
IN34A
D3
IN34A
C4
1000pF
C5
1.0μF
C6
1.0μF
R4
1K
R5
1K
R2
180K
C3
1000pF
R1
30K
C9
1.0μF
"IC"
CA3035
C8
.01μF
R6
2.7K
J1
C1
5000pF
L1
(SEE
TEXT)
C2
5000pF
R7
1.5K
C10
1μF
S1
B1

180-KHZ RECEIVER—Single IC is equivalent of three transistors in providing gain of 129 dB for amplifying tone-modulated signal picked up from transmitter at other end of 30-inch support rod when in presence of metal. Diode D2 demodulates signal after first IC stage, and other two IC stages amplify resulting audio tone sufficiently to drive 2,000-ohm headphones and indicating meter. Pickup loop L1 has 34 turns of No. 22 enamel wound around plastic case of receiver. Use 9-V battery such as Eveready 216BP. Meter is 500-μA d-c. Article gives construction details.—C. D. Rakes, Treasure Witcher, *Science & Electronics*, April/May 1970, p 39–44 and 80.


C2
30μF
R1
2.2K
R5
3.3K
R8
330Ω
R10
27K
C7
.082μF
R13
56K
B1
9V
Q1
2N2712
Q2
2N2712
C3
20μF
Q3
2N2712
Q4
2N2712
J1
C1
1μF
R9
50K
C6
20μF
R4
68K
C4
30μF
C8
20μF
C9
8μF
J4
R2
10Ω
R3
56K
R6
2.7K
R11
15K
R12
2.2K
R14
22K
R15
2.2K
S1
R7
100K
C5
.1μF
J2
J3
P2
P3
VERTICAL
COIL
HORIZONTAL
COIL
HORIZONTAL
COIL
P1

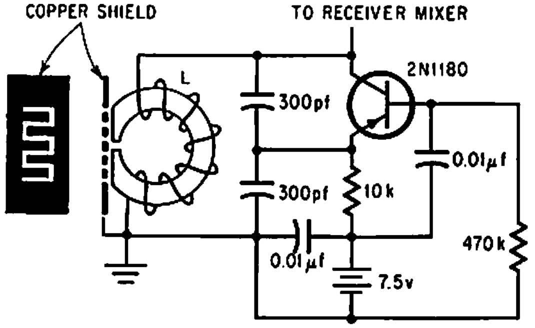
THREE-COIL TREASURE FINDER—Uses inductance bridge method of detecting, with a-f rather than r-f coupling. Circuit breaks into oscillation when metal is present between horizontal and vertical coils. Will detect 3-inch nail or aluminum bottle cap buried at depth of 2 inches, or garbage-can lid at 2½ ft. Has maximum sensitivity for iron objects. Each horizontal coil has 470 turns of No. 32 wire on 1½ x 3 inch form, and vertical coil has 870 turns on 1½ x 2¾ inch form. Article gives construction details. Tone in headphones has maximum volume when hidden metal is midway between vertical coil and either horizontal coil. Oscillators Q1 and Q3 are about 2 kHz.—L. Huggard, Build a "Different" Metal Locator, *Popular Electronics*, Feb. 1969, p 53–58.

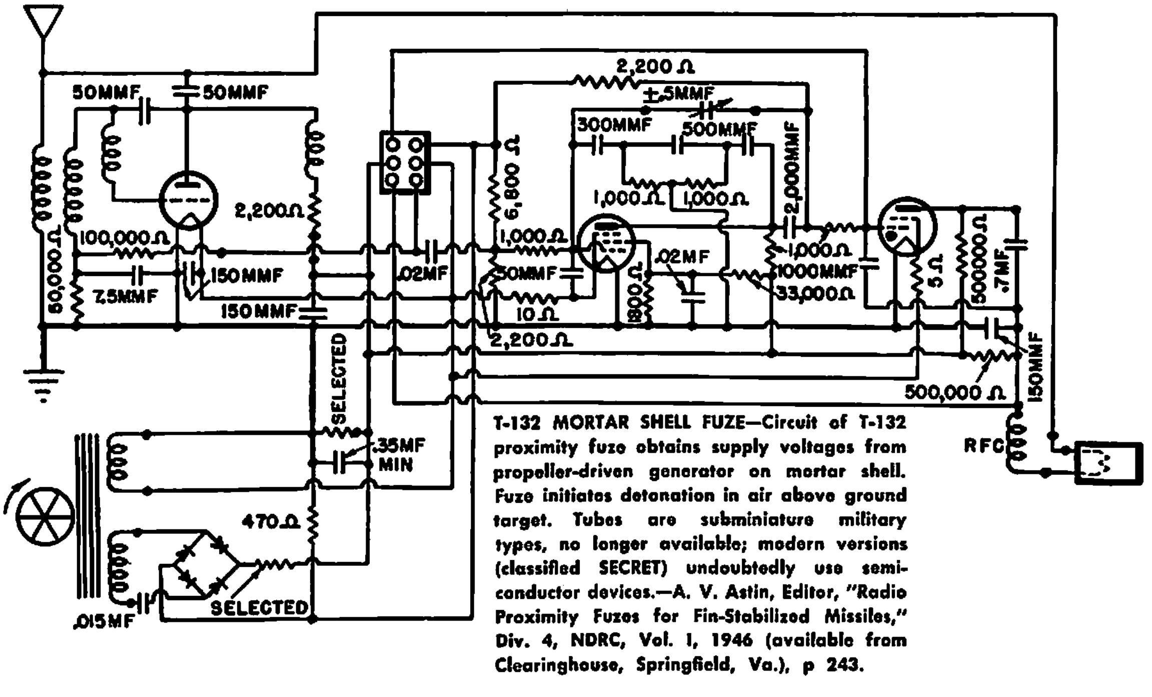

-9V
R_1
C_1
R_3
C_3
R_5
C_7
R_8
C_{13}
C_4
C_{10}
Q_1
Q_2
R_2
R_6
L_1
C_2
C_8
C_{11}
C_5
C_6
COPPER TUBING
12 TURNS No. 24 ENAMELED COPPER WIRE
COAXIAL CABLE
-9V
R_{10}
R_{12}
C_{15}
R_4
R_7
R_9
C_{14}
Q_3
EARPHONES
CR_1
CR_2
C_9
C_{12}
C_{16}
R_{11}
R_{13}

$C_1 C_7 C_{14}$ = 0.01 microfarad, 25 volts or greater
C_2 = 1800 picofarads, 25 volts or greater
$C_3 C_{13}$ = 3900 picofarads, 25 volts or greater
$C_4 C_9 C_{10}$ = 0.001 microfarad, 25 volts or greater
$C_5 C_6$ = 0.004 microfarad, 25 volts or greater
C_8 = 680 microfarads, 25 volts or greater
C_{11} = 20 picofarads, variable type, Hammarlund No. MAC-20 or equivalent
C_{12} = 0.02 microfarad, 25 volts or greater
C_{15} = 50 microfarads, 6 volts, electrolytic
C_{16} = 0.1 microfarad, 25 volts or greater
$CR_1 CR_2$ = silicon rectifier, type 1N34A
R_1R_5 = 22,000 ohms, 1/2 watt, 10%
R_2R_6 = 47000 ohms, 1/2 watt, 10%
R_3R_8 = 2200 ohms, 1/2 watt, 10%
R_4R_7 = 1 megohm, 1/2 watt, 10%
• = 68,000 ohms, 1/2 watt, 10%
R_{10} = 10,000 ohms, 1/2 watt, 10%
R_{11} = 91,000 ohms, 1/2 watt, 10%
R_{12} = 680 ohms, 1/2 watt, 10%
R_{13} = 6800 ohms, 1/2 watt, 10%
$Q_1Q_2Q_3$ = transistor, RCA SK3020
L_1 = 50 to 140 microhonries, adjustable
Copper tubing: 1/4-inch diameter, 3.14 feet (enough for loop of 1-foot diameter)
No. 24 enameled copper wire: about 40 feet (enough for 12 turns of 1-foot diameter and connections)
Coaxial cable: about 3 feet (exact amount depends on length of handle)
Earphones = 200 ohms

METAL DETECTOR—Can be used to locate buried treasure, underground pipes, and other buried metal objects. When search coil is near object, tone in earphone changes or cuts off completely. Uses two oscillators; Q1 is approximately 300 kHz as determined by L1 and C2, and Q2 operates at frequency determined by C11 and inductance of search coil and objects near it. L1 is adjusted for tone in phones, and C11 then adjusted for maximum sensitivity as indicated by motorboating sound. Book gives complete construction details.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 138.

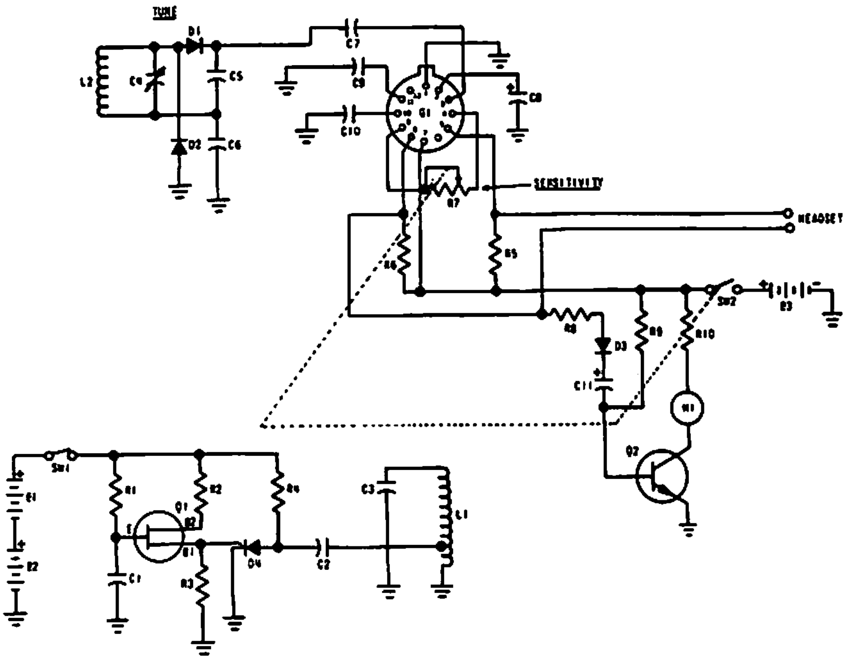
FINDING HIDDEN BRASS NAILS—Oscillating detector frequency changes about 1 kHz when nonmagnetic screw or nail is in magnetic field near gap in cut toroid. Used to detect concealed fasteners that could wreck saw blades or tear sandpaper during refitting of wood deck or bulkhead of ship. Coil is in tank circuit of Colpitts oscillator, clamped to laminated copper plate acting as electrostatic shield. Change in oscillator frequency changes beat frequency output of receiver mixer, producing change in audio output.—D. B. Hoisington, Oscillator as Detector, *Electronics*, March 18, 1968, p 95.


COPPER SHIELD
TO RECEIVER MIXER
L
2N1180
300pf
300pf
0.01μf
10k
0.01μf
470k
7.5v

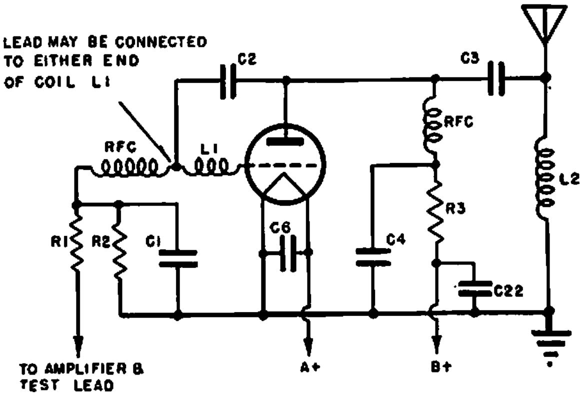

50MMF
50MMF
2,200Ω
100,000Ω
7.5MMF
150MMF
150MMF
50,000Ω
.02MF
6,800Ω
1,000Ω
50MMF
10Ω
2,200Ω
2,200Ω
±5MMF
300MMF
500MMF
2,000MMF
1,000Ω
1,000Ω
.02MF
1800Ω
1,000Ω
1000MMF
33,000Ω
5Ω
500000Ω
.7MF
150MMF
500,000Ω
RFC
SELECTED
.35MF MIN
470Ω
.015MF
SELECTED

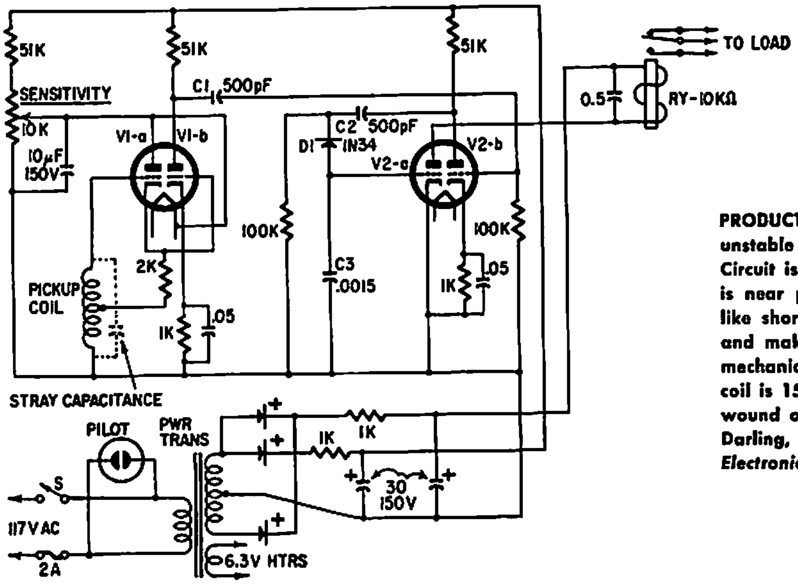
T-132 MORTAR SHELL FUZE—Circuit of T-132 proximity fuze obtains supply voltages from propeller-driven generator on mortar shell. Fuze initiates detonation in air above ground target. Tubes are subminiature military types, no longer available; modern versions (classified SECRET) undoubtedly use semiconductor devices.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. 1, 1946 (available from Clearinghouse, Springfield, Va.), p 243.

IC BURIED-METAL DETECTOR—Consists of single-transistor transmitter using 2N2646 ujt as oscillator driving scr, to feed highly directional 4 by 6-inch loop L1 wound around transmitter housing. Receiving loop of same size is similarly wound around receiver using Westinghouse WC183T IC and GE-5 transistor Q2. Transmitter and receiver are mounted at opposite ends of 3-foot wood rod held horizontally several feet above ground while walking over area being searched. When loops are properly oriented at right angles to each other, with no metal in vicinity, nothing is heard in phones. Metal object within range gives 175-Hz tone in phones and unusual deflection of 1-mA d-c meter. Book gives construction and adjustment data. Values are: R1 15K; R2 220; R3 22; R4 470; R5, R6 270; R7 5K; R8 47K; R9 330K; R10 1.8K; C1 0.3 μF; C2 1 μF; C3, C5, C6 0.001 μF; C4 2,000 pF; C7, C10 0.003 μF; C8, C9, C11 10 μF; B1, B2 9 V, B3 4.5 V; D1, D2, D3 1N38B; D4 2N3228 scr; L1 74 turns #27 tapped two turns from end; L2 68 turns.—R. M. Brown, "Electronic Hobbyist's IC Projects Handbook," TAB Books, Blue Ridge Summit, Pa., 1968, p 116.


TUNE
D1
C7
L2
C4
C5
C9
C8
C10
G1
D2
C6
SENSITIVITY
R7
HEADSET
R6
R5
SW2
B3
R8
D3
R9
R10
C11
M1
Q2
SW1
B1
B2
R1
R2
R4
C3
L1
Q1
E
B2
B1
D4
C2
C1
R3

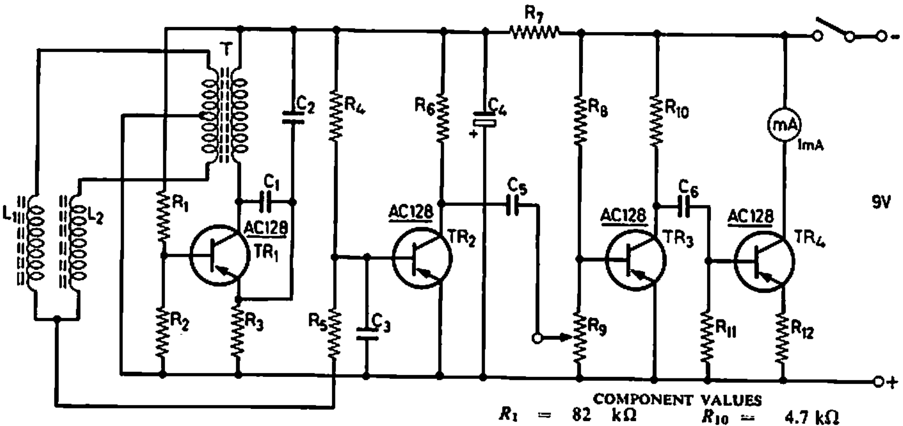
REACTION-GRID DETECTOR IN FUZE—Used in M-168 and T-92-E1 bomb fuzes to initiate detonation about 50 feet above ground or water. Antenna is nose of fuze. Values are: R1 100K; R2 47K; R3 2.2K; C1 5 pF; C2, C3 30 pF; C4 5 pF; C6, C22 150 pF; triode NR3A.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 225.


LEAD MAY BE CONNECTED TO EITHER END OF COIL L1
C2
C3
RFC
L1
RFC
L2
R3
R1
R2
C1
C6
C4
C22
TO AMPLIFIER & TEST LEAD
A+
B+


51K
51K
51K
SENSITIVITY
10K
10μF 150V
C1 500pF
C2 500pF
D1 1N34
V1-a
V1-b
V2-a
V2-b
100K
100K
C3 .0015
2K
1K
.05
1K
.05
PICKUP COIL
STRAY CAPACITANCE
TO LOAD
0.5
RY-10KΩ
PILOT
PWR TRANS
S
117VAC
2A
1K
1K
30 150V
6.3V HTRS

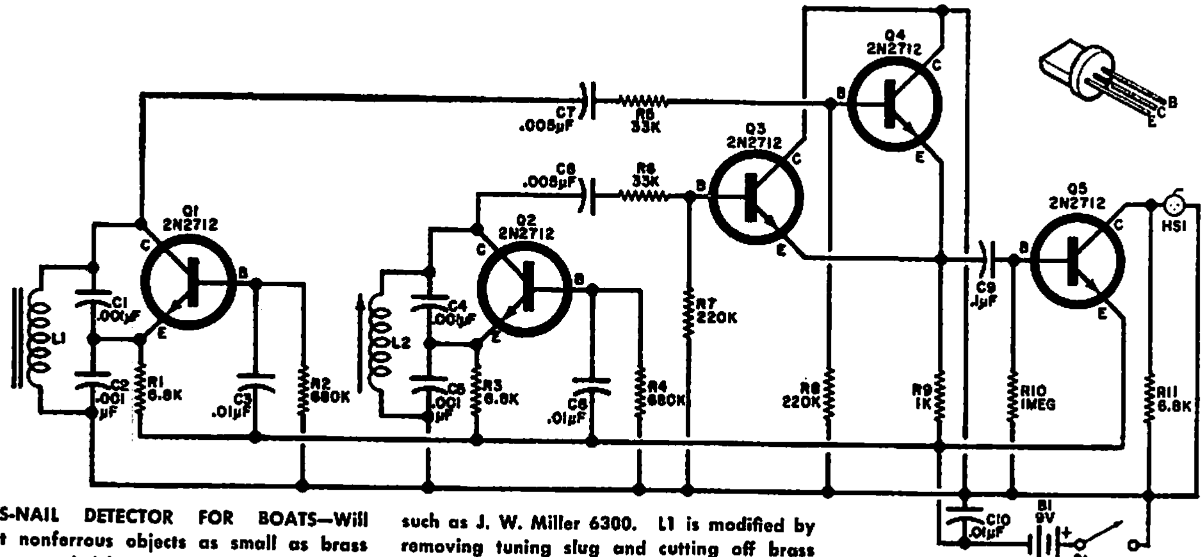
PRODUCTION-LINE METAL DETECTOR—Uses unstable oscillator with coil in sensing probe. Circuit is adjusted to oscillate when no metal is near probe. Presence of metal then acts like shorted turn in coil, stopping oscillation and making relay pull in to actuate electromechanical counter or other load. Pickup coil is 150 turns center-tapped and scramble-wound on 1-inch-diameter paper form.—D. D. Darling, Simple Rf Proximity Detectors, *Radio-Electronics*, Dec. 1966, p 47–48.

METAL DETECTOR—Will detect any metal. Nonmagnetic materials increase circuit losses of sensing inductor, thus reducing its inductance, whereas ferromagnetic materials reduce reluctance of magnetic circuits and thereby increase inductance. Can be used for locating metal, such as nails and shell particles, embedded in wood to be worked with machine tools, locating iron rods in reinforced concrete, locating pipes and wiring in walls, locating metal objects in cows before surgery, locating bullets at scene of murder, and tracing buried pipes. L1 and L2 are 550 turns of 0.2-mm enameled copper wound on ferroxcube type 4B rods 10 mm in diameter and 10 cm long. Transformer T has 180-turn primary and 200-turn c-t secondary of same wire wound on type 22/12-4C4 pot core without air gap. Frequency of oscillator TR1 is about 3 kHz. Article gives construction, alignment, and operating instructions.—J. F. van Oort, Brief Items of Interest, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 25, No. 3, 1964–1965, p 123–128.


R7
T
C2
R4
R6
C4
R8
R10
mA
1mA
C1
C5
C6
9V
L1
L2
R1
AC128
TR1
AC128
TR2
AC128
TR3
AC128
TR4
R2
R3
R5
C3
R9
R11
R12
+

COMPONENT VALUES

R_1 = 82 kΩ
R_2 = 18 kΩ
R_3 = 220 Ω
R_4 = 390 kΩ
R_5 = 22 kΩ
R_6 = 5.6 kΩ
R_7 = 330 Ω
R_8 = 390 kΩ
R_9 = 20 kΩ
R_{10} = 4.7 kΩ
R_{11} = 18 kΩ
R_{12} = 330 Ω
C_1 = 12 nF
C_2 = 39 nF
C_3 = 0.1 μF
C_4 = 60 μF
C_5 = 0.1 μF
C_6 = 0.1 μF

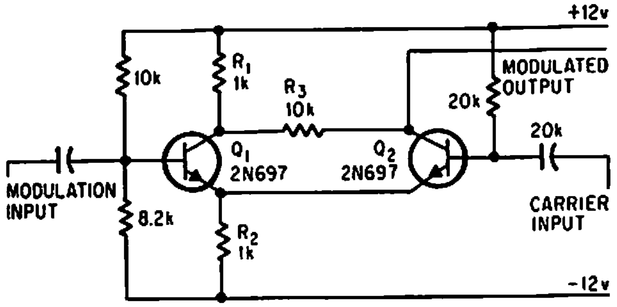

Q4
2N2712
C
B
E
C7
.005μF
R5
33K
Q3
2N2712
C6
.005μF
R6
33K
B
C
E
Q5
2N2712
HS1
Q1
2N2712
Q2
2N2712
C
B
E
C1
.001μF
L1
C2
.001
μF
R1
6.8K
C3
.01μF
R2
680K
C4
.001μF
L2
C5
.001
μF
R3
6.8K
C6
.01μF
R4
680K
R7
220K
C9
.1μF
R8
220K
R9
1K
R10
1MEG
R11
6.8K
C10
.01μF
B1
9V
S1
+

BRASS-NAIL DETECTOR FOR BOATS—Will detect nonferrous objects as small as brass brads concealed by paint, to prevent damage to sanders or power saws when working on boats. Will also detect magnetic objects, although maximum range is about 2 inches. L1 and L2 are high-Q ferrite antenna coils, such as J. W. Miller 6300. L1 is modified by removing tuning slug and cutting off brass tuning screw flush with core. Article gives other modifications required, along with construction details and sources for parts. Q1 and Q2 are audio oscillators that beat to produce audio tone in high-impedance earphone HS1 which changes when L1 is near metal.—J. S. Simonton, Jr., Carpenter's Mate—Tiny Metal Locator for Tiny Metal, *Popular Electronics*, Sept. 1969, p 69–72.

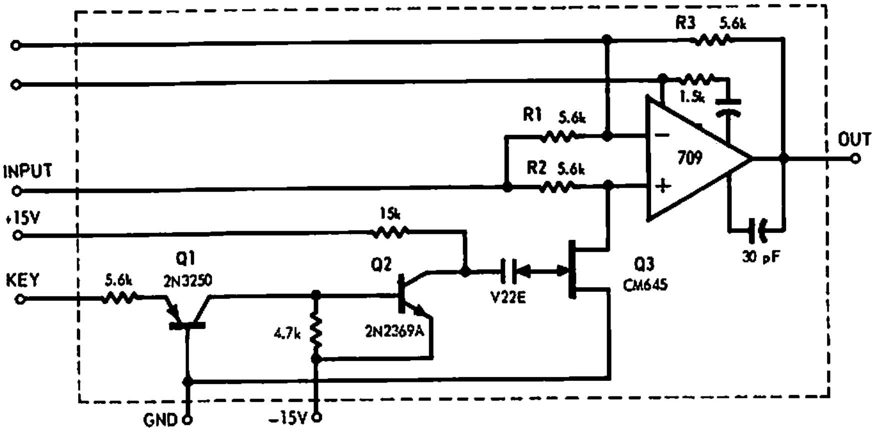
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 52

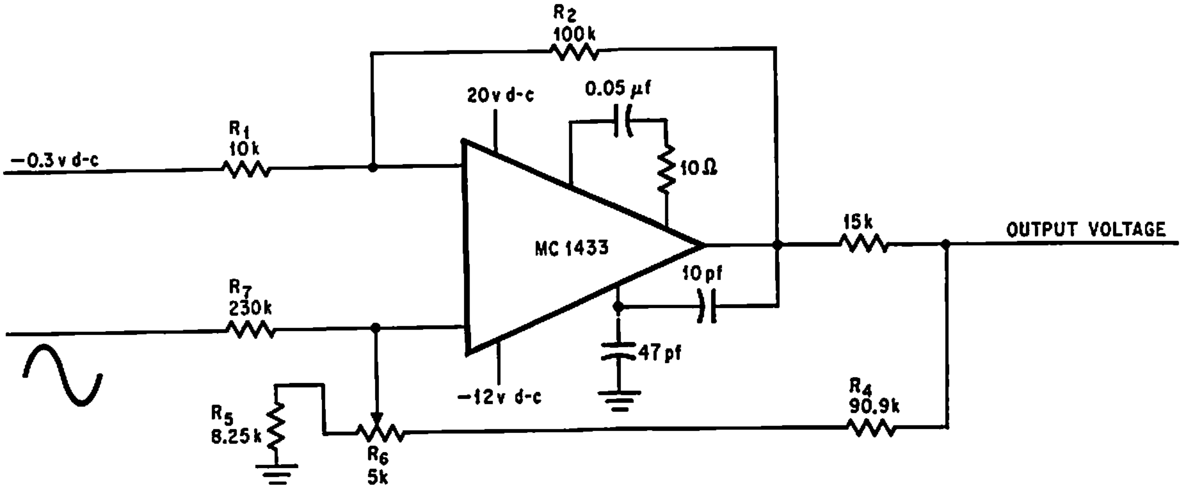
Modulator Circuits


+12v
10k
R1
1k
R3
10k
Q1
2N697
Q2
2N697
20k
MODULATED OUTPUT
20k
CARRIER INPUT
MODULATION INPUT
8.2k
R2
1k
-12v

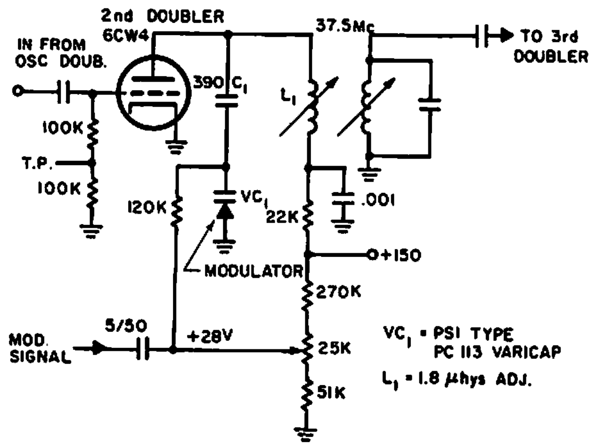
SUBAUDIO ON 2-KHZ SUBCARRIER—Requires only two transistors in simple differential amplifier circuit. Article also gives modification for amplitude modulation at radio frequencies.—A. Pichard, 100% Amplitude Modulation With Two Transistors, *Electronics*, June 12, 1967, p 104–105.


R3 5.6k
1.5k
R1 5.6k
R2 5.6k
709
OUT
INPUT
+15V
15k
KEY
5.6k
Q1
2N3250
Q2
2N2369A
4.7k
V22E
Q3
CM645
30 pF
GND
-15V

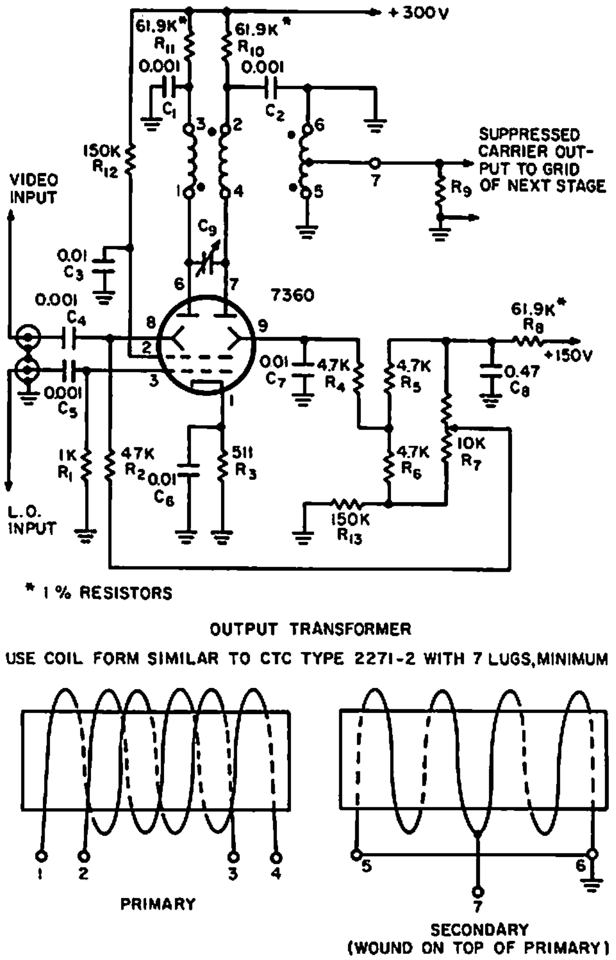
FULL-WAVE PHASE-SENSITIVE—Analog switch Q1-Q3 is controlled by key or reference signal, usually 0 to +3 V logic. With analog switch closed (key at 0 V), amplifier gain is −1. With switch open, gain is 0. May also be used as square-wave modulator. Frequency range is d-c to 500 kHz. Output voltage range is −9 V to +9 V.—F. L. Schmid, Full-Wave Phase-Sensitive Demodulator, *EDN*, Sept. 1, 1969, p 73.

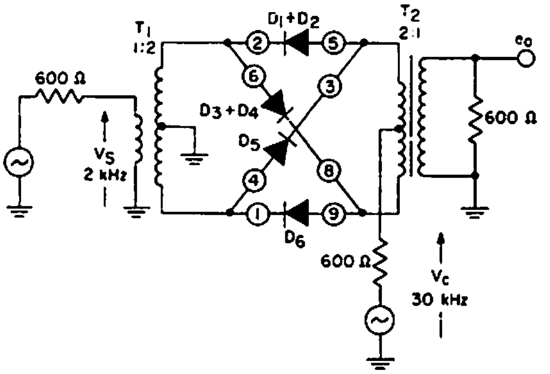

R2
100k
20v d-c
0.05 μf
R1
10k
−0.3 v d-c
10Ω
MC 1433
15k
OUTPUT VOLTAGE
R7
230k
10 pf
47 pf
−12 v d-c
R5
8.25k
R6
5k
R4
90.9k

A-M WITHOUT CARRIER SUPPRESSION—IC opamp delivers modulating output that varies around d-c level, for amplitude modulation without carrier suppression in double balanced mixer. D-c input at upper left changes level along with a-c signal fed to noninverting input of IC.—K. Hanneman, Modulating Current Supplied by Op Amp, *Electronics*, Aug. 5, 1968, p 107.


2nd DOUBLER
6CW4
IN FROM OSC DOUB.
37.5Mc
TO 3rd DOUBLER
390
C₁
L₁
100K
T.P.
100K
120K
VC₁
22K
.001
+150
MODULATOR
270K
MOD. SIGNAL
5/50
+28V
25K
51K
VC₁ = PSI TYPE PC 113 VARICAP
L₁ = 1.8 μhys ADJ.

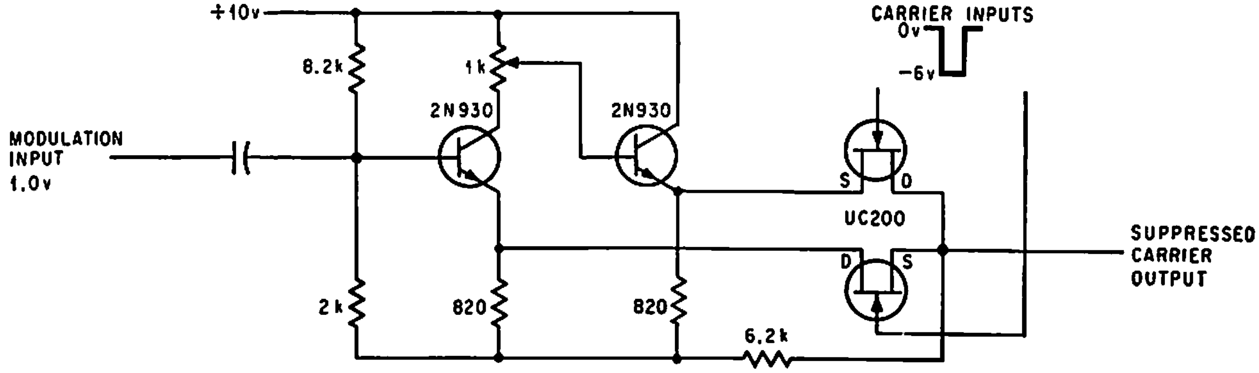
VARACTOR PHASE MODULATOR—Input of 7 V p-p produces 1 radian of phase modulation at 150 MHz from oscillator-doubler of crystal-controlled vhf signal generator.—G. Costa, VHF Signal Uses Varactor for Phase Modulation, *Electronic Design*, Oct. 26, 1964, p 58–59.


+300V
61.9K*
R₁₁
61.9K*
R₁₀
0.001
C₁
0.001
C₂
150K
R₁₂
VIDEO INPUT
SUPPRESSED CARRIER OUTPUT TO GRID OF NEXT STAGE
R₉
C₉
0.01
C₃
0.001
C₄
7360
61.9K*
R₈
+150V
0.47
C₈
0.001
C₅
0.01
C₇
4.7K
R₄
4.7K
R₅
1K
R₁
47K
R₂
0.01
C₆
511
R₃
4.7K
R₆
10K
R₇
150K
R₁₃
L.O. INPUT
* 1 % RESISTORS
OUTPUT TRANSFORMER
USE COIL FORM SIMILAR TO CTC TYPE 2271-2 WITH 7 LUGS, MINIMUM
PRIMARY
SECONDARY (WOUND ON TOP OF PRIMARY)

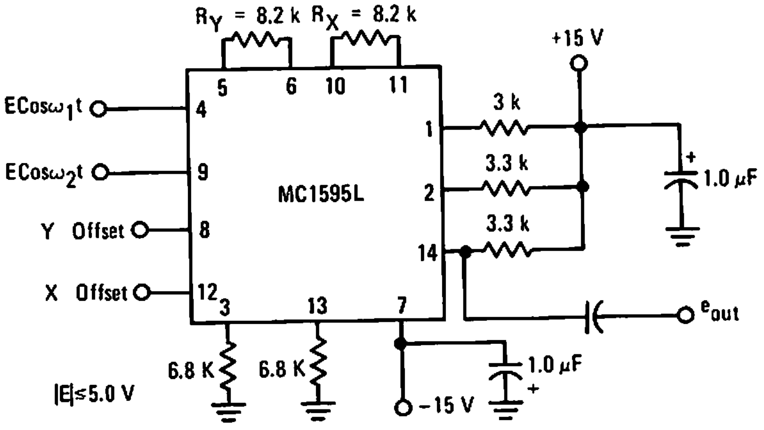

T₁
1:2
D₁+D₂
T₂
2:1
e₀
600 Ω
600 Ω
D₃+D₄
D₅
D₆
Vs
2 kHz
600 Ω
Vc
30 kHz

RING MODULATOR—Uses four diodes from CA3019 diode array for suppressing both carrier frequency and signal frequency, so output theoretically contains only upper and lower sidebands. For single-sideband transmission, one sideband can be eliminated by selective filtering.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 306.

54-DB CARRIER SUPPRESSION—Special transformer simplifies nulling of carrier in balanced modulator using 7360 beam deflection tube. Transformer consists of bifilar primary, wound first and lacquered in position, and split secondary wound on top of primary.—J. L. Christensen and D. Johnson, Balanced Modulator Transformer Increases Carrier Suppression, *Electronic Design*, Jan. 18, 1969, p 46–47.

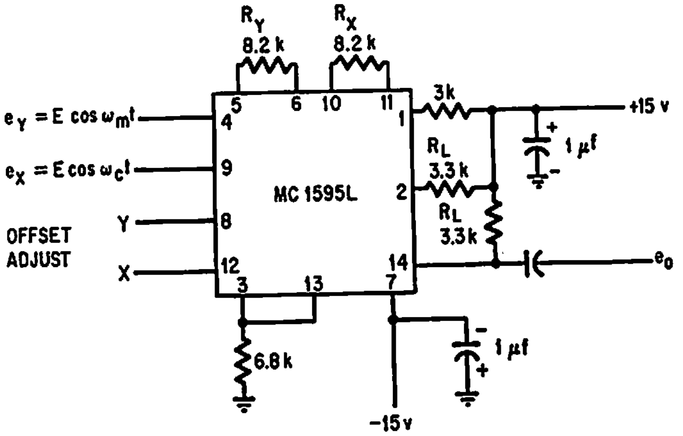

+10v
8.2k
1k
2N930
2N930
CARRIER INPUTS
0v
-6v
MODULATION INPUT 1.0v
S
D
UC200
D
S
SUPPRESSED CARRIER OUTPUT
2k
820
820
6.2k

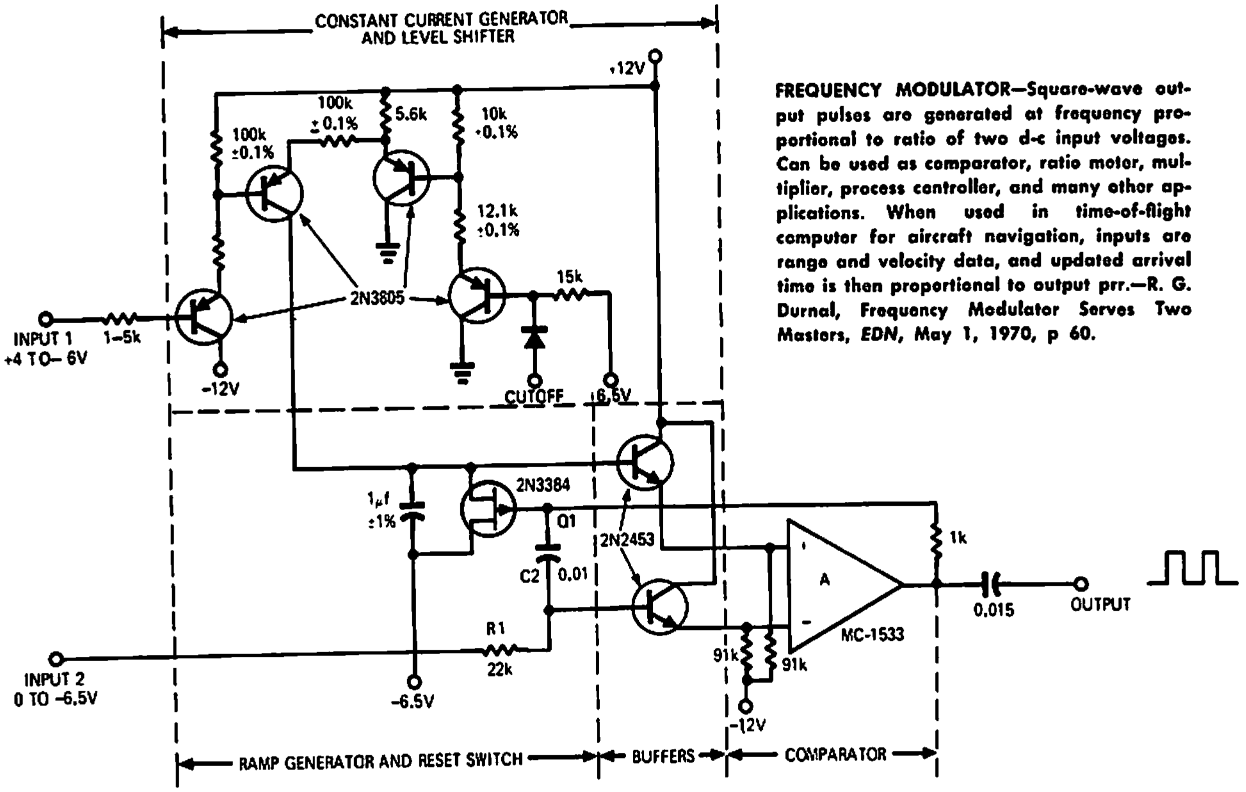
SWITCHED-FET SUPPRESSED-CARRIER—At 100 kHz modulated with 5 kHz, carrier signal rejection is 50 dB and modulation signal rejection 60 dB. Requires no transformers or complex balancing techniques. Modulating signal must be maintained below 1 V peak-to-peak. —C. H. McDermott, Suppressed Carrier Modulator With Noncritical Components, *Electronics*, Oct. 31, 1966, p 70.


R_Y = 8.2 k
R_X = 8.2 k
+15 V
ECosω_1t
ECosω_2t
Y Offset
X Offset
MC1595L
5
6
10
11
4
9
8
12
3
13
7
1
2
14
3 k
3.3 k
3.3 k
1.0 μF
1.0 μF
e_{out}
6.8 K
6.8 K
-15 V
|E|≤5.0 V

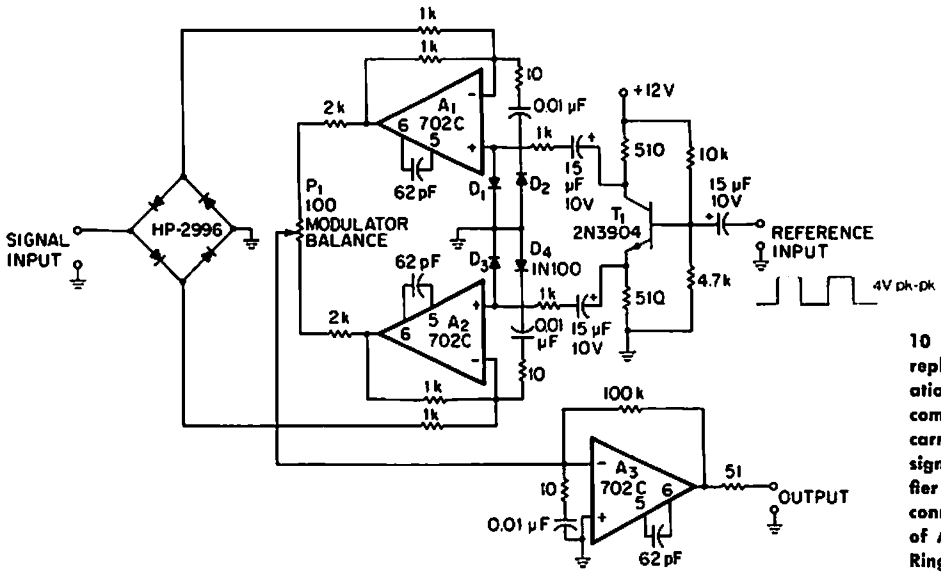
BALANCED MODULATOR—Uses IC linear multiplier as suppressed-carrier modulator, with 1.6-kHz audio tone on 40-kHz carrier as one application.—E. Renschler, The Monolithic Multiplier Breakthrough, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 27–36.

40-KHZ BALANCED MODULATOR—Motorola monolithic multiplier serves as balanced modulator for 1.6-kHz input signal. Article tells how to design external circuits to handle maximum input voltage swing without introducing nonlinearity.—E. Renschler and D. Weiss, Try the Monolithic Multiplier as a Versatile A-C Design Tool, *Electronics*, June 8, 1970, p 100–105.

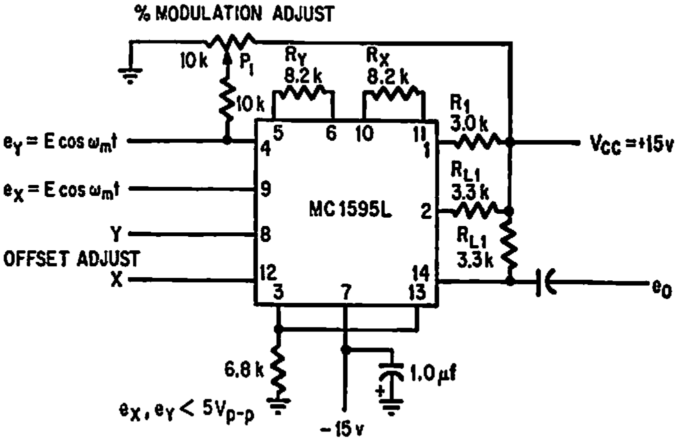

R_Y
8.2 k
R_X
8.2 k
e_Y = E cos ω_mt
e_X = E cos ω_ct
OFFSET ADJUST
Y
X
MC 1595L
5
6
10
11
4
9
8
12
3
13
1
2
14
7
3k
R_L
3.3 k
R_L
3.3 k
+15 v
1 μf
e_0
6.8 k
1 μf
-15 v


CONSTANT CURRENT GENERATOR AND LEVEL SHIFTER
+12V
100k ±0.1%
100k ±0.1%
5.6k
10k ±0.1%
12.1k ±0.1%
2N3805
15k
INPUT 1 +4 TO -6V
1-5k
-12V
CUTOFF
+6.5V
2N3384
1μf ±1%
Q1
C2
0.01
2N2453
1k
A
MC-1533
0.015
OUTPUT
INPUT 2 0 TO -6.5V
R1
22k
-6.5V
91k
91k
-12V
RAMP GENERATOR AND RESET SWITCH
BUFFERS
COMPARATOR

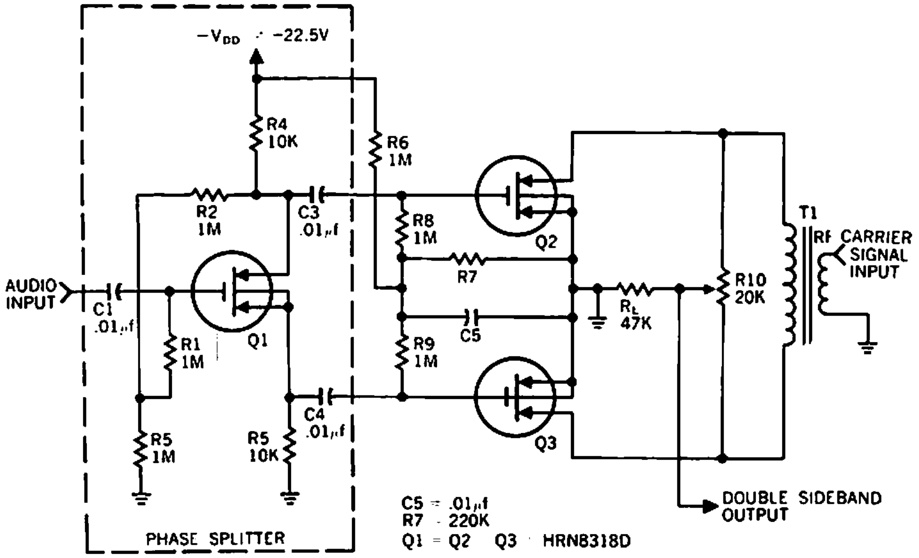
FREQUENCY MODULATOR—Square-wave output pulses are generated at frequency proportional to ratio of two d-c input voltages. Can be used as comparator, ratio motor, multiplier, process controller, and many other applications. When used in time-of-flight computer for aircraft navigation, inputs are range and velocity data, and updated arrival time is then proportional to output prr.—R. G. Durnal, Frequency Modulator Serves Two Masters, *EDN*, May 1, 1970, p 60.


1k
1k
10
0.01 μF
+12V
2k
A1
6 702C
5
1k
510
10k
15 μF 10V
15 μF 10V
62pF
D1
D2
T1
2N3904
P1
100
MODULATOR BALANCE
SIGNAL INPUT
HP-2996
REFERENCE INPUT
4V pk-pk
62pF
D3
D4
1N100
1k
51Ω
4.7k
2k
5 A2
6 702C
0.01 μF
15 μF 10V
10
1k
1k
100k
A3
702C
10
0.01 μF
62pF
51
OUTPUT

10 HZ—1 MHZ RING MODULATOR—Opamps replace transformers, to provide reliable operation over wide frequency range without component changes. A1 and A2 gate hot-carrier diodes and condition signal. Incoming signal is passed into each unity-gain amplifier during half of reference cycle and disconnected during other half. A3 sums outputs of A1 and A2.—J. R. Nielsen, Transformerless Ring Modulator, *EEE*, Feb. 1970, p 116.

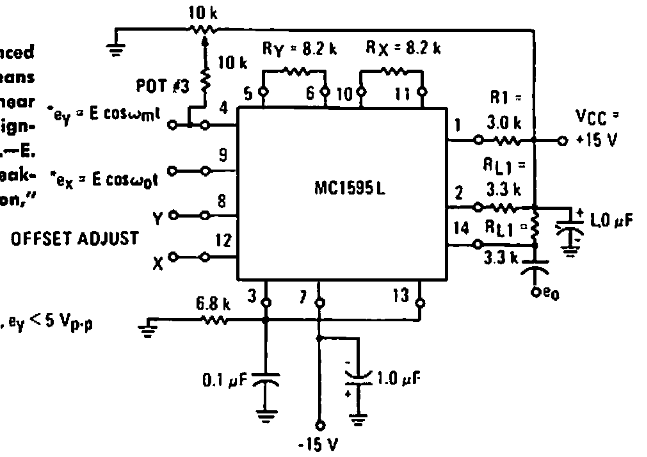

% MODULATION ADJUST
10k
P1
10k
RY 8.2k
RX 8.2k
R1 3.0k
eY = E cos ωmt
eX = E cos ωmt
Y
OFFSET ADJUST
X
MC1595L
5 6 10 11
4
1
9
2
8
12
14
3 7 13
RL1 3.3k
RL1 3.3k
VCC = +15v
e0
6.8k
1.0 μf
eX, eY < 5Vp-p
-15v

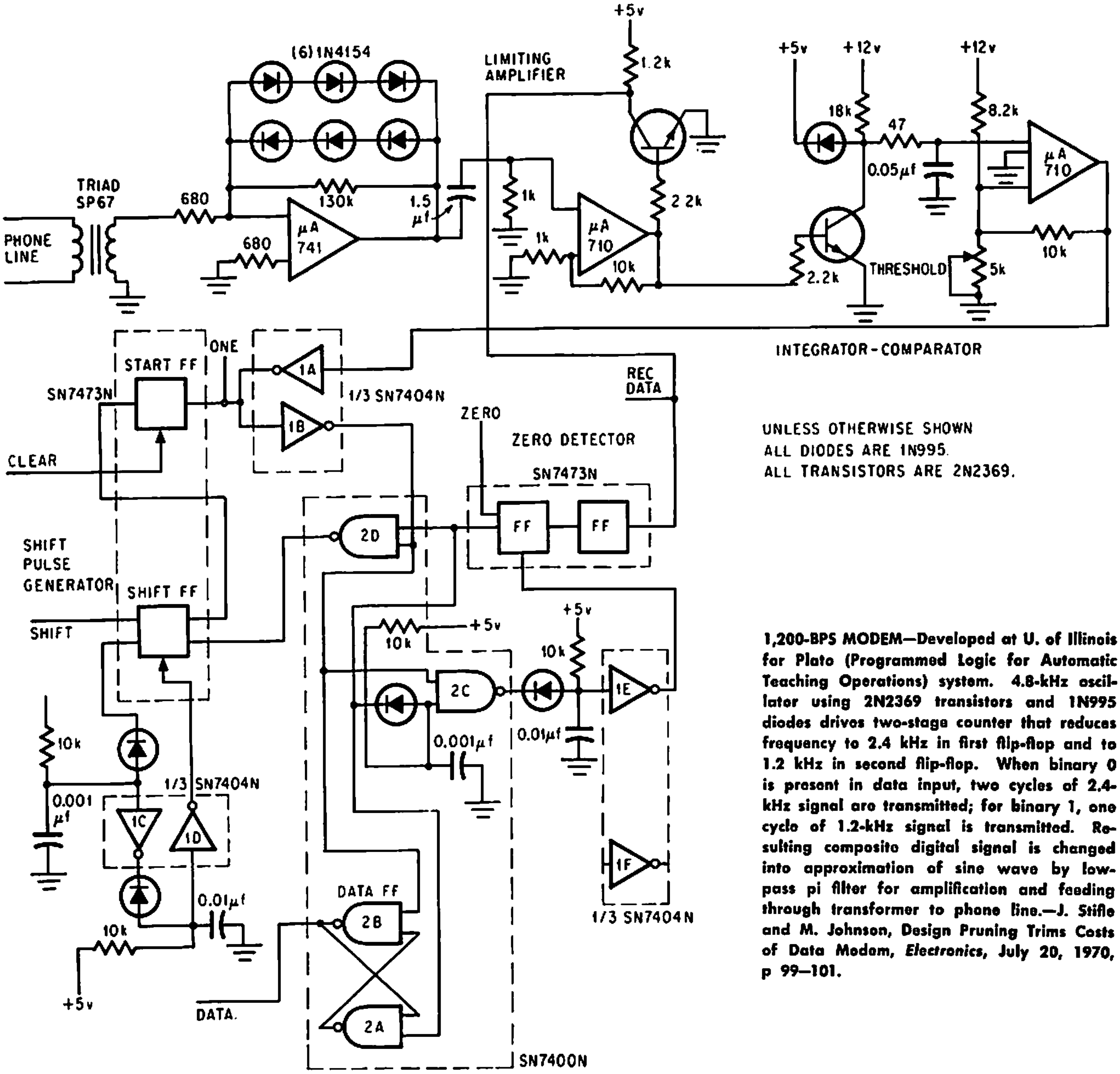
IC FOR A-M—Motorola monolithic multiplier performs amplitude modulation by adding d-c term to modulating signal with pot P1.—E. Renschler and D. Weiss, Try the Monolithic Multiplier as a Versatile A-C Design Tool, *Electronics*, June 8, 1970, p 100–105.


−VDD = −22.5V
R4 10K
R6 1M
R2 1M
C3 .01μf
R8 1M
Q2
T1
RF CARRIER SIGNAL INPUT
AUDIO INPUT
C1 .01μf
R7
R10 20K
Q1
C5
RL 47K
R1 1M
R9 1M
C4 .01μf
Q3
R5 1M
R5 10K
PHASE SPLITTER
DOUBLE SIDEBAND OUTPUT
C5 = .01μf
R7 = 220K
Q1 = Q2 = Q3 = HRN8318D

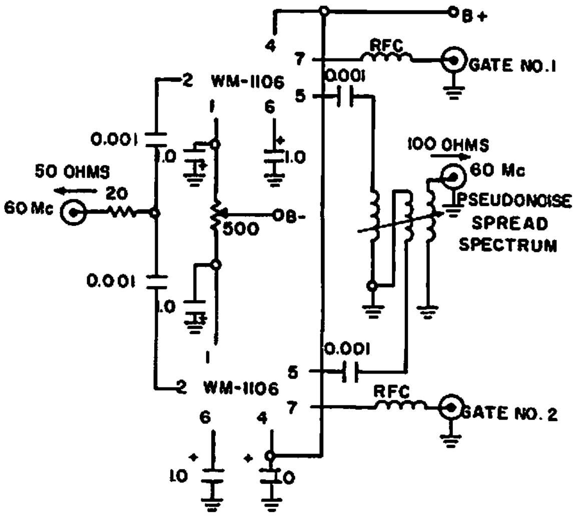
MOSFET BALANCED MODULATOR—Provides audio modulation of r-f carrier signal for double-sideband generation. Mosfet Q1 acts as phase splitter having extremely high input impedance, for driving other two mosfets out of phase to produce double sideband. R10 serves for balancing output signals accurately, for use in modulating linear r-f power amplifiers.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 42.

A-M WITH IC MULTIPLIER—Similar to balanced modulator, but with d-c term added by means of potentiometer 3. IC is Motorola linear four-quadrant multiplier. With careful alignment, 100% modulation is possible.—E. Renschler, The Monolithic Multiplier Breakthrough, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 27–36.

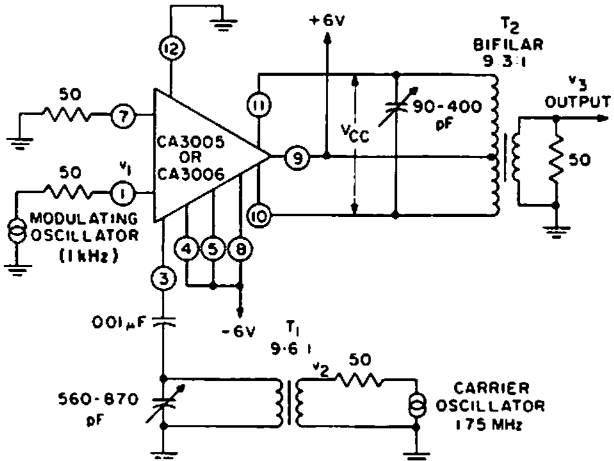

10 k
10 k
POT #3
R_Y = 8.2 k
R_X = 8.2 k
*e_y = E cos ωmt
*e_x = E cos ω_0t
Y
X
OFFSET ADJUST
MC1595L
R1 = 3.0 k
VCC = +15 V
R_{L1} = 3.3 k
R_{L1} = 3.3 k
1.0 µF
e_0
6.8 k
0.1 µF
1.0 µF
-15 V
*e_x, e_y < 5 $V_{p\text{-}p}$


(6) 1N4154
TRIAD SP67
PHONE LINE
680
680
130k
µA 741
1.5 µf
LIMITING AMPLIFIER
+5v
1.2k
1k
1k
µA 710
2.2k
10k
+5v
+12v
+12v
18k
47
0.05µf
2.2k
THRESHOLD
8.2k
µA 710
5k
10k
INTEGRATOR-COMPARATOR
START FF
SN7473N
ONE
1A
1B
1/3 SN7404N
CLEAR
REC DATA
ZERO
ZERO DETECTOR
SN7473N
FF
FF
2D
SHIFT PULSE GENERATOR
SHIFT FF
SHIFT
10k
+5v
10k
+5v
2C
0.001µf
0.01µf
1E
10k
0.001 µf
1/3 SN7404N
1C
1D
0.01µf
10k
+5v
DATA FF
2B
2A
DATA
1F
1/3 SN7404N
SN7400N
UNLESS OTHERWISE SHOWN
ALL DIODES ARE 1N995.
ALL TRANSISTORS ARE 2N2369.

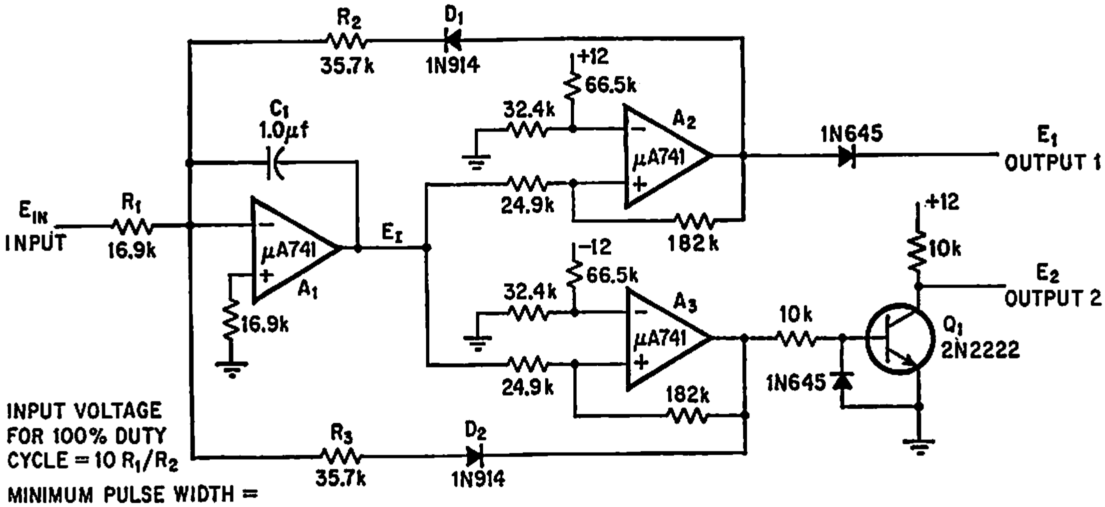
1,200-BPS MODEM—Developed at U. of Illinois for Plato (Programmed Logic for Automatic Teaching Operations) system. 4.8-kHz oscillator using 2N2369 transistors and 1N995 diodes drives two-stage counter that reduces frequency to 2.4 kHz in first flip-flop and to 1.2 kHz in second flip-flop. When binary 0 is present in data input, two cycles of 2.4-kHz signal are transmitted; for binary 1, one cycle of 1.2-kHz signal is transmitted. Resulting composite digital signal is changed into approximation of sine wave by low-pass pi filter for amplification and feeding through transformer to phone line.—J. Stifle and M. Johnson, Design Pruning Trims Costs of Data Modem, *Electronics*, July 20, 1970, p 99–101.


B+
4
7
RFC
GATE NO. 1
2 WM-1106
0.001
1
6
5
0.001
1.0
1.0
100 OHMS
60 Mc
50 OHMS
20
60 Mc
PSEUDONOISE SPREAD SPECTRUM
500
B-
0.001
1.0
0.001
1
5
2 WM-1106
RFC
6
4
7
GATE NO. 2
1.0
1.0

PHASE MODULATOR FOR 60-MHZ I-F—Provides 180-deg shift in phase of output signal each time switching signal is applied to modulator, to give coded noise-like output. Operates with pseudo-random code having maximum code rate of 5 megabits per second. Switching time is faster than 30 ns. Uses two gated IC video amplifiers fed in parallel, with outputs fed to push-pull transformer.—S. G. Shepherd and A. E. Seman, Design With Integrated Circuits at 60 Mc, *Electronic Design,* Aug. 2, 1965, p 30–33.


12
+6V
T_2
BIFILAR
9:3:1
V_3
OUTPUT
50
7
11
90-400 pF
V_{CC}
CA3005 OR CA3006
9
50
50
V_1
1
MODULATING OSCILLATOR (1 kHz)
10
4
5
8
3
.001 μF
-6V
T_1
9:6:1
V_2
50
560-870 pF
CARRIER OSCILLATOR 1.75 MHz

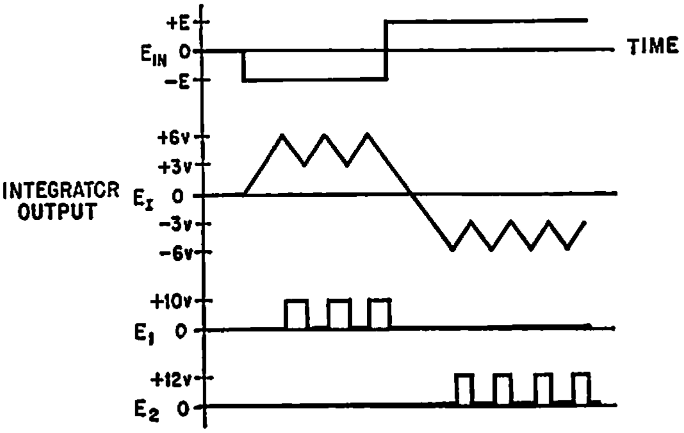
SUPPRESSED-CARRIER MODULATOR—Uses IC r-f amplifier as double-sideband modulator. Carrier suppression is function of bilateral symmetry and modulation-to-carrier drive ratio. Carrier output is 25 dB below double-sideband output when drive V1 is 10 mV and V2 is 31.5 mV.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 229.


R_2
35.7k
D_1
1N914
+12
66.5k
C_1
1.0μf
32.4k
A_2
μA741
1N645
E_1
OUTPUT 1
24.9k
182k
E_{IN}
INPUT
R_1
16.9k
μA741
A_1
E_I
+12
10k
16.9k
-12
66.5k
E_2
OUTPUT 2
32.4k
A_3
μA741
10k
Q_1
2N2222
24.9k
1N645
182k
R_3
35.7k
D_2
1N914

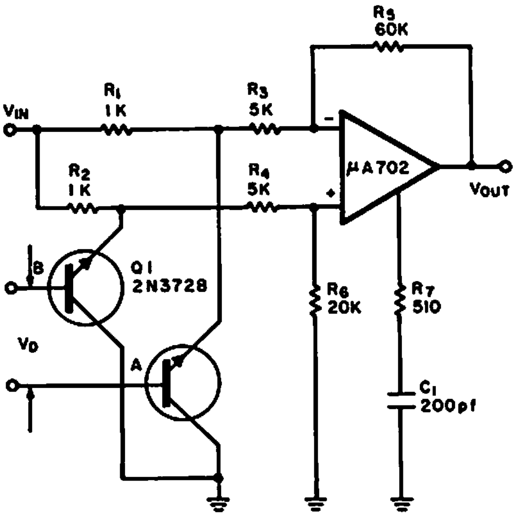
INPUT VOLTAGE FOR 100% DUTY CYCLE = 10 R_1/R_2

MINIMUM PULSE WIDTH = $3R_2C_1/10$

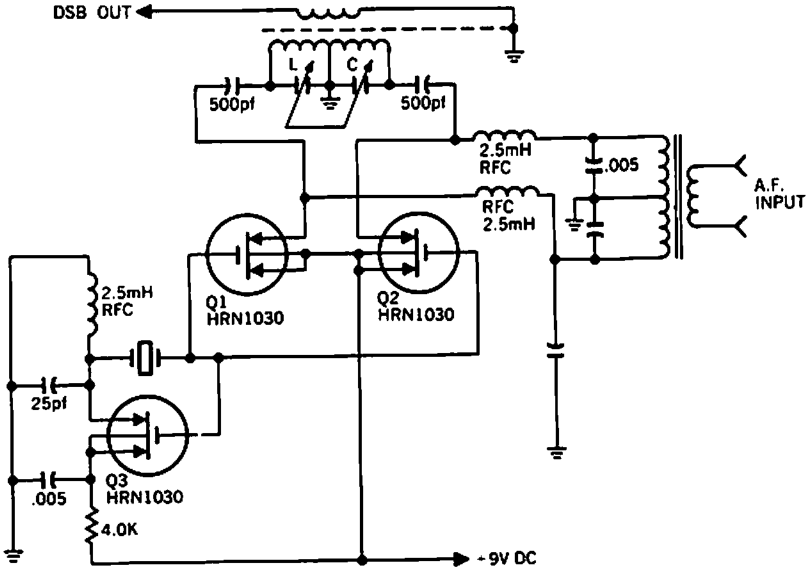
MAXIMUM FREQUENCY = $10/R_2C_1$



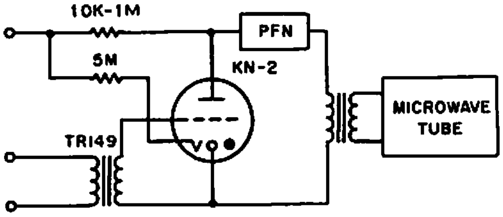
BANG-BANG SUBSTITUTE—Provides variations in pulse width and frequency for solenoid-type pneumatic valves in missile and space vehicles, to give both coarse and fine control having many advantages over conventional bang-bang systems. Circuit gives large savings in gas and energy consumption. For small control signals, valves are modulated with minimum pulse width for just barely opening valve. For large control signals, system changes to bang-bang mode.—W. A. Cooke, Pulse Modulator Regulates Pneumatic Valve Closure, *Electronics,* Sept. 1, 1969, p 80–81.


R5
60K
VIN
R1
1K
R3
5K
R2
1K
R4
5K
μA702
VOUT
B
Q1
2N3728
R6
20K
R7
510
VD
A
C1
200pf

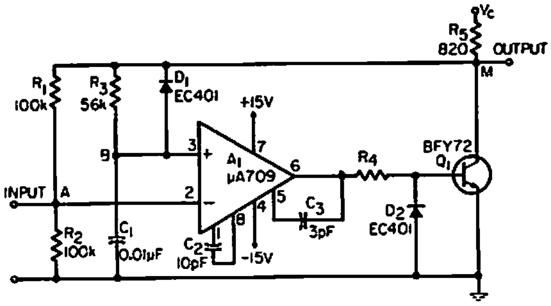
TRANSFORMERLESS MODEM—Uses Fairchild IC opamp as full-wave modulator-demodulator operating over wide range of frequencies. Input switch Q1 alternately switches IC from inverting (transistor A ON) to noninverting (transistor B ON) amplifier. Push-pull drive signal can be obtained from IC flip-flop. Values shown give gain of 10 and bandwidth of 10 MHz.—C. J. Amato, The Integrated Operational Amplifier: A Versatile and Economical Circuit, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 189—194.


DSB OUT
L
C
500pf
500pf
2.5mH
RFC
.005
RFC
2.5mH
A.F.
INPUT
2.5mH
RFC
Q1
HRN1030
Q2
HRN1030
25pf
.005
Q3
HRN1030
4.0K
-9V DC

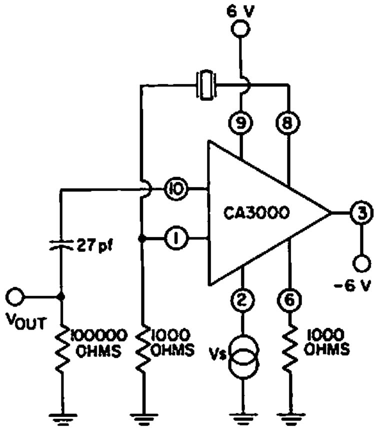
DOUBLE-SIDEBAND GENERATOR—Simple crystal oscillator drives two mosfet r-f switches that are modulated out of phase with audio input signal to generate double-sideband r-f carrier signal.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 43.


10K-1M
PFN
5M
KN-2
MICROWAVE
TUBE
TR149

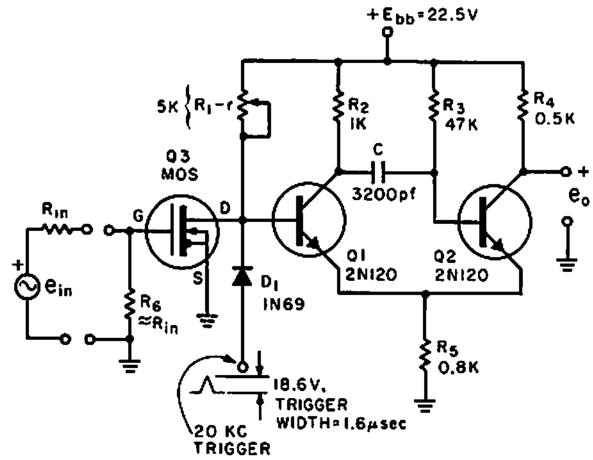
BEACON MODULATOR—Input pulse trips Krytron gas-filled switch tube, producing high peak current through pulse-forming network and output transformer, for pulse modulation of high-power microwave radar tube.—Krytrons—Cold Cathode Switch Tubes, EG&G, Boston, Mass., KR-100, 1968.


Vc
R5
820
OUTPUT
M
R1
100k
R3
56k
D1
EC401
+15V
B
3
A1
μA709
7
6
R4
BFY72
Q1
INPUT
A
2
5
C3
3pF
4
8
D2
EC401
R2
100k
C1
0.01μF
C2
10pF
1
-15V

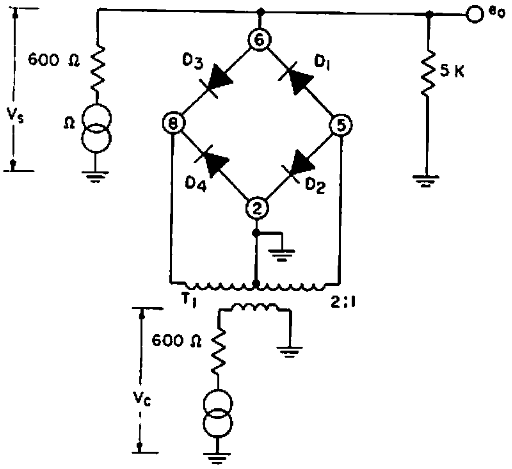
ANALOG MULTIPLIER—Single opamp connected as one-shot accepts input frequencies from 1 to 1,000 Hz and control voltages from 0.1 to 15 V, and delivers constant-width output pulses with amplitudes proportional to product of input frequency and d-c control voltage. Multiplication accuracy is 0.1%. Q1 may be any suitable switching transistor with low VCE.—B. Stojanovic, Pulse-Height Modulator Multiplies Voltage by Frequency, *EEE*, July 1968, p 99—100.


6 V
9
8
10
CA3000
3
27pf
1
-6 V
VOUT
2
6
100000
OHMS
1000
OHMS
Vs
1000
OHMS

MODULATED CRYSTAL IC—Introduction of audio signal at terminal 2 of IC d-c amplifier operating as crystal oscillator gives a-m modulation. High-pass filter must be used at output. Carrier frequency may be up to 1 MHz, depending on crystal used.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 125.


+Ebb=22.5V
5K
R1-r
R2
1K
R3
47K
R4
0.5K
Q3
MOS
C
3200pf
Rin
G
D
S
+
ein
R6
≈Rin
D1
1N69
Q1
2N120
Q2
2N120
+
eo
R5
0.8K
18.6V,
TRIGGER
WIDTH=1.6μsec
20 KC
TRIGGER

IC PDM—Audio input voltage varies resistance of mosfet Q3, which in turn varies base voltage of Q1 and duration of output pulse. Designed for construction as integrated-circuit chip. For peak input under 1 V, output pulse amplitude is above 2 V and modulation index is 0.25 to 0.75. Trigger rate of 20 kHz was chosen because it is high enough for sampling audio signal and low enough for easy filtering. Unmodulated pulse duration is 25 μs. Uses RCA insulated-gate depletion-type mosfet.—A. J. Wall, Converting a Pulse Modulator Into An Integrated Chip, *Electronic Design*, Feb. 17, 1964, p 60–65.


600 Ω
Vs
Ω
6
D3
D1
8
5
D4
D2
2
5K
eo
T1
2:1
600 Ω
Vc

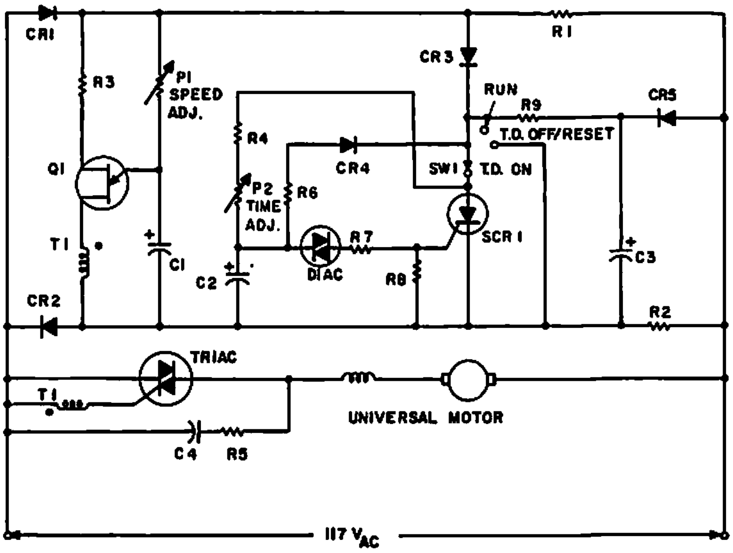
T1—TECHNITROL No. 851166 OR EQUIV.

IC BALANCED MODULATOR—Uses CA3019 four-diode IC array in symmetrical bridge network that minimizes carrier frequency at output. Carrier of one polarity makes all diodes conduct and effectively short-circuits signal source. Carrier of opposite polarity cuts off all diodes and allows signal current to flow to load. If all diodes are identical, bridge is perfectly balanced and no carrier current reaches load.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 300.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 53

Motor Control Circuits



CR1
R3
P1 SPEED ADJ.
Q1
T1
C1
CR2
R4
P2 TIME ADJ.
R6
C2
CR4
DIAC
R7
R8
SW1
T.D. ON
RUN
R9
T.D. OFF/RESET
CR3
SCR 1
R1
CR5
C3
R2
TRIAC
UNIVERSAL MOTOR
C4
R5
117 V_{AC}

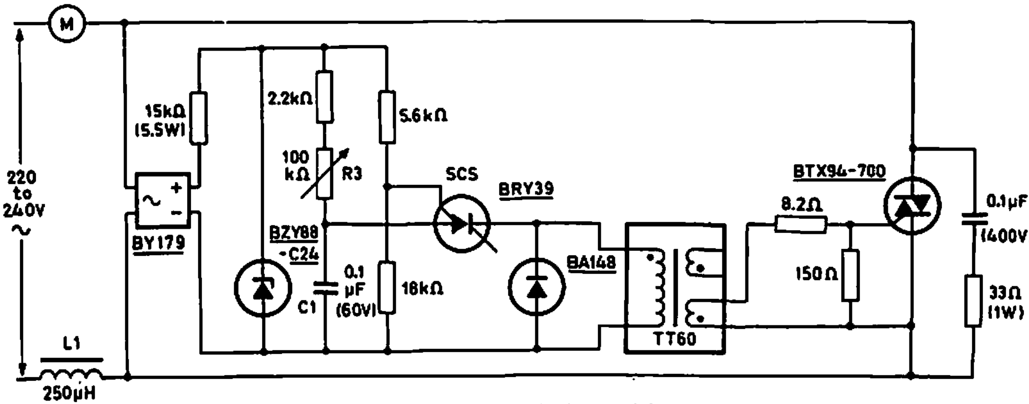
CR1 THROUGH CR5 GE A14B
Q1 : GE 2N2646
DIAC : GE ST2
SCR1 : GE C106B
TRIAC : GE SC40BX43

T1 : 1:1 PULSE TRANFORMER (SPRAGUE 11Z12)
C1 : .1μF 50V
C2 : 100μF 50V
C3 : .5μF 200V

C4 .1μF 200V
R1-R2 33K 1/2W
R3 390Ω 1/2W
R4 10K 1/2W
R9 10K 2W

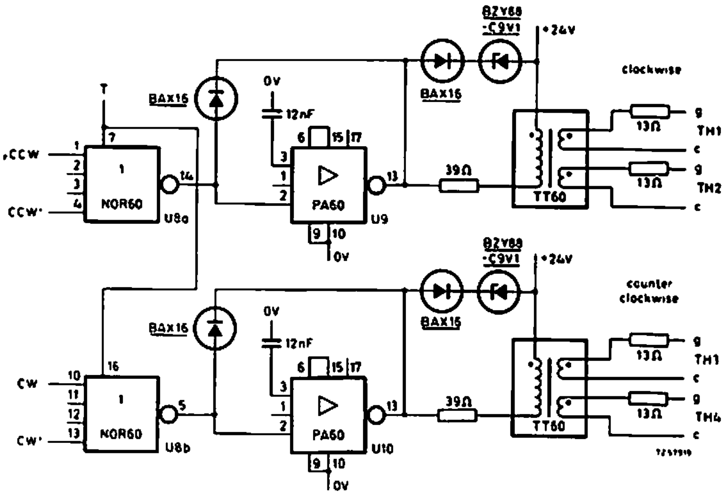
R5-R6 100Ω 1/2W
R7-R8 1K 1/2W
P1 500K 1/2W
P2 1M 1/2W

DIAC-TRIAC FULL-WAVE WITH DELAY—Built-in time delay for automatic turn-off permits setting P2 to turn off motor of mixer or other appliance automatically after desired period of operation. Circuit can be reset for next cake by switching SW1 to OFF/RESET position. RUN position bypasses delay. —A. A. Adam, Speed Controls for Universal Motors, General Electric, Syracuse, N.Y., No. 200.57, 1966, p 11.

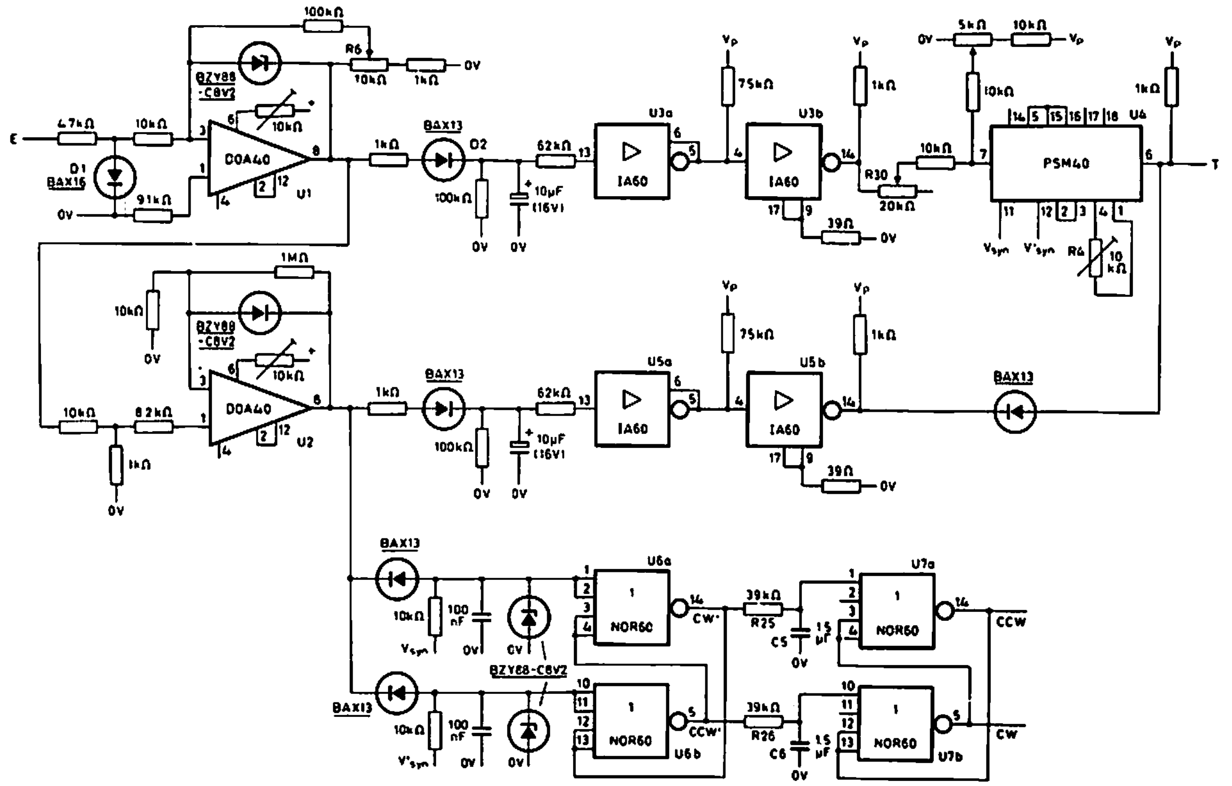


M
220 to 240V ~
15kΩ (5.5W)
BY179
2.2kΩ
100 kΩ
R3
BZY88 -C24
C1
0.1 μF (60V)
5.6kΩ
18kΩ
SCS
BRY39
BA148
TT60
8.2Ω
150Ω
BTX94-700
0.1μF (400V)
33Ω (1W)
L1
250μH

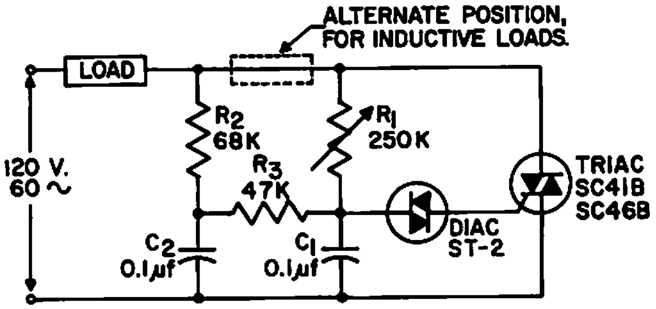
4.5-KW SQUIRREL-CAGE FAN MOTOR—Circuit has no hysteresis effect (no lag between change of speed setting and resultant change in motor speed). Circuit is designed for 220-250 V a-c line operation. Choke L1 limits steepness of current transients and helps suppress rfi.—G. J. Derksen and G. J. Tobisch, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 80, 1970.


BZY88-C9V1
+24V
clockwise
T
BAX16
0V
12nF
CCW
CCW'
NOR60
U8a
PA60
U9
39Ω
13Ω
TH1
TH2
TT60
counter clockwise
CW
CW'
U8b
U10
TH4

D-C MOTOR THYRISTOR TRIGGERING—Uses Philips IC unit to convert clockwise and counterclockwise commands from logic circuit to triggering required for operating d-c motor at either of two predetermined speed levels in either direction or stopping motor. Report describes operation in detail.—W. B. Rosink, Reversible Two-Speed D. C. Motor Supply, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 79.

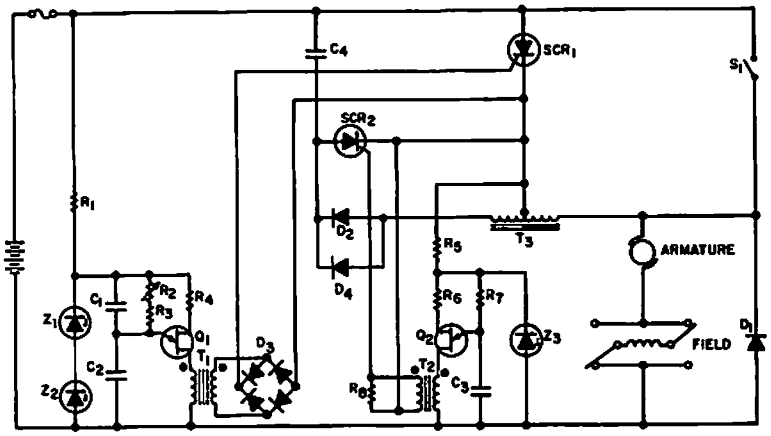

100kΩ
R6
10kΩ
1kΩ
0V
BZY88-C8V2
E
4.7kΩ
10kΩ
D1
BAX16
91kΩ
DOA40
U1
BAX13
D2
62kΩ
100kΩ
10μF (16V)
U3a
U3b
IA60
Vp
75kΩ
1kΩ
R30
20kΩ
39Ω
5kΩ
PSM40
U4
T
Vsyn
V'syn
R4
10kΩ
1MΩ
82kΩ
DOA40
U2
U5a
U5b
U6a
NOR60
CW'
39kΩ
R25
C5
15μF
U7a
CCW
U6b
CCW'
BZY88-C8V2
R26
C6
U7b
CW

D-C MOTOR CONTROL LOGIC—Requires a-c control signal that can be varied in amplitude and phase, applied to terminal E. Gives control in both directions at two predetermined speeds. When control signal drops below certain value, motor changes from high to low speed. At still lower signal level, motor stops. If signal phase is then reversed, motor starts in opposite direction, and runs at low or high speed level depending on amplitude of control signal. Operation of Philips IC units is described in report. Output leads CCW, CW, and T go to thyristor triggering circuit for motor.—W. B. Rosink, Reversible Two-Speed D. C. Motor Supply, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 79.


ALTERNATE POSITION, FOR INDUCTIVE LOADS.
LOAD
120 V.
60 ~
R2
68K
R3
47K
R1
250K
TRIAC
SC41B
SC46B
C2
0.1μf
C1
0.1μf
DIAC
ST-2

EXTENDED-RANGE FULL-WAVE—Use of extra capacitor C2 in basic 600-W diac-triac circuit extends range for reliable phase control, particularly at low output settings. Place load in alternate position for motors.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 16.

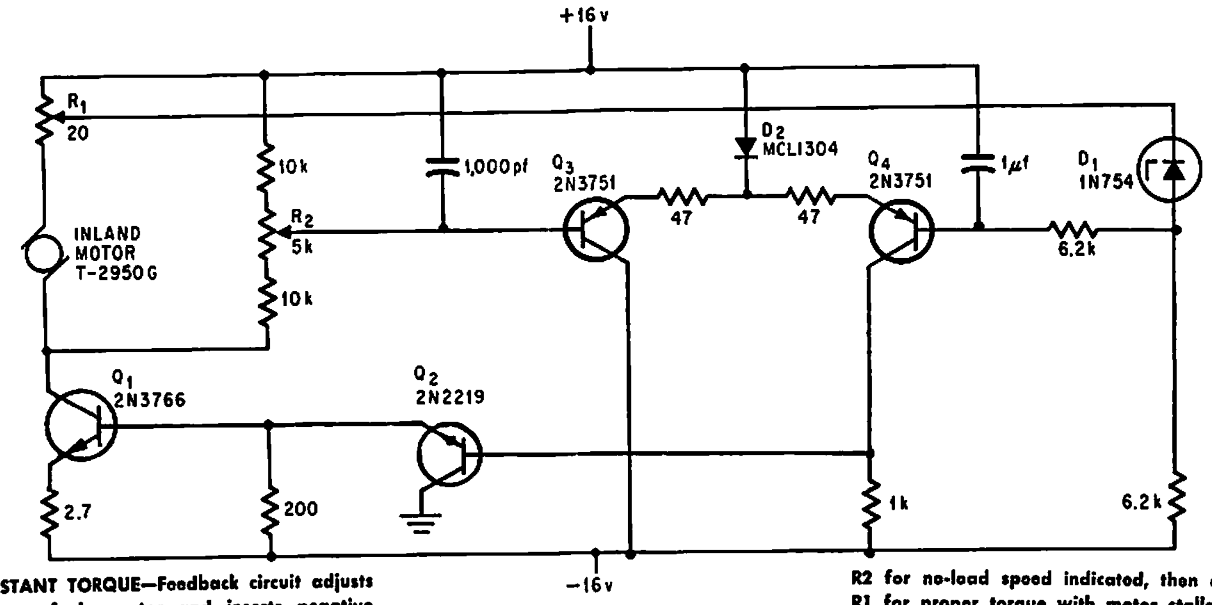
BATTERY-VEHICLE CONTROLLER—Uses rapid-acting scr switch, known as Jones chopper, in series with d-c series motor to control speed of battery-powered vehicle such as golf cart. At low speeds, ON time is much less than OFF time so average voltage across motor is low. OFF time is changed by R2 in timer, for smooth control and high efficiency. Operates as variable-frequency constant-pulse-width system. Pulse repetition rate range is about 100 to 400 Hz. Values are for 36-V battery and maximum motor current of 110 A. Article gives design equations.—"SCR Manual," 4th Edition, General Electric, 1967, p 237–243.


C4
SCR1
S1
SCR2
D2
D4
T3
ARMATURE
R1
R5
R6
R7
Z1
C1
R2
R3
R4
Q1
T1
D3
Q2
Z3
D1
FIELD
C2
Z2
R8
T2
C3

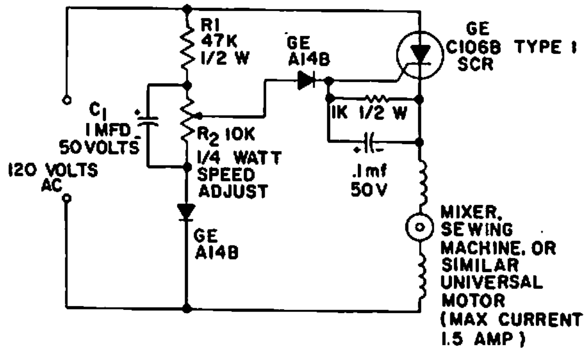
C_1—0.1μf, 100V
C_2—0.1μf, 100V
C_3—0.22μf, 100V
C_4—50μf, 115VAC GE 28F1102
D_1—G E 1N2155
D_2—G E 1N3673A
D_3—THYRECTOR GE 6RS21VA20D
Q_1—G E 2N2646
Q_2—G E 2N2647

R_1—220Ω, 2W
R_2—0 TO 100K POTENTIOMETER (TAPER Z)
R_3—20K, 1/2W
R_4—330Ω, 1/2W
R_5—270Ω, 2W
R_6—330Ω, 1/2W
R_7—15K, 1/2W
R_8—100Ω, 1/2W

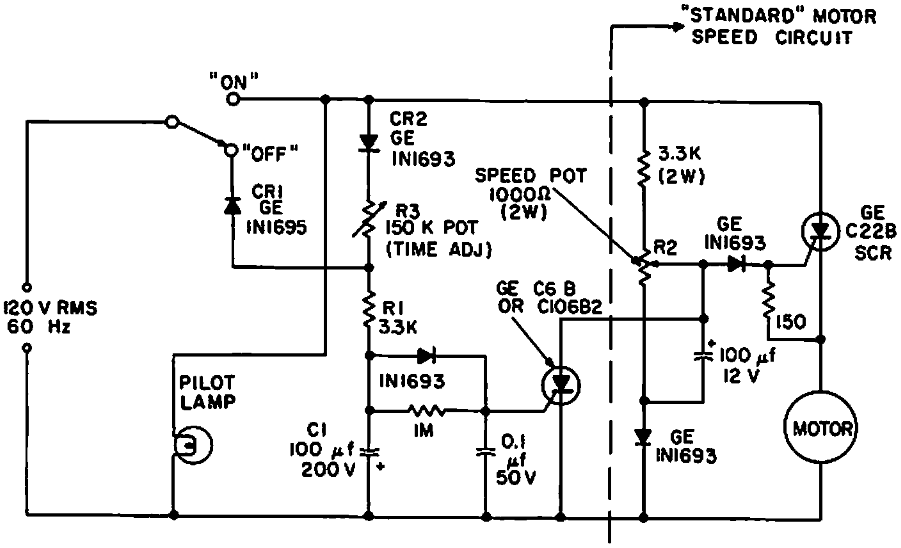
SCR_1—G E C154B
SCR_2—G E C140B
T_1, T_2 } PULSE ENGINEERING TYPE PE 2229
T_3—G E 9T46Y7009
Z_1—G E 1N1771
Z_2—G E 1N1771
Z_3—G E 1N1773


+16 v
R1
20
10k
R2
5k
10k
1,000 pf
INLAND MOTOR T-2950G
Q3
2N3751
47
D2
MCL1304
47
Q4
2N3751
1μf
D1
1N754
6.2k
Q1
2N3766
Q2
2N2219
2.7
200
1k
6.2k
−16 v

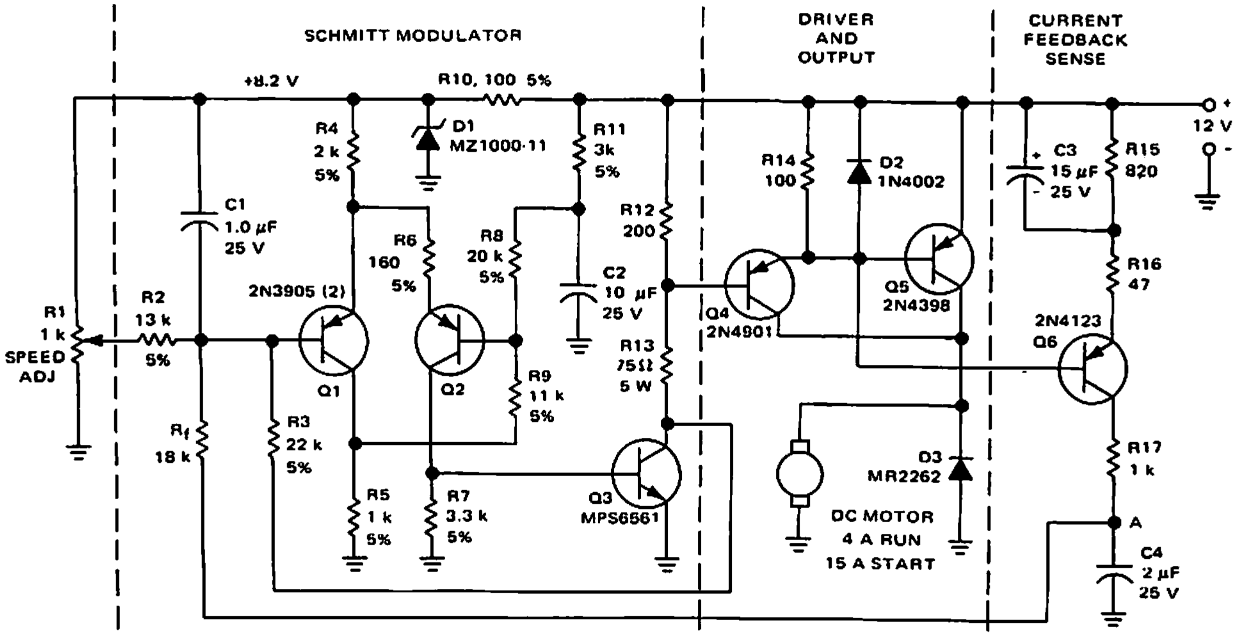
CONSTANT TORQUE—Feedback circuit adjusts voltage of d-c motor and inserts negative or positive adjustable resistance in series with motor, to offset typical variation of up to 20% in slope of torque-speed curve caused by variations in strength of permanent magnet. Used for constant-speed, constant-tension magnetic tape drive. To adjust for slope, set R2 for no-load speed indicated, then adjust R1 for proper torque with motor stalled.—E. S. Busby, Feedback Circuit Keeps Motor's Torque Constant, *Electronics*, Sept. 2, 1968, p 72.


R1
47K
1/2 W
GE
A14B
GE
C106B TYPE 1
SCR
C1
1 MFD
50 VOLTS
R2 10K
1/4 WATT
SPEED
ADJUST
1K 1/2 W
.1 mf
50 V
120 VOLTS
AC
GE
A14B
MIXER,
SEWING
MACHINE, OR
SIMILAR
UNIVERSAL
MOTOR
(MAX CURRENT
1.5 AMP)

SEWING-MACHINE MOTOR CONTROL—Can be used in place of carbon-pile speed control for sewing machines, food mixers, and other household appliances using universal a-c/d-c motors. Speed-dependent feedback gives excellent torque even at slow speeds. C1 is optional, and may sometimes improve performance. A selenium 6RS5PX7 double diode assembly may be used in place of the two A14B silicon diodes shown.—Silicon Controlled Rectifier, General Electric, Syracuse, N.Y., No. 150.9, 1969.


"STANDARD" MOTOR
SPEED CIRCUIT
"ON"
"OFF"
CR2
GE
1N1693
CR1
GE
1N1695
SPEED POT
1000Ω
(2W)
3.3K
(2W)
R3
150 K POT
(TIME ADJ)
R2
GE
1N1693
GE
C22B
SCR
120 V RMS
60 Hz
R1
3.3K
GE C6 B
OR C106B2
150
100 μf
12 V
1N1693
1M
PILOT
LAMP
C1
100 μf
200 V
0.1
μf
50 V
GE
1N1693
MOTOR

UNIVERSAL-MOTOR CONTROL WITH SELF-TIMING—Shuts motor off automatically after predetermined time delay determined by setting of R3. R2 determines speed. Suitable for blenders and larger food mixers having motors rated at up to 2 A. Maximum obtainable delay with circuit shown is above 30 s. Pilot lamp remains on until main power switch is turned off, after timer stops motor.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 37.

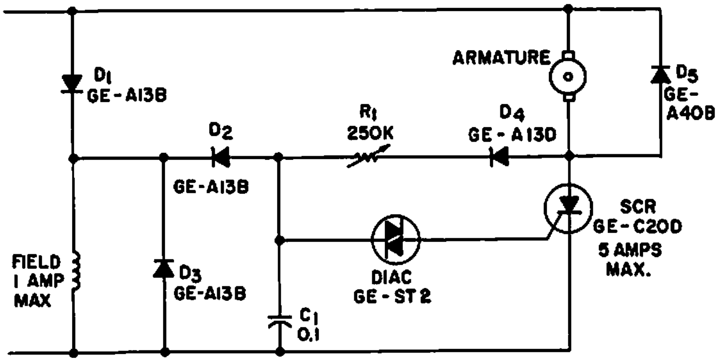

SCHMITT MODULATOR
DRIVER
AND
OUTPUT
CURRENT
FEEDBACK
SENSE
+8.2 V
R10, 100 5%
R4
2 k
5%
D1
MZ1000-11
R11
3k
5%
R14
100
D2
1N4002
C3
15 μF
25 V
R15
820
+
12 V
-
C1
1.0 μF
25 V
R6
160
5%
R8
20 k
5%
R12
200
C2
10 μF
25 V
Q5
2N4398
R16
47
R1
1 k
SPEED
ADJ
R2
13 k
5%
2N3905 (2)
Q1
Q2
R9
11 k
5%
R13
75Ω
5 W
Q4
2N4901
2N4123
Q6
Rf
18 k
R3
22 k
5%
R5
1 k
5%
R7
3.3 k
5%
Q3
MPS6561
D3
MR2262
DC MOTOR
4 A RUN
15 A START
R17
1 k
A
C4
2 μF
25 V

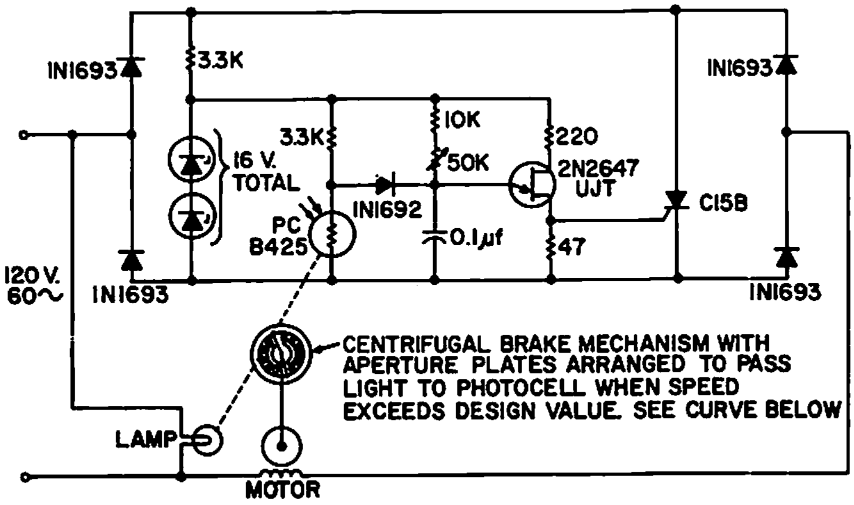
*ADJUST TO SUIT MOTOR

ALL RESISTORS ARE ±5%, 1/2 W UNLESS MARKED

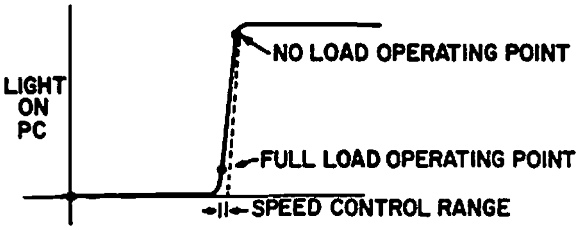
12-V PWM D-C CONTROL—Provides speed control of 12-V 4-A d-c motor, with good regulation at any given speed. Schmitt trigger Q1-Q2 and phase inverter Q3 produce variable-width variable-frequency pulse waveform whose duty cycle and frequency are a function of R1 and feedback current through Rf. Output of Schmitt modulator feeds Darlington-connected power amplifier Q4-Q5 that drives motor. Free-wheeling diode D3 suppresses inductive kickback of motor, while D2 protects Q5 from voltage transients of motor.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–30.

HALF-WAVE CONTROL FOR SHUNT MOTOR—Provides speed control for d-c shunt motor designed for operation on half-wave rectified 120-V a-c supply. D1 provides field current, with D3 smoothing its waveform. Diac-scr combination supplies armature current, with D5 for smoothing. At end of each positive half-cycle, field voltage drops to zero and C1 discharges through D2. Voltage across C1 is thus zero at start of each positive half-cycle, regardless of setting of speed control R1. Voltage rating of scr is twice that required for resistive load, or 400 V, because of counter emf of armature at high speeds.—E. K. Howell, Speed Control for Shunt-Wound DC Motors, General Electric, Syracuse, N.Y., No. 200.44, 1965, p 5.

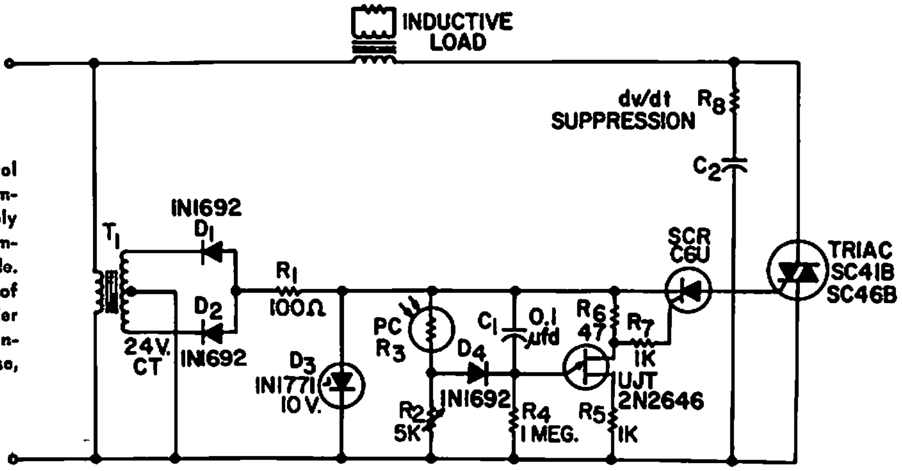

D1
GE-A13B
D2
GE-A13B
R1
250K
D4
GE-A13D
ARMATURE
D5
GE-A40B
SCR
GE-C20D
5 AMPS MAX.
FIELD
1 AMP
MAX
D3
GE-A13B
C1
0.1
DIAC
GE-ST2

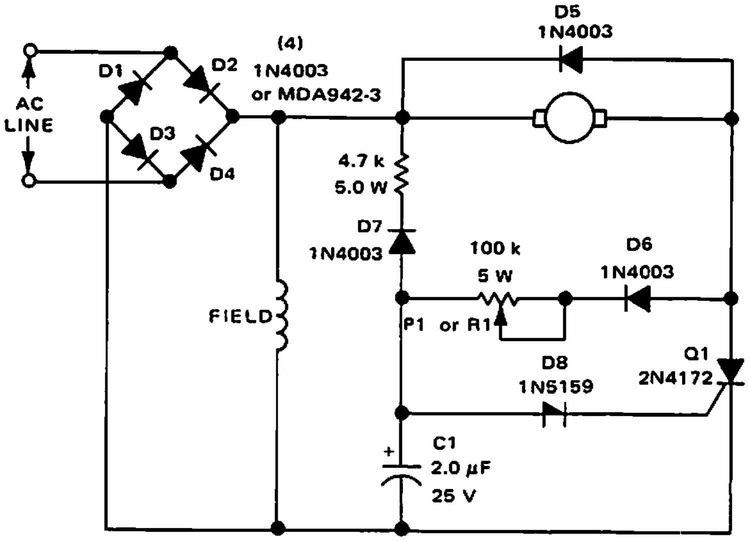

1N1693
3.3K
1N1693
3.3K
10K
220
50K
2N2647
UJT
16 V.
TOTAL
1N1692
C15B
PC
B425
0.1µf
47
120 V.
60~
1N1693
1N1693
CENTRIFUGAL BRAKE MECHANISM WITH APERTURE PLATES ARRANGED TO PASS LIGHT TO PHOTOCELL WHEN SPEED EXCEEDS DESIGN VALUE. SEE CURVE BELOW
LAMP
MOTOR

PHOTOELECTRIC-FEEDBACK A-C CONTROL—Centrifugal mechanism acts as variable shutter between lamp and photocell, to hold speed of induction motor constant within fairly tight limits.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 21.

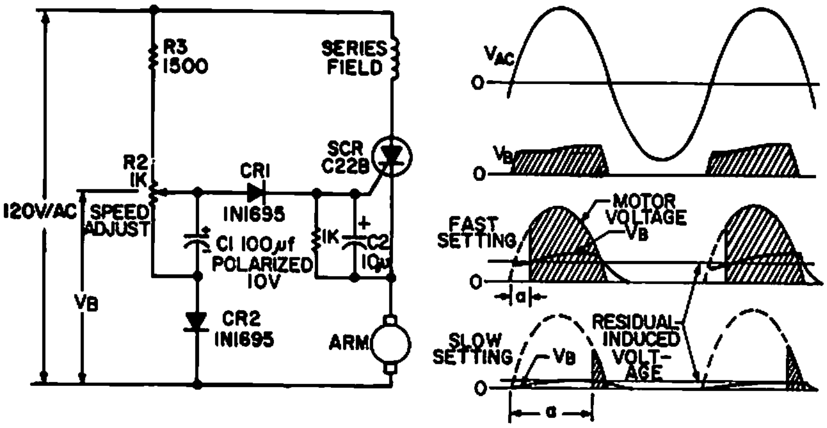


600-W RAMP-AND-PEDESTAL—Refined control circuit for inductive load eliminates d-c components of load current by deriving ujt supply voltage directly from a-c line to ensure symmetry of triggering angle on each half-cycle. Circuit design provides reliable triggering of triac under all conditions.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 16.

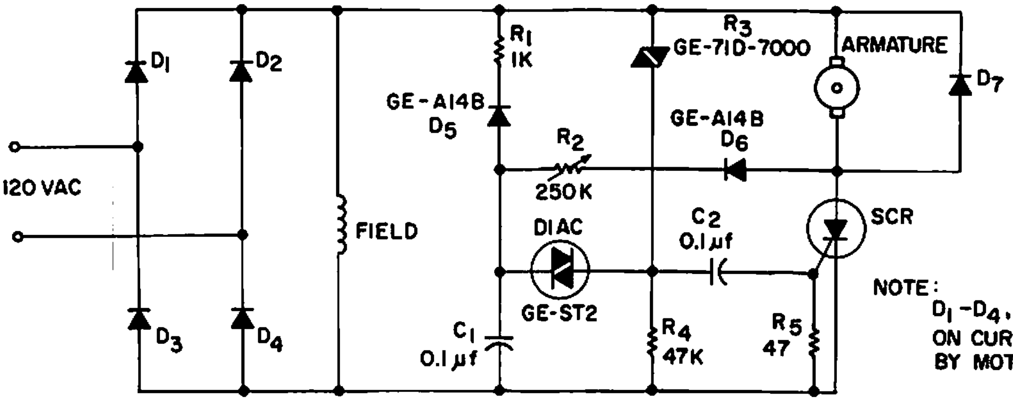

INDUCTIVE LOAD
dv/dt SUPPRESSION
R8
C2
T1
1N1692
D1
R1
100Ω
D2
1N1692
24V. CT
D3
1N1771
10 V.
PC
R3
C1
0.1 µfd
R6
47
R7
1K
SCR
C6U
TRIAC
SC41B
SC46B
D4
1N1692
R2
5K
R4
1 MEG.
R5
1K
UJT
2N2646


D5
1N4003
(4)
1N4003
or MDA942-3
AC LINE
D1
D2
D3
D4
4.7 k
5.0 W
D7
1N4003
100 k
5 W
D6
1N4003
P1 or R1
FIELD
D8
1N5159
Q1
2N4172
C1
2.0 μF
25 V
+

FULL-WAVE FOR SHUNT-WOUND—Power for 1/15th-hp 5,000-rpm 115-V d-c motor is supplied from full-wave bridge. Free-wheeling diode D5 is necessary across armature for scr Q1 to turn off. Four-layer diode D8 provides stable firing point for Q1. Speed pulsations occurred only at very low speed settings. Provides much better speed regulation than with comparable half-wave control.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–25.


R3
1500
SERIES FIELD
120V/AC
R2
1K
SPEED ADJUST
CR1
1N1695
SCR
C22B
C1 100μf
POLARIZED
10V
1K
C2
10μf
+
VB
CR2
1N1695
ARM
VAC
0
VB
0
FAST SETTING
MOTOR VOLTAGE
VB
0
a
SLOW SETTING
VB
RESIDUAL-INDUCED VOLTAGE
0
a

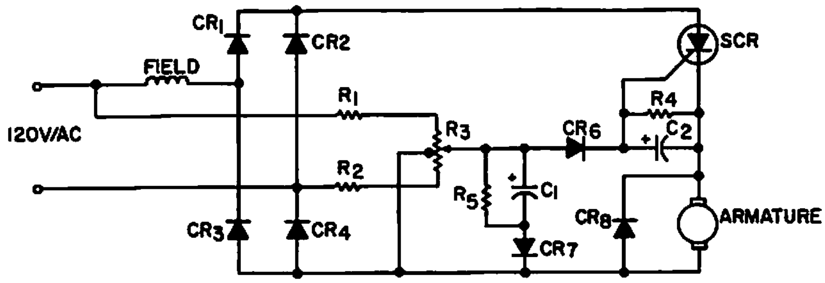
UNIVERSAL MOTOR CONTROL—Widely used for power tools and sewing machines. Compares voltage across capacitor with generated emf in armature to regulate motor speed. To avoid changing motor connections, series field may be left in armature circuit.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 23.


D1
D2
120 VAC
D3
D4
FIELD
R1
1K
GE-A14B
D5
R2
250K
DIAC
GE-ST2
C1
0.1μf
R3
GE-71D-7000
GE-A14B
D6
C2
0.1μf
R4
47K
R5
47
ARMATURE
D7
SCR

NOTE:
D_1-D_4, D_7 SCR SELECT ON CURRENT REQUIRED BY MOTOR.

LINE-VOLTAGE COMPENSATION WITH SPEED CONTROL—Provides armature voltage control of 115-V d-c shunt motor operating from a-c line through bridge rectifier. Field is directly across rectifier. Compensation for changes in line voltage is provided only at reduced speeds, by shifting voltage required across C1 to produce triggering of scr.—E. K. Howell, Speed Control for Shunt-Wound DC Motors, General Electric, Syracuse, N.Y., No. 200.44, 1965, p 4.

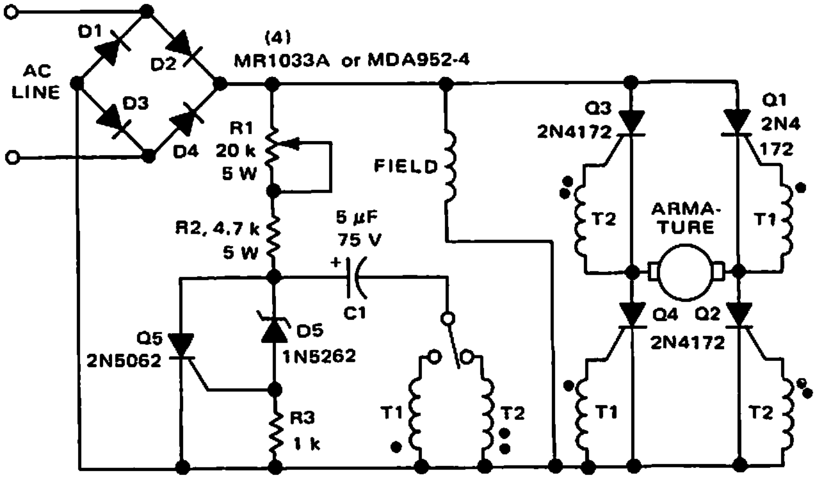
REVERSIBLE HALF-WAVE UNIVERSAL—Armature current is always in same direction because scr is fed by bridge rectifier. Direction of field current depends on which polarity of applied voltage is present at time scr conducts. Direction of rotation is changed by causing conduction in either positive or negative half-cycle of supply voltage. Feedback control of motor speed is achieved by comparing counter emf of armature with capacitor voltage.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 23.


CR1
CR2
SCR
FIELD
R1
R4
120V/AC
R3
CR6
C2
R2
R5
C1
CR8
ARMATURE
CR3
CR4
CR7

R1 : 1500
R2: 1500
R3: 3000 CT
R4: 1000
R5: 470

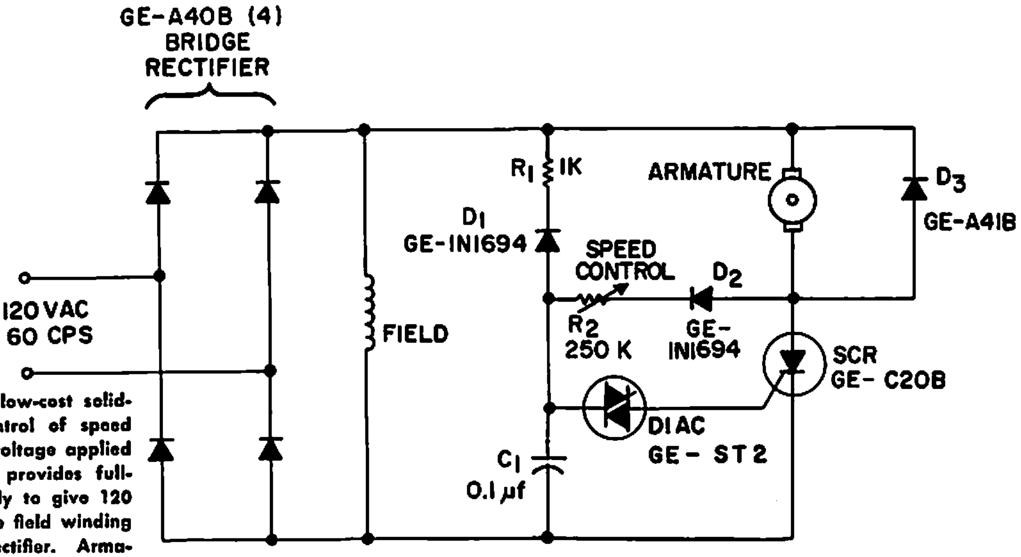
C1 : 200μf
C2: 5μf
CR1-4 : A40B
CR6-7 : 1N1694

SCR : C20B
CR8 : A40B
MOTOR: SERIES, REVERSIBLE

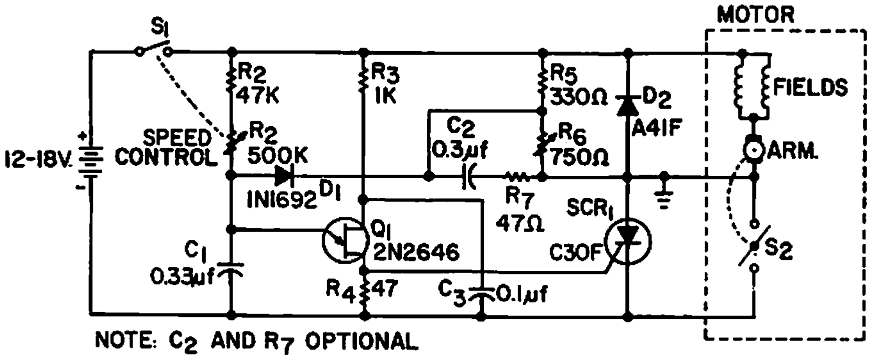

AC LINE
D1
D2
D3
D4
(4)
MR1033A or MDA952-4
R1 20 k 5 W
R2, 4.7 k 5 W
5 μF 75 V
C1
Q5 2N5062
D5 1N5262
R3 1 k
FIELD
T1
T2
Q3 2N4172
Q1 2N4172
ARMATURE
Q4 Q2 2N4172

T1 and T2 are Sprague 11Z13

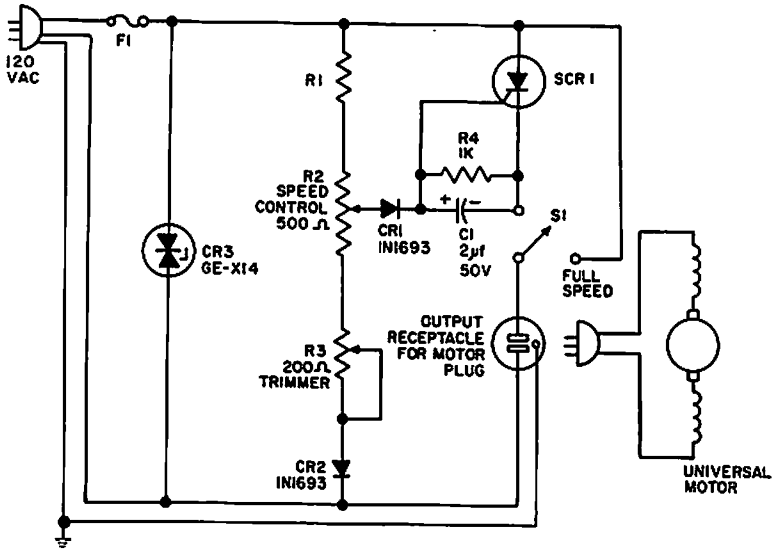
REVERSING SHUNT-WOUND—Controls both speed and direction of 1/15th-hp 5,000-rpm 115-V shunt-wound d-c motor. Field is connected across bridge rectifier and armature is in scr bridge. Switch reverses armature current and direction of rotation by triggering opposite diagonal pair of scr's. R1 controls speed.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–27.


GE-A40B (4) BRIDGE RECTIFIER
120 VAC 60 CPS
FIELD
R1 1K
D1 GE-1N1694
ARMATURE
D3 GE-A41B
SPEED CONTROL
R2 250 K
D2 GE-1N1694
SCR GE-C20B
DIAC GE-ST2
C1 0.1 μf

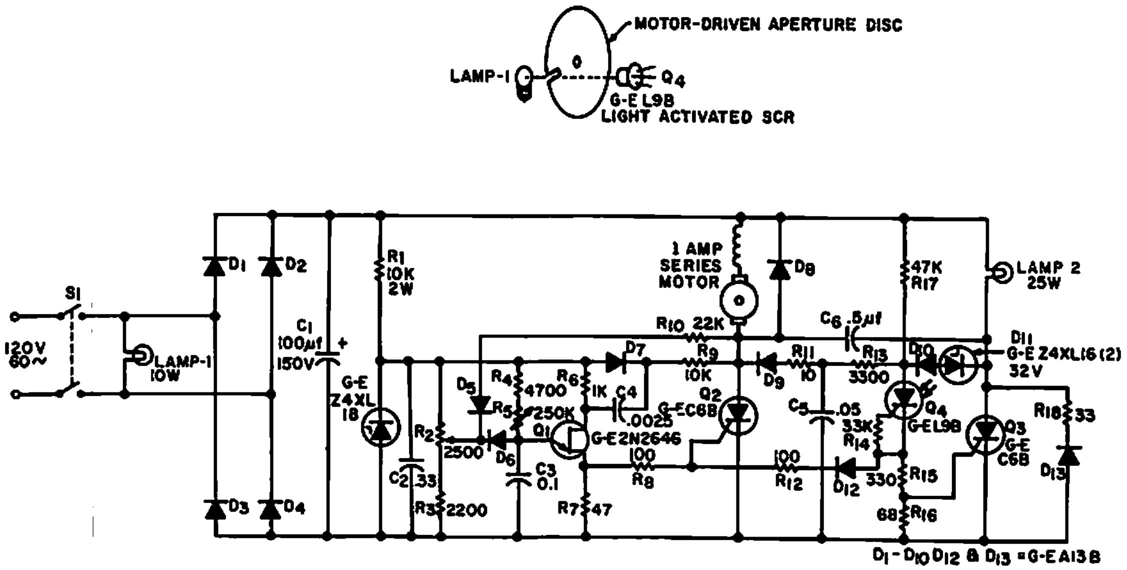
SHUNT D-C CONTROL—Simple low-cost solid-state circuit gives smooth control of speed over wide range, by varying voltage applied to armature. Bridge rectifier provides full-wave rectification of a-c supply to give 120 V d-c for 1/8th-hp motor whose field winding is connected directly across rectifier. Armature voltage is controlled by changing point in each half-cycle at which scr is turned on, with scr turning off only at end of each half-cycle.—E. K. Howell, Speed Control for Shunt-Wound DC Motors, General Electric, Syracuse, N.Y., No. 200.44, 1965, p 1.


S1
R2 47K
R3 1K
R5 330Ω
D2 A41F
MOTOR
FIELDS
ARM.
S2
SPEED CONTROL
R2 500K
12-18V.
C2 0.3μf
R6 750Ω
R7 47Ω
SCR1
C30F
1N1692
D1
Q1 2N2646
C1 0.33μf
R4 47
C3 0.1μf
NOTE: C2 AND R7 OPTIONAL

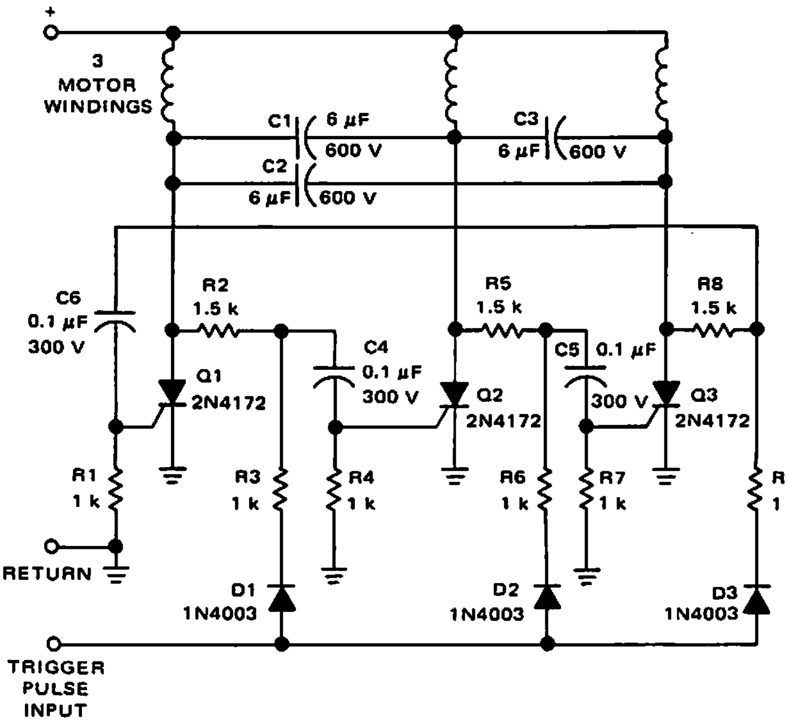
LOW-VOLTAGE D-C MOTOR CONTROL—Low-cost control operating from battery solves commutation problem with mechanical contact that bypasses scr twice per revolution of motor. Speed of motor is synchronous with that of ujt which turns on scr, giving very precise control of speed.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 24.


120 VAC
F1
R1
SCR 1
R4 1K
R2 SPEED CONTROL 500 Ω
CR1 1N1693
C1 2μf 50V
S1
FULL SPEED
CR3 GE-X14
OUTPUT RECEPTACLE FOR MOTOR PLUG
R3 200Ω TRIMMER
CR2 1N1693
UNIVERSAL MOTOR

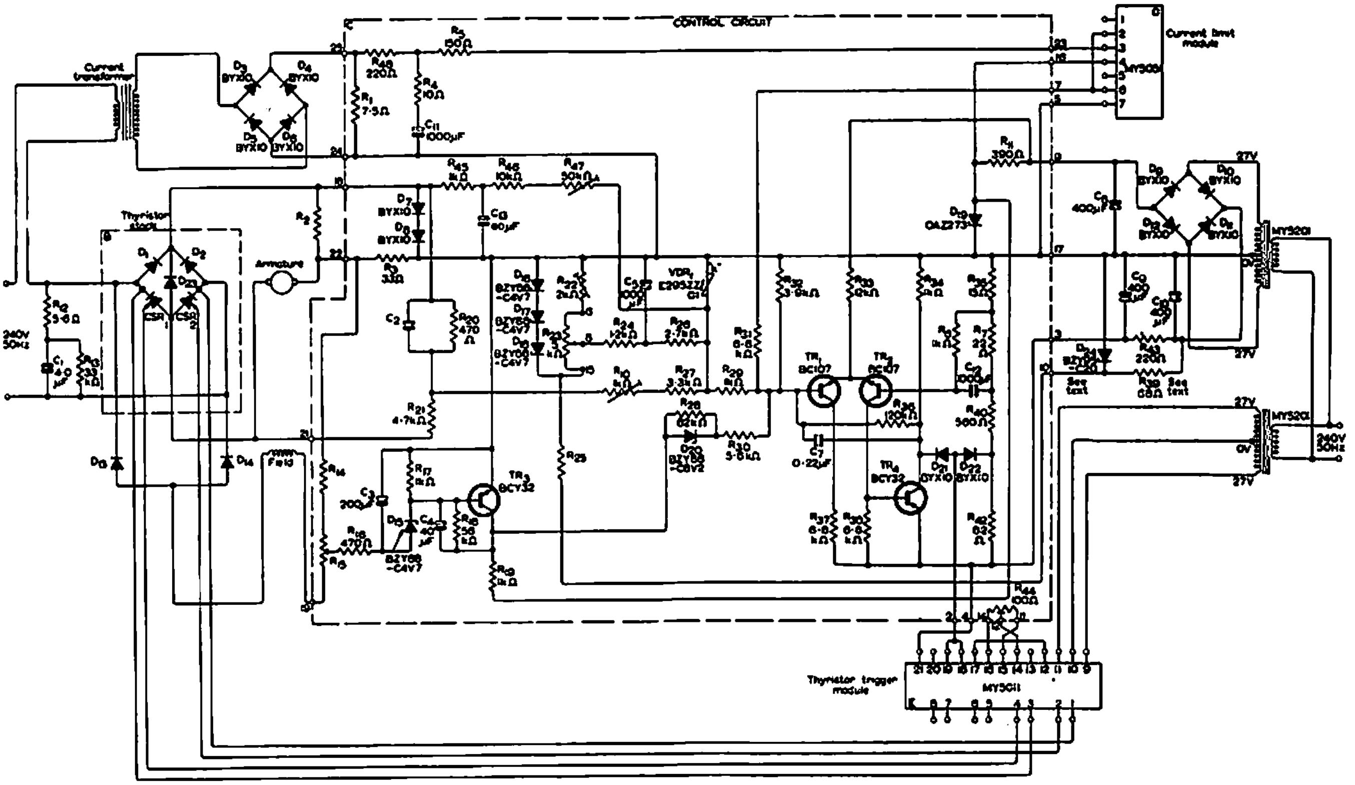
PLUG-IN SPEED CONTROL—Single black-box half-wave scr phase control can be used on variety of electric appliances and tools having series universal brush-type motors, such as with electric drills, power saws, sanders, lathes, fans, movie projectors, and food mixers or blenders. Requires no rewiring of motor. For motors rated 3 A max, use GE-X1 scr, 3-A fuse, and 2,500-ohm 4-W resistor for R1. For motors up to 5 A, use C30B scr, 5-A fuse, and 2,500-ohm 4-W resistor for R1. —"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 131.


MOTOR-DRIVEN APERTURE DISC
LAMP-1
Q4
G-E L9B
LIGHT ACTIVATED SCR
S1
120V 60~
LAMP-1 10W
D1
D2
D3
D4
C1 100μf 150V
R1 10K 2W
G-E Z4XL 18
C2 .33
R2 2500
R3 2200
D5
R4 4700
R5 250K
D6
C3 0.1
Q1 G-E 2N2646
R6 1K
C4 .0025
D7
R7 47
R8 100
1 AMP SERIES MOTOR
R10 22K
R9 10K
Q2 G-E C6B
D8
D9
R11 10
C5 .05
R12 100
D12
C6 .5μf
R13 3300
R14 33K
47K R17
D10
D11 G-E Z4XL16 (2) 32V
Q4 G-E L9B
330 R15
68 R16
LAMP 2 25W
R18 33
Q3 G-E C6B
D13
D1 - D10 D12 & D13 = G-EA13B

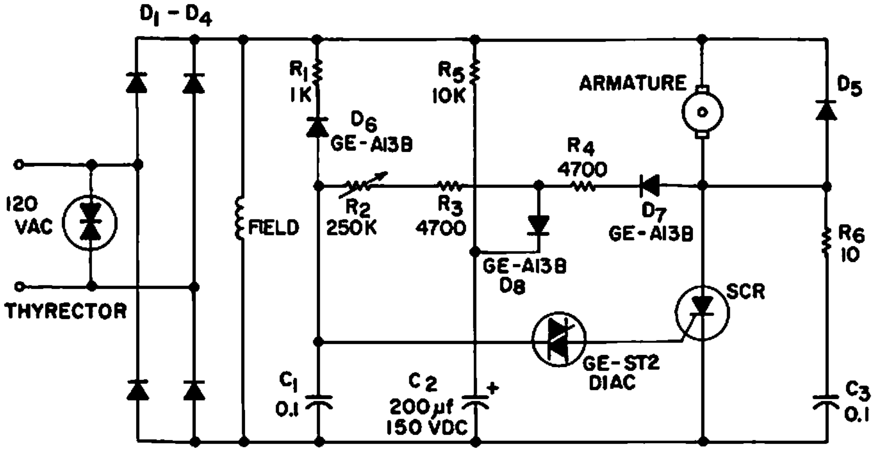
PRECISION SPEED CONTROL—Uses aperture disc on armature shaft to interrupt light from lamp to lascr and produce scr turnoff signal for ujt-synchronous drive through flip-flop and scr. Optional system eliminates wear of mechanical switch and does not load motor. Faster response time of lascr permits higher oscillator frequency and either higher motor speeds or multiple interruptions per revolution. Phase-detector principle employed produces linear output for full 360-deg range of phase error, with full output for any input frequency below reference frequency, and nearly zero output for inputs above reference.—E. K. Howell, Solid State Control for DC Motors Provides Variable Speed with Synchronous-Motor Performance, General Electric, Syracuse, N.Y., No. 200.43, 1965, p 7.


+
3 MOTOR WINDINGS
C1 6 µF 600 V
C2 6 µF 600 V
C3 6 µF 600 V
C6 0.1 µF 300 V
R2 1.5 k
R5 1.5 k
R8 1.5 k
C4 0.1 µF 300 V
C5 0.1 µF 300 V
Q1 2N4172
Q2 2N4172
Q3 2N4172
R1 1 k
R3 1 k
R4 1 k
R6 1 k
R7 1 k
R9 1 k
RETURN
D1 1N4003
D2 1N4003
D3 1N4003
TRIGGER PULSE INPUT

3-PHASE INDUCTION—Forced self-commutated inverter for three-phase induction motor is actually ring counter having one motor winding as load for each stage. Successive firings of scr's create moving flux field around stator for developing torque on rotor for speeds up to 7,200 rpm. Interchanging any two of the three windings with switches will reverse rotation.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–17.

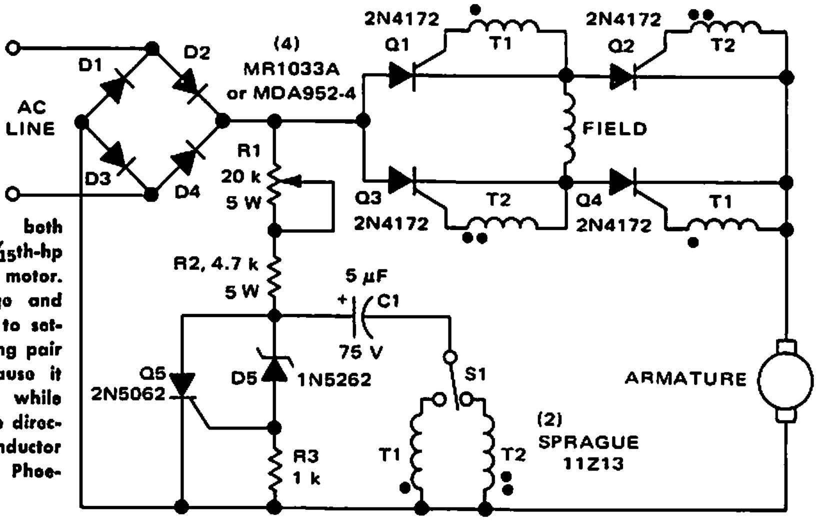

CONTROL CIRCUIT
Current transformer
Current limit module
MY300
Thyristor stack
B
Armature
Field
240V 50Hz
CSR 1
CSR 2
TR1 BC107
TR2 BC107
TR3 BCY32
TR4 BCY32
VDR E295ZZ/01
MY5201
27V
0V
Thyristor trigger module
MY5011
See text

ARMATURE-VOLTAGE SPEED CONTROL—Uses bridge to measure back emf of motor, which is proportional to motor speed when field is constant. Short-term speed regulation against load change can be as good as 1% at full speed, and long-term regulation as bad as 10%. Chief causes of speed drift are changes in field flux caused by temperature rise in windings or changes in supply voltage. Designed for 5-hp d-c shunt motor. B is Mullard thyristor stack with current rating 1.5 times full-load motor current. D13 and D14 are Mullard BYX22-800 or others to suit field current. R2 is 1/10th of armature resistance, R14 is 1/64th of field resistance, and R15 is 1/32nd of field resistance. R25 is 330. D24 and R39 improve speed regulation.—J. Merrett, Thyristor Speed Control Circuit Design for D. C. Shunt Motors Supplied from A. C. Mains, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 438, 1967.

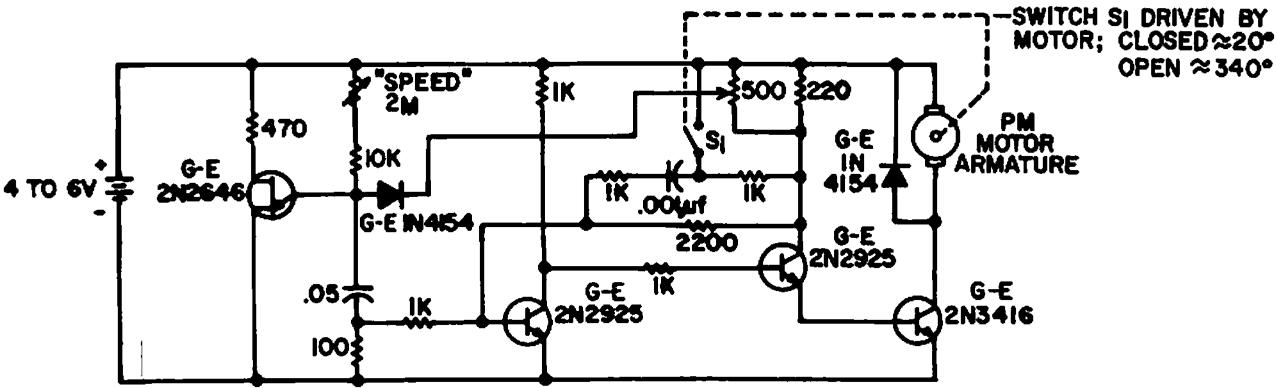

D1 - D4
R1
1K
R5
10K
ARMATURE
D5
D6
GE-A13B
R4
4700
120
VAC
R2
250K
R3
4700
D7
GE-A13B
FIELD
R6
10
GE-A13B
D8
SCR
THYRECTOR
GE-ST2
DIAC
C1
0.1
C2
200μf
150 VDC
C3
0.1

NOTE:
MOTOR SIZE DETERMINES TYPES SCR, $D_1 - D_5$, & THYRECTOR

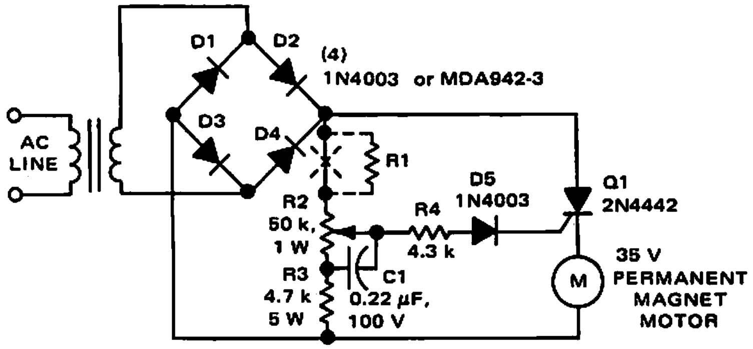
SOFT-START SHUNT D-C MOTOR CONTROL—Addition of R6 and C3 across scr improves commutation in basic armature voltage control circuit by limiting rate at which voltage is applied to scr after turnoff. If motor failed to commutate at low-speed setting, violent speed fluctuations would occur because it would be driven suddenly to high speed at which commutation occurs reliably. Thyrector across a-c line suppresses high-voltage transients that could damage semiconductors in circuit. R2 controls speed.—E. K. Howell, Speed Control for Shunt-Wound DC Motors, General Electric, Syracuse, N.Y., No. 200.44, 1965, p 3.


2N4172
Q1
T1
2N4172
Q2
T2
D1
D2
(4)
MR1033A
or MDA952-4
AC
LINE
FIELD
D3
D4
R1
20 k
5 W
Q3
2N4172
T2
Q4
2N4172
T1
R2, 4.7 k
5 W
5 μF
C1
75 V
Q5
2N5062
D5
1N5262
S1
ARMATURE
(2)
SPRAGUE
11Z13
R3
1 k
T1
T2

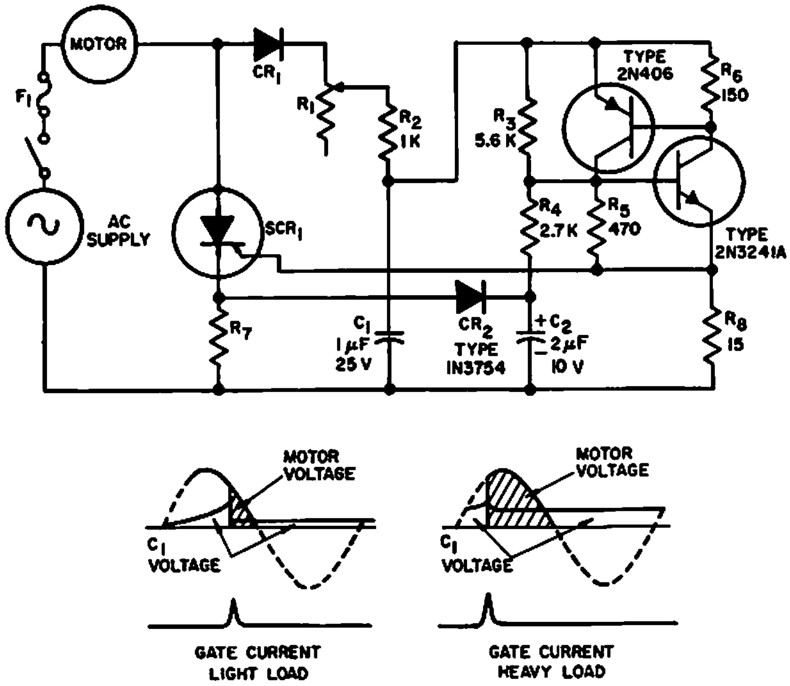
REVERSING SERIES-WOUND—Controls both speed and direction of rotation of $1/15$th-hp 5,000-rpm 115-V series-wound d-c motor. Scr's Q1-Q4 are connected in bridge and triggered in diagonal pairs according to setting of reversing switch S1. Conducting pair determines direction of rotation because it determines direction of field current while armature current always flows in same direction. Speed control is R1.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–26.


SWITCH S1 DRIVEN BY MOTOR; CLOSED ≈20° OPEN ≈340°
"SPEED"
2M
1K
500
220
470
10K
PM
MOTOR
ARMATURE
S1
G-E
IN
4154
4 TO 6V
G-E
2N2646
G-E IN4154
1K
.001μf
1K
2200
G-E
2N2925
.05
1K
G-E
2N2925
1K
G-E
2N3416
100

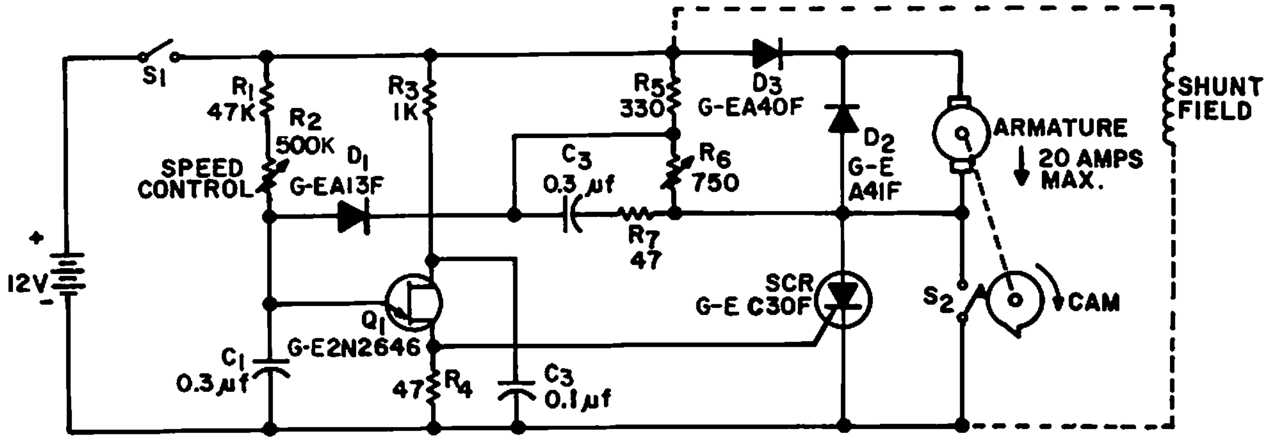
SMALL P-M MOTOR CONTROL—Four-transistor circuit provides adjustable speed control, synchronous with output of ujt relaxation oscillator, for small battery-operated permanent-magnet motors such as are used in phonographs, tape recorders, and recording instruments. Ujt oscillator drives flip-flop that energizes motor. Switch S1, driven by cam on armature shaft, reverses flip-flop and thereby interrupts motor current several times per revolution when closed momentarily by cams. With fixed oscillator frequency, motor speed can be changed in discrete octave steps by changing number of switch closures per revolution from 1 to 2 to 4 to 8, etc., mechanically or electrically.—E. K. Howell, Solid State Control for DC Motors Provides Variable Speed with Synchronous-Motor Performance, General Electric, Syracuse, N.Y., No. 200.43, 1965, p 7.


D1
D2
(4)
1N4003 or MDA942-3
AC
LINE
D3
D4
R1
D5
1N4003
Q1
2N4442
R2
50 k,
1 W
R4
4.3 k
R3
4.7 k
5 W
C1
0.22 µF,
100 V
M
35 V
PERMANENT
MAGNET
MOTOR

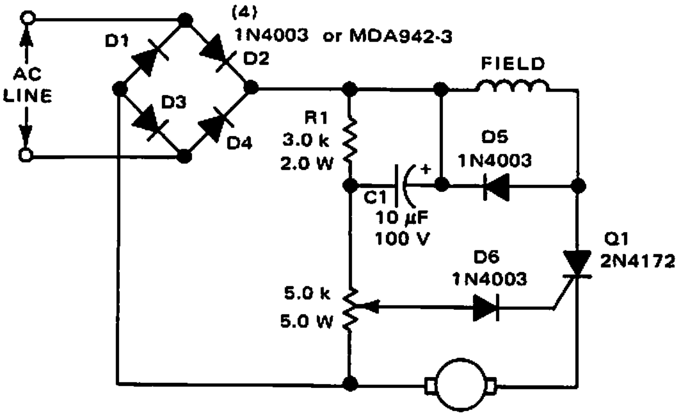
35-V P-M CONTROL—Uses step-down transformer and bridge rectifier to permit use of component values that give phase control of d-c motor over full half-cycle. Gives excellent speed control from stall up to 20,500 rpm. Small but not objectionable pulsation occurs at light loads and slow speeds, but effect vanishes when motor is fully loaded.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–28.


MOTOR
F1
CR1
R1
R2
1K
R3
5.6 K
TYPE
2N406
R6
150
AC
SUPPLY
SCR1
R4
2.7K
R5
470
TYPE
2N3241A
R7
C1
1µF
25V
CR2
TYPE
1N3754
+C2
2µF
10 V
R8
15
MOTOR
VOLTAGE
C1
VOLTAGE
GATE CURRENT
LIGHT LOAD
MOTOR
VOLTAGE
C1
VOLTAGE
GATE CURRENT
HEAVY LOAD

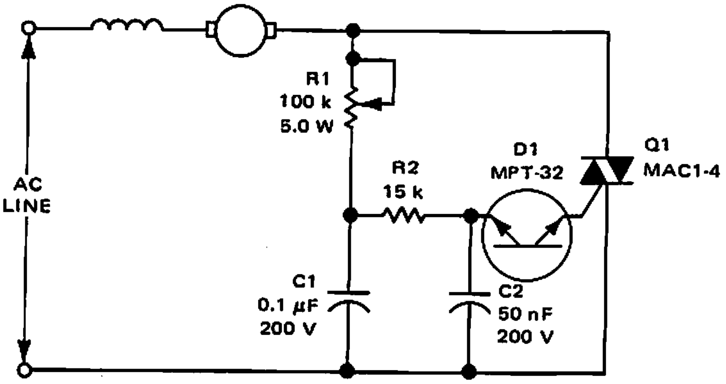
HALF-WAVE SCR WITH REGENERATIVE TRIGGERING—Uses two-transistor regenerative trigger approximating performance of avalanche diode. R7 must be matched with motor rating, in range from 0.1 ohm for larger universal motors to 1 ohm for smaller types. For scr ratings up to 25 A, CR1 is 1N3755 and R1 is 75K with 120-V a-c supply. —"Silicon Power Circuits Manual," RCA, N.J., SP-51, p 246.


S1
R1
47K
R2
500K
SPEED
CONTROL
D1
G-EA13F
R3
1K
R5
330
D3
G-EA40F
C3
0.3 µf
R6
750
R7
47
D2
G-E
A41F
ARMATURE
20 AMPS
MAX.
SHUNT
FIELD
+
12V
-
Q1
G-E2N2646
C1
0.3µf
47
R4
C3
0.1µf
SCR
G-E C30F
S2
CAM

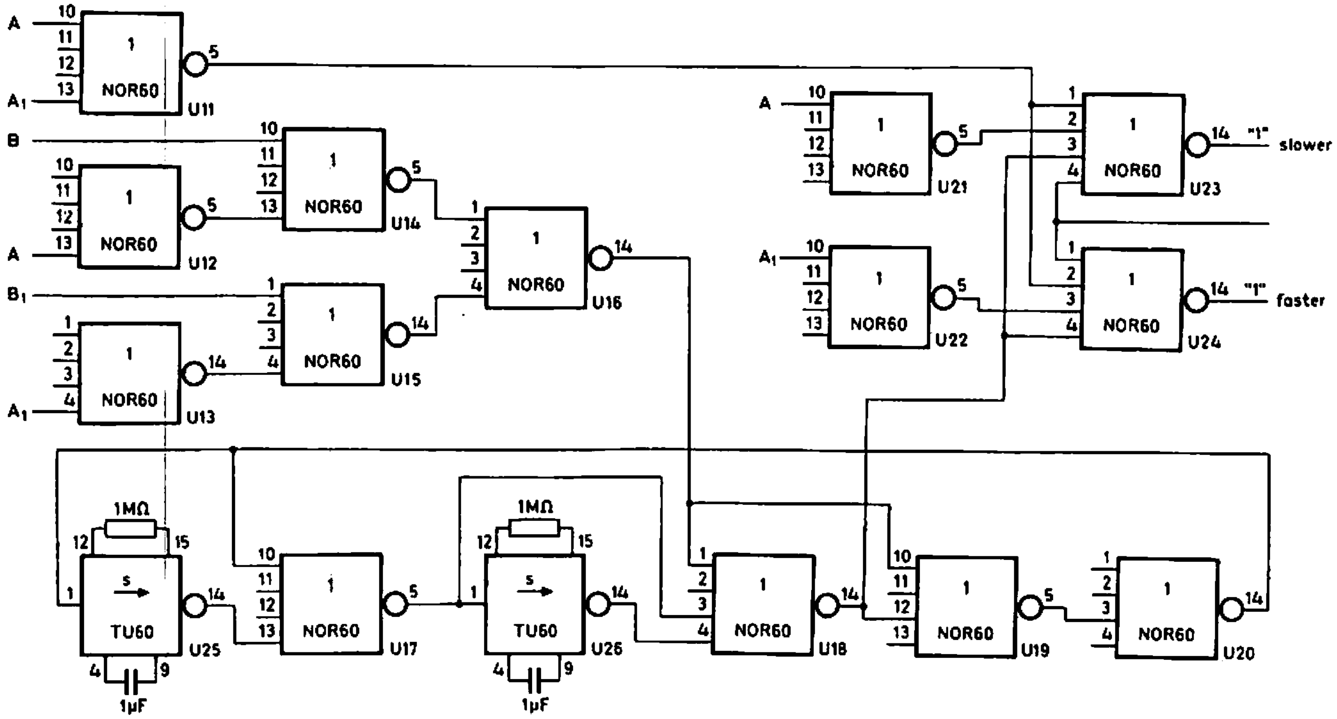
P-M MOTOR SYNCHRONOUS CONTROL—Maintains speed of shunt or permanent-magnet d-c motor at rate determined by output of variable-frequency ujt relaxation oscillator Q1. Each ujt output trigger makes scr pass motor current until cam switch on armature closes and bypasses scr. Motor is then without current until next trigger. Motor speed is held in synchronism with oscillator up to torque limit of motor, with that torque being maintained at all lower speeds down to locked rotor. However, with locked rotor, motor cannot be turned off because commutating switch S2 is not tripped; S1 must then be opened.—E. K. Howell, Solid State Control for DC Motors Provides Variable Speed with Synchronous-Motor Performance, General Electric, Syracuse, N.Y., No. 200.43, 1965, p 5.


(4)
1N4003 or MDA942-3
AC
LINE
D1
D2
D3
D4
FIELD
R1
3.0 k
2.0 W
D5
1N4003
C1
10 μF
100 V
+
D6
1N4003
Q1
2N4172
5.0 k
5.0 W

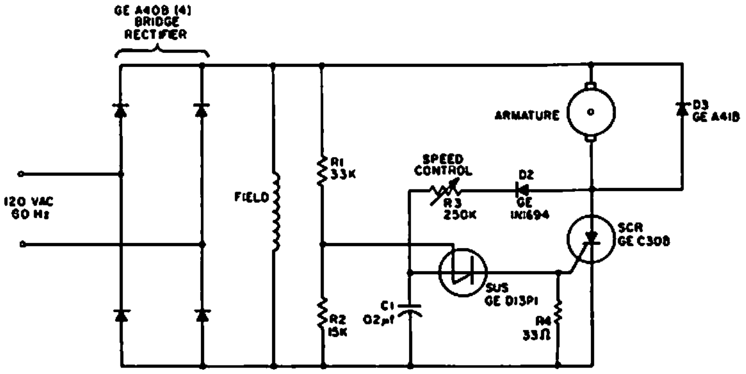
COMPENSATED FULL-WAVE DRIVE—Uses full-wave rectifier on a-c line to drive series-wound d-c motor, with scr providing speed control. Diode D5 provides current path for energy stored in inductive field of motor, to allow scr to turn off. Designed for 1/15th-hp 5,000-rpm 115-V d-c motor, but circuit is capable of controlling motors up to 1/4th-hp.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1—21.


AC
LINE
R1
100 k
5.0 W
R2
15 k
D1
MPT-32
Q1
MAC1-4
C1
0.1 μF
200 V
C2
50 nF
200 V

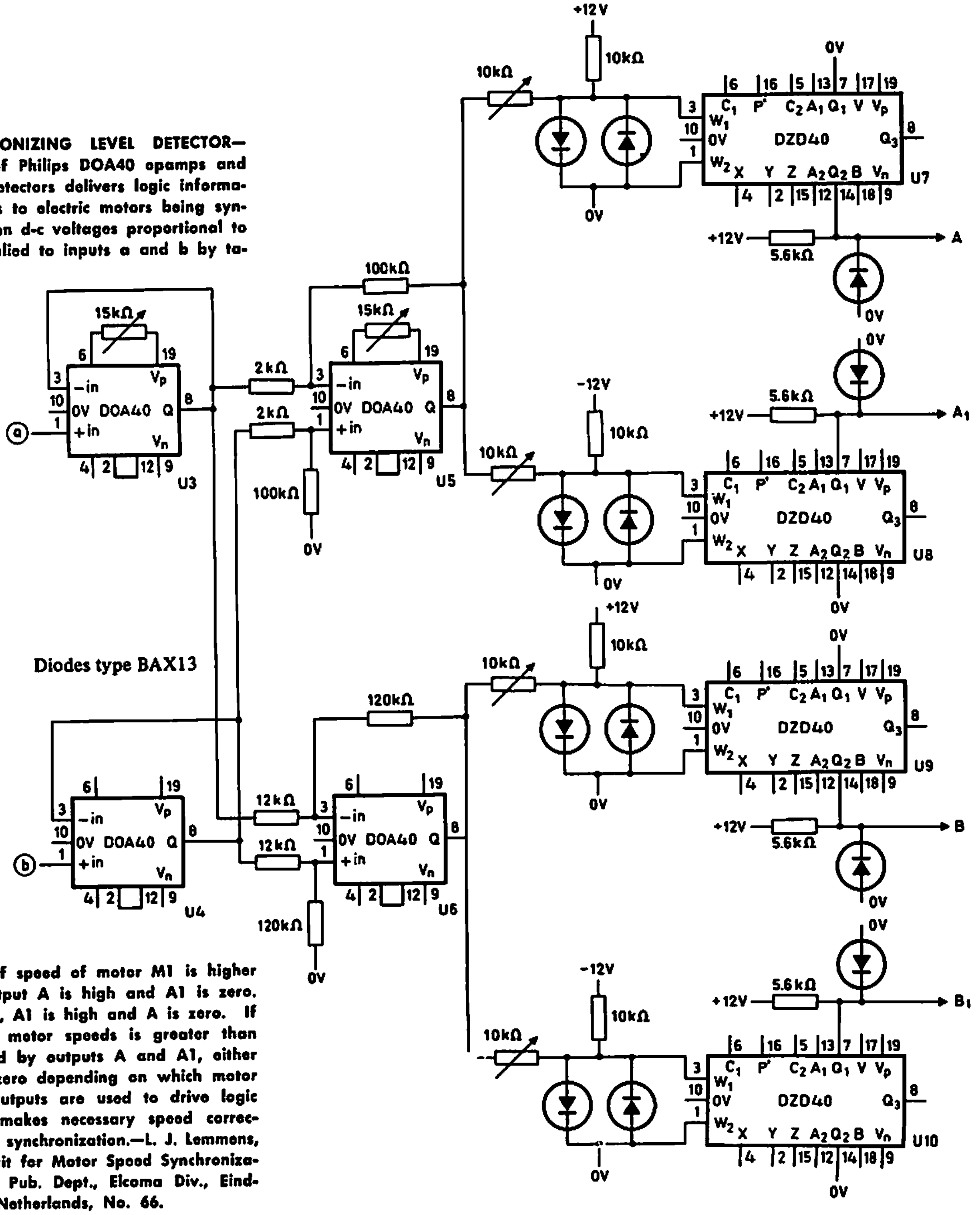
UNCOMPENSATED FULL-WAVE DRIVE—Uses three-layer diode D1 with triac for speed control of series-wound 115-hp 5,000-rpm 115-V d-c motor operating from a-c line. Motor can provide greater maximum torque than with half-wave control.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1—20.


A
A1
B
B1
NOR60
U11
U12
U13
U14
U15
U16
U17
U18
U19
U20
U21
U22
U23
U24
TU60
U25
U26
1MΩ
1μF
"1" slower
"1" faster

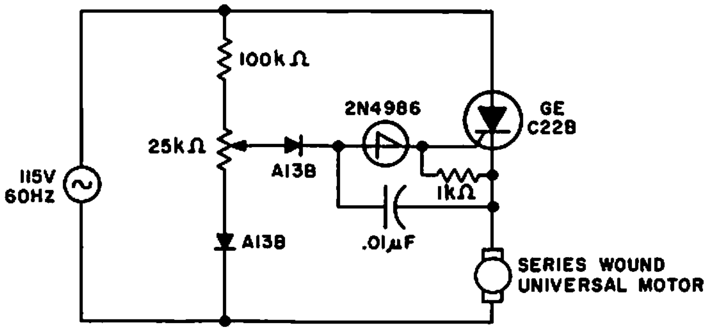
SPEED-SYNCHRONIZING LOGIC—Combination of Philips NOR60 and TU60 gates converts outputs of speed-synchronizing level detector to voltages required for speeding up or slowing down appropriate motor to give synchronization.—L. J. Lemmens, Control Circuit for Motor Speed Synchronization, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 66.


GE A40B (4) BRIDGE RECTIFIER
120 VAC 60 Hz
FIELD
R1 33K
R2 15K
SPEED CONTROL
R3 250K
D2 GE 1N1694
ARMATURE
D3 GE A41B
SCR GE C30B
SUS GE D13P1
C1 0.2μf
R4 33Ω

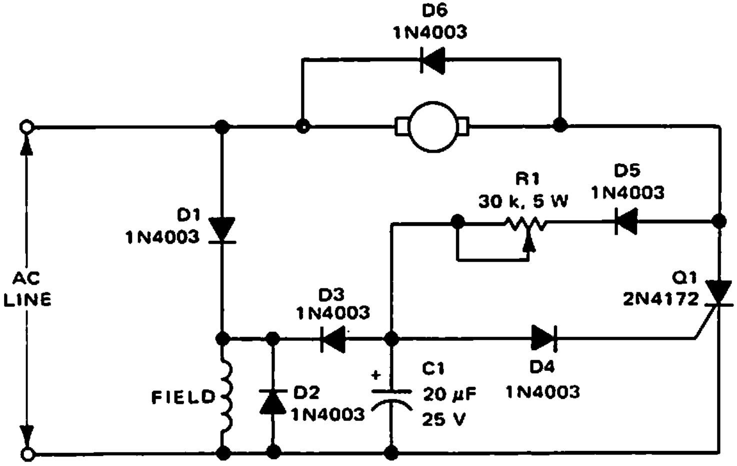
SHUNT-WOUND ½-HP D-C MOTOR CONTROL—Simple, low-cost solid-state speed control uses bridge rectifier for full-wave rectification of a-c supply. Field winding is permanently connected across d-c output of bridge. Provides smooth wide-range control of speed by controlling voltage applied to armature. Speed regulation is 10%.—"SCR Manual," 4th Edition, General Electric, 1967, p 213–215.


+12V
10kΩ
0V
-12V
DZD40
U7
U8
U9
U10
A
A1
B
B1
5.6kΩ
100kΩ
120kΩ
15kΩ
2kΩ
12kΩ
DOA40
U3
U4
U5
U6
a
b
Diodes type BAX13

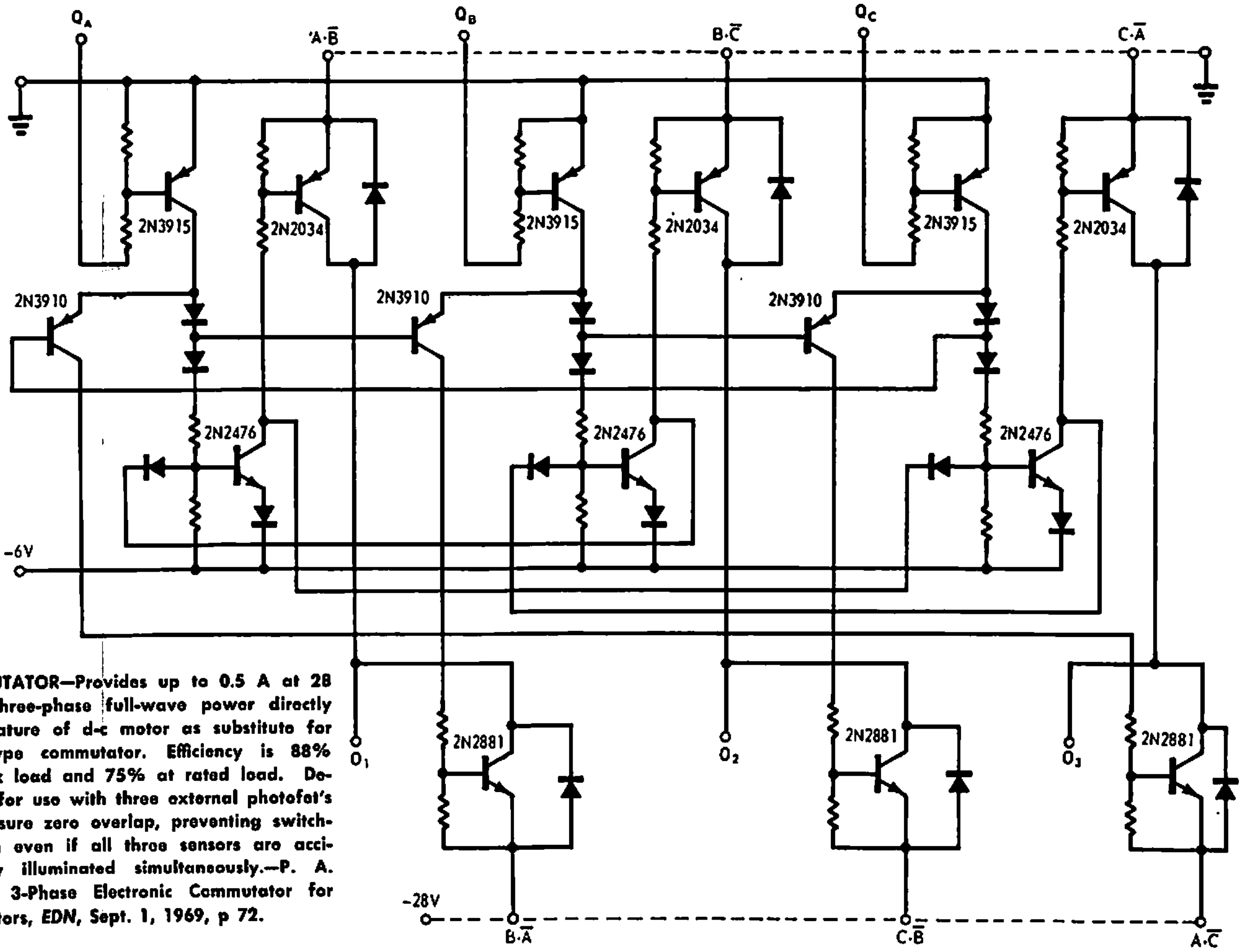
SPEED-SYNCHRONIZING LEVEL DETECTOR—Combination of Philips DOA40 opamps and DZD40 zero detectors delivers logic information on speeds to electric motors being synchronized, when d-c voltages proportional to speed are applied to inputs a and b by tachometers. If speed of motor M1 is higher than M2, output A is high and A1 is zero. If M2 is fast, A1 is high and A is zero. If difference in motor speeds is greater than limits covered by outputs A and A1, either B1 or B is zero depending on which motor is faster. Outputs are used to drive logic circuit that makes necessary speed corrections to give synchronization.—L. J. Lemmens, Control Circuit for Motor Speed Synchronization, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 66.


100kΩ
25kΩ
2N4986
GE C228
A13B
A13B
1kΩ
.01μF
115V 60HZ
SERIES WOUND UNIVERSAL MOTOR

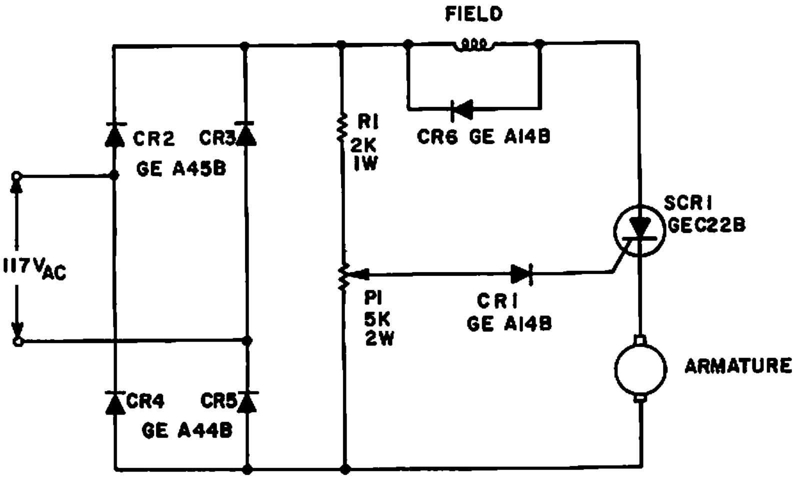
SUS SPEED CONTROL—Switching action of 2N4986 (or 2N4990) silicon unilateral switch permits use of smaller capacitors without affecting reliability of thyristor triggering.—Silicon Unilateral Switch 2N4983/2N4986, General Electric, Syracuse, N.Y., No. 65.25, 1967.


D6 1N4003
AC LINE
D1 1N4003
R1 30 k, 5 W
D5 1N4003
Q1 2N4172
D3 1N4003
D4 1N4003
FIELD
D2 1N4003
+
C1 20 μF 25 V

HALF-WAVE FOR SHUNT-WOUND—Field of shunt-wound $\frac{1}{15}$th-hp 5,000-rpm 115-V d-c motor is supplied through diode D1 during half-cycle in which scr Q1 conducts. D2 serves as free-wheeling diode across field.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–23.

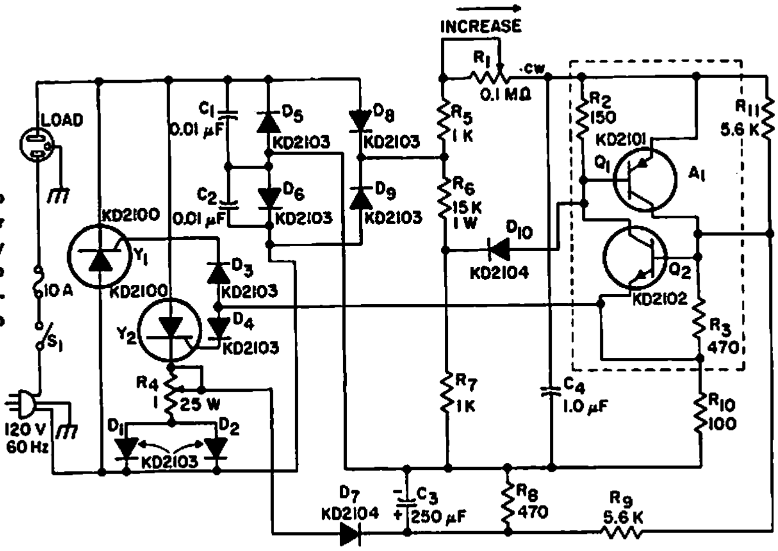

Q_A
A·$\bar{B}$
Q_B
B·$\bar{C}$
Q_C
C·$\bar{A}$
2N3915
2N2034
2N3915
2N2034
2N3915
2N2034
2N3910
2N3910
2N3910
2N2476
2N2476
2N2476
-6V
O_1
O_2
O_3
2N2881
2N2881
2N2881
-28V
B·$\bar{A}$
C·$\bar{B}$
A·$\bar{C}$

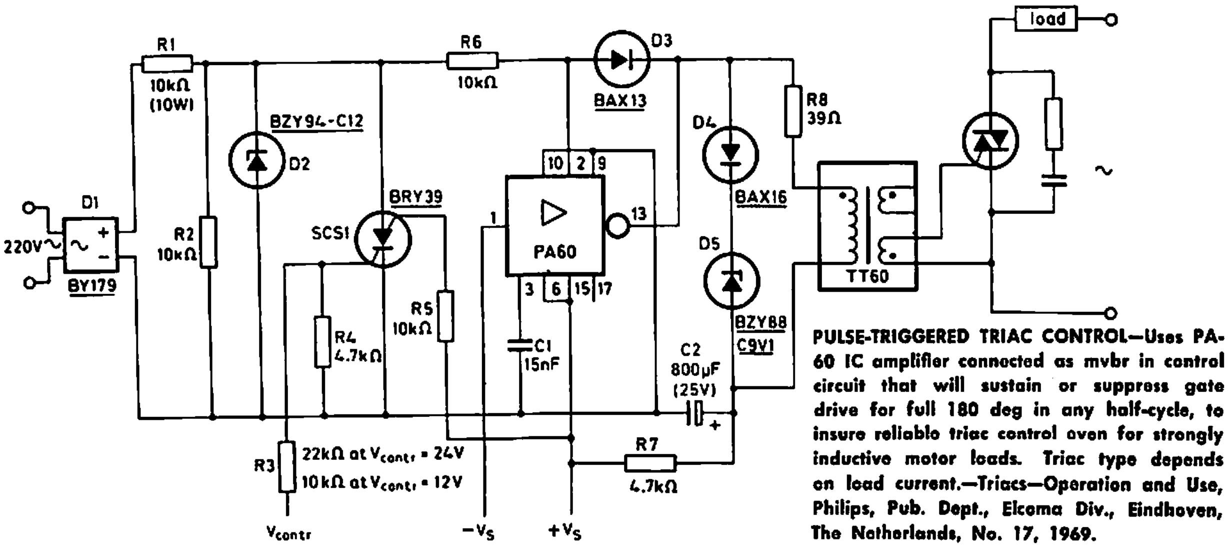
COMMUTATOR—Provides up to 0.5 A at 28 V of three-phase full-wave power directly to armature of d-c motor as substitute for brush-type commutator. Efficiency is 88% at peak load and 75% at rated load. Designed for use with three external photofet's that assure zero overlap, preventing switch-through even if all three sensors are accidentally illuminated simultaneously.—P. A. Studer, 3-Phase Electronic Commutator for DC Motors, *EDN*, Sept. 1, 1969, p 72.


FIELD
CR2
CR3
GE A45B
CR6 GE A14B
R1
2K
1W
117VAC
SCR1
GEC22B
P1
5K
2W
CR1
GE A14B
ARMATURE
CR4
CR5
GE A44B

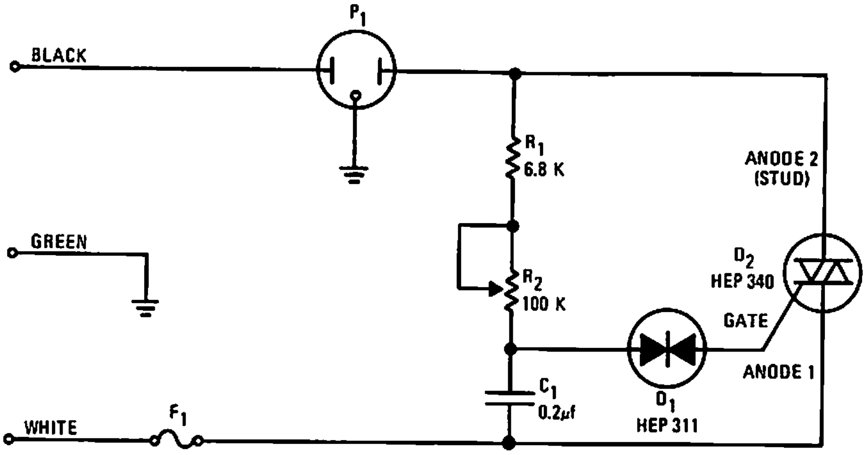
FULL-WAVE D-C MOTOR CONTROL WITH FEEDBACK—Requires separate connections for armature and field. Full-wave bridge supplies required d-c voltage for circuit and motor. Counter emf of armature provides feedback signal. One drawback is possibility of hunting at low speed settings, where there may not be sufficient time for scr to turn off.—A. A. Adem, Speed Controls for Universal Motors, General Electric, Syracuse, N.Y., No. 200.57, 1966, p 10.

5-A UNIVERSAL SERIES-WOUND—Uses two scr's, each conducting on one half-cycle, for smooth control over entire speed range. May also be used as dimmer for 600-W lamp load.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 57.


INCREASE
R1
CW
0.1 MΩ
LOAD
C1
0.01 μF
D5
KD2103
D8
KD2103
R5
1 K
R2
150
KD2101
Q1
A1
R11
5.6 K
C2
0.01 μF
D6
KD2103
D9
KD2103
R6
15 K
1 W
D10
KD2104
KD2100
Y1
D3
KD2103
Q2
KD2102
10 A
KD2100
Y2
D4
KD2103
R3
470
S1
R4
1
25 W
R7
1K
C4
1.0 μF
R10
100
120 V
60 Hz
D1
D2
KD2103
D7
KD2104
C3
250 μF
R8
470
R9
5.6 K

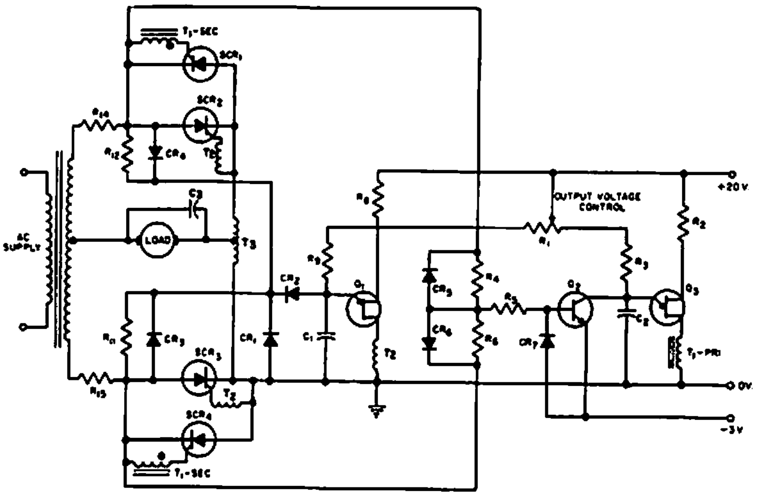

load
R1
10kΩ
(10W)
R6
10kΩ
D3
BAX13
R8
39Ω
BZY94-C12
D2
D4
BAX16
D1
220V~
BY179
R2
10kΩ
SCS1
BRY39
10
2
9
1
PA60
13
3
6
15
17
TT60
D5
BZY88
C9V1
R4
4.7kΩ
R5
10kΩ
C1
15nF
C2
800μF
(25V)
R7
4.7kΩ
R3
22kΩ at Vcontr = 24V
10kΩ at Vcontr = 12V
Vcontr
−VS
+VS
~

PULSE-TRIGGERED TRIAC CONTROL—Uses PA-60 IC amplifier connected as mvbr in control circuit that will sustain or suppress gate drive for full 180 deg in any half-cycle, to insure reliable triac control even for strongly inductive motor loads. Triac type depends on load current.—Triacs—Operation and Use, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1969.

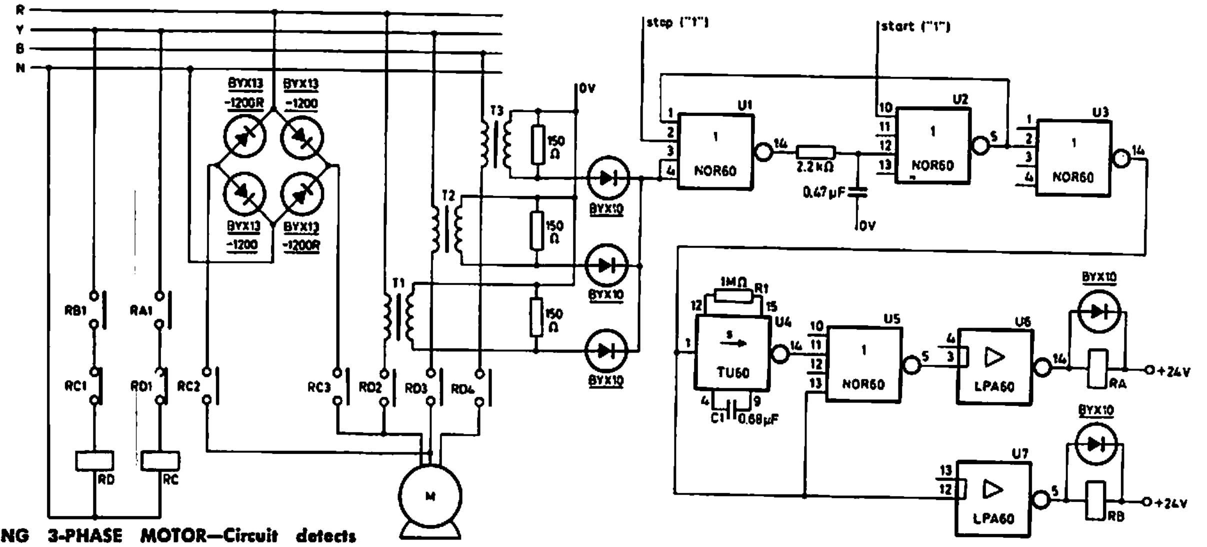

P1
BLACK
GREEN
WHITE
F1
R1
6.8 K
R2
100 K
C1
0.2μf
D1
HEP 311
D2
HEP 340
GATE
ANODE 2
(STUD)
ANODE 1

TRIAC POWER CONTROL—Simple and inexpensive control may be used for universal motors, incandescent lamps, or other devices to a maximum power of 600 W. Article gives construction details. P1 is polarized outlet. R2 varies speed or brightness from 0 to 98%, but for electric drills the torque will be low at low speeds. For continuous use at full load, mount triac D2 on heat sink to prevent overheating and loss of control.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 55.

FULL-WAVE REVERSING D-C MOTOR DRIVE—Designed around SCR2-SCR3 with common cathodes controlled by ujt Q1 and SCR1-SCR4 with common anodes controlled by ujt Q3. Transistor clamp Q2 synchronizes firing of Q3 to anode voltages across SCR1 and SCR4. At extreme left-hand position of R1, full output voltage appears across load. When arm of R1 is moved to right of center, polarity of load is reversed. If R1 is moved rapidly through center position, plugging occurs (motor acts as generator).—"SCR Manual," 4th Edition, General Electric, 1967, p 216–217.

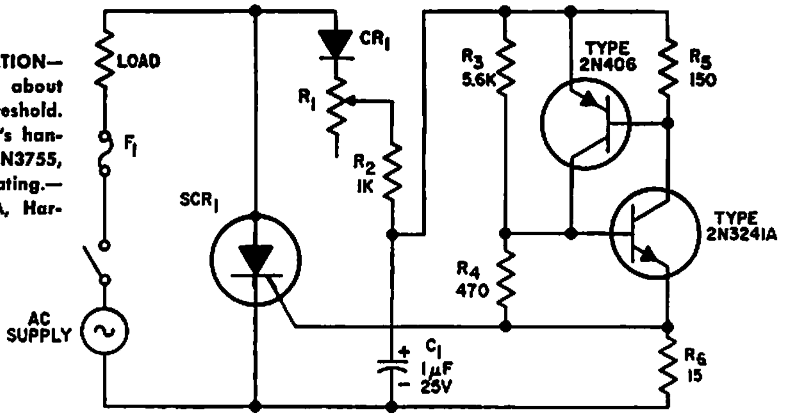

T1-SEC
SCR1
SCR2
SCR3
SCR4
R10
R11
R12
R15
CR3
CR4
CR1
CR2
CR5
CR6
CR7
T2
T3
C1
C2
C3
LOAD
AC SUPPLY
R1
R2
R3
R4
R5
R6
R8
R9
Q1
Q2
Q3
OUTPUT VOLTAGE CONTROL
T1-PRI
+20V
0V
-3V

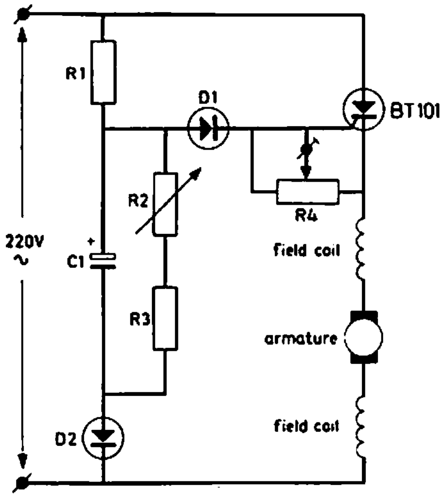
R_1—100K LINEAR POT
R_2,R_8—470 OHMS, 1/2 WATT
R_3,R_9—2700 OHMS, 1/2 WATT
R_4,R_6—10K, 2 WATTS
R_5—4700 OHMS, 1/2 WATT
R_{11},R_{12}—2200 OHMS, 2 WATTS
R_{14},R_{15}—2 OHMS, 300 WATTS OR LESS, DEPENDING ON RATING OF LOAD
C_1,C_2—0.2 MFD
SCR_1,SCR_2,SCR_3,SCR_4—GE SCR (VOLTAGE RATING DEPENDENT ON SECONDARY TRANSFORMER VOLTAGE)
$CR_1,CR_2,CR_3,CR_4,CR_5,CR_6$—GE 1N1695
CR_7—GE 1N1692
Q_1,Q_3—GE 2N1671A
Q_2—GE 2N335
T_1,T_2—PE2231, UTC H51, OR EQUIVALENT
T3, C3 } AS REQUIRED BY LOAD


R
Y
B
N
BYX13 -1200R
BYX13 -1200
BYX13 -1200
BYX13 -1200R
0V
T3
T2
T1
150 Ω
BYX10
RB1
RA1
RC1
RD1
RC2
RC3
RD2
RD3
RD4
RD
RC
M
stop ("1")
start ("1")
U1
NOR60
U2
NOR60
U3
NOR60
2.2kΩ
0.47μF
0V
1MΩ
R1
U4
TU60
C1
0.68μF
U5
NOR60
U6
LPA60
RA
+24V
U7
LPA60
RB
+24V

BRAKING 3-PHASE MOTOR—Circuit detects excessive drop in speed of motor and applies d-c braking current to windings to stop motor quickly and minimize disruption to sequence of operations on production line, then switches off braking current to avoid burning out motor winding. Uses Philips IC logic blocks.—Asynchronous Motor Braking Control, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 92, 1970.

HALF-WAVE SCR WITHOUT REGULATION—Gives maximum conduction angle of about 170 deg and 8-V firing-voltage threshold. R1 is 75K speed control for 120-V scr's handling loads up to 25 A a-c, CR1 is 1N3755, and scr depends on load current rating.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 241.

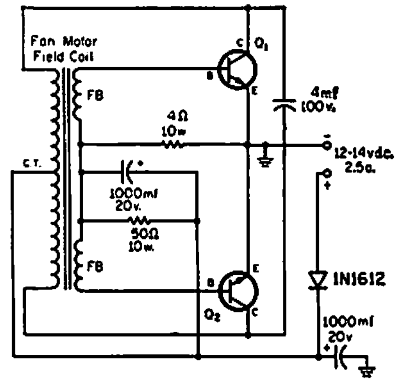

LOAD
F_1
AC SUPPLY
CR_1
R_1
R_2 1K
SCR_1
R_3 5.6K
TYPE 2N406
R_5 150
TYPE 2N3241A
R_4 470
C_1 1μF 25V
R_6 15


R1
D1
BT101
R2
R4
220V ∿
C1
field coil
R3
armature
D2
field coil

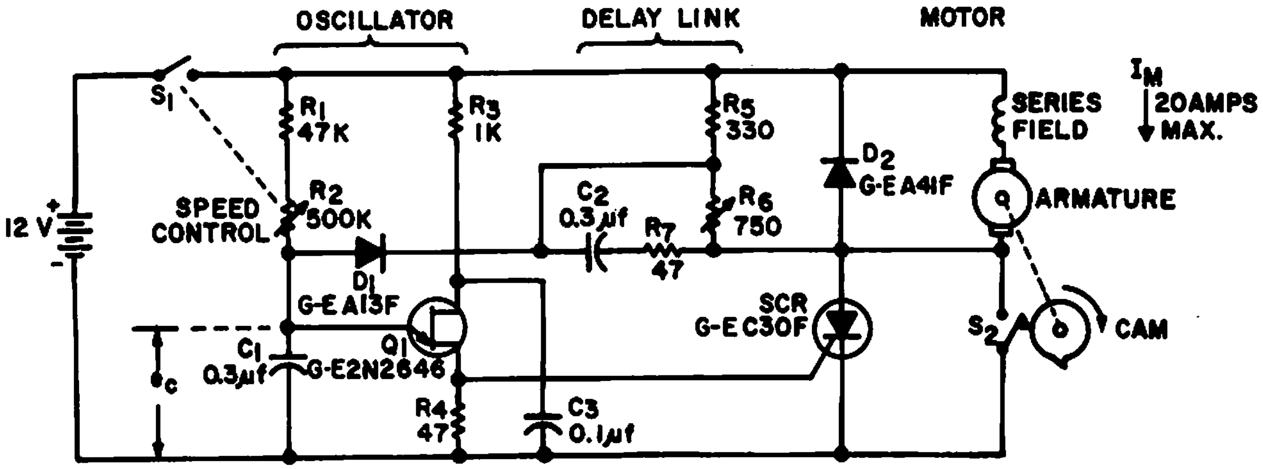
R1 = 4.7 kΩ, 7.0 W
R2 = 2.0 kΩ; 2.0 W
*R3 = 120 Ω; 0.5 W
R4 = 500 Ω; 0.5 W
*C1 = 47 μF; 63 V
D1, D2 = BYX10

* these values depend on the minimum speed requirement.

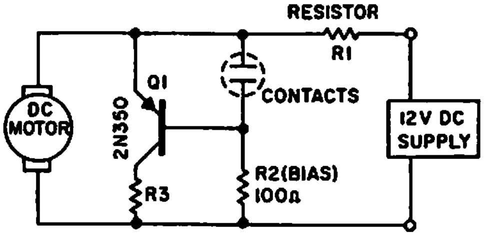
MIXER SPEED CONTROL—Single low-cost thyristor provides smooth continuous speed control of universal a-c motor for mixer or electric drill. R3 determines minimum speed setting. Typical speed ratio is 3:1. Requires only two connections to motor, as compared to circuits in which thyristor is between armature and one field coil.—Simple Speed Control for Small A. C. Series Motors, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1968.


Fan Motor Field Coil
FB
C.T.
Q1
4mf 100v
4Ω 10w
1000mf 20v
50Ω 10w
12-14vdc 2.5a
FB
Q2
1N1612
1000mf 20v

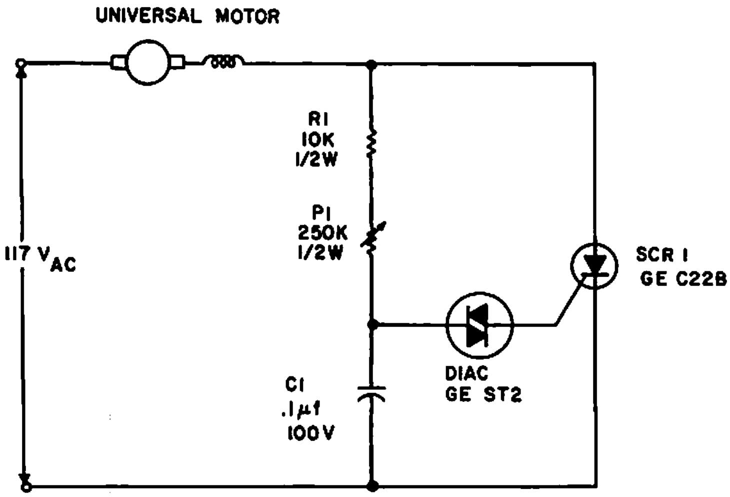
CONVERTER FOR FAN MOTOR—Operates from 12-V storage battery, drawing 2.5 A, and develops sufficient power to drive cooling fan motor at frequency of about 68 Hz without noise-producing d-c motor brushes. Motor can be ordinary rim-drive phonograph motor with field coil rewound as shown, or Gonset 115-011 motor available from Mamco, Racine, Wisc. Transistors are RCA 40251.—W. F. Frankart, Brushless D. C. Fan Motor, CQ, May 1966, p 49.


OSCILLATOR
DELAY LINK
MOTOR
S_1
12 V
R_1 47K
SPEED CONTROL
R_2 500K
D_1 G-E A13F
C_1 0.3μf
Q1 G-E2N2646
I_C
R_3 1K
R_4 47
C_3 0.1μf
C_2 0.3μf
R_7 47
R_5 330
R_6 750
D_2 G-E A41F
SCR G-E C30F
SERIES FIELD
I_M 20AMPS MAX.
ARMATURE
S_2
CAM

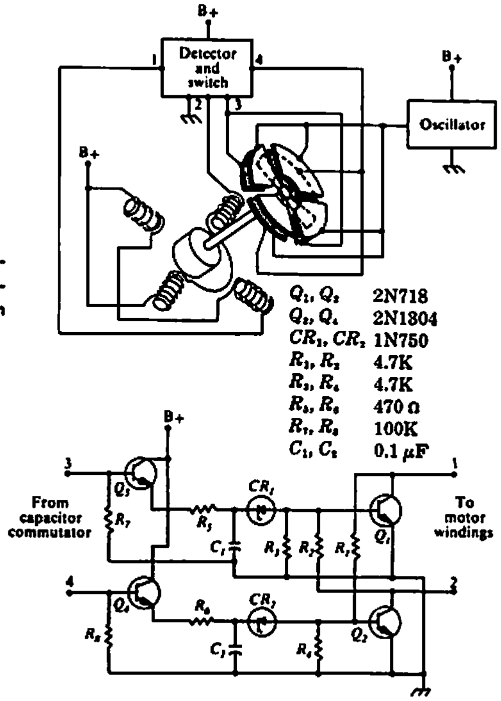
SYNCHRONOUS SERIES-MOTOR CONTROL—Relaxation oscillator Q1 generates trigger pulses for scr. With operation from d-c source, scr conducts current through motor until cam switch on armature closes and momentarily bypasses current around scr. Motor is then without current until arrival of next trigger. D2 eliminates most of arcing at S2. Article gives detailed description of circuit action during under-speed and over-speed conditions to maintain synchronism with ujt frequency.—E. K. Howell, Solid State Control for DC Motors Provides Variable Speed With Synchronous-Motor Performance, General Electric, Syracuse, N.Y., No. 200.43, 1965, p 4.


RESISTOR
R1
Q1
CONTACTS
DC MOTOR
2N350
12V DC SUPPLY
R3
R2(BIAS)
100Ω

TRANSISTOR SUPPLEMENTS CENTRIFUGAL SWITCH—Q1 provides dynamic braking path for armature and improves speed regulation. When switch contacts open, Q1 is biased on through R2, to reduce arcing at contacts.—T. F. Bright, Bridge Circuit Temperature Stabilizes Relay Operation, "400 Ideas for Design Selected from Electronic Design," Haydon Book Co., N.Y., 1964, p 98.

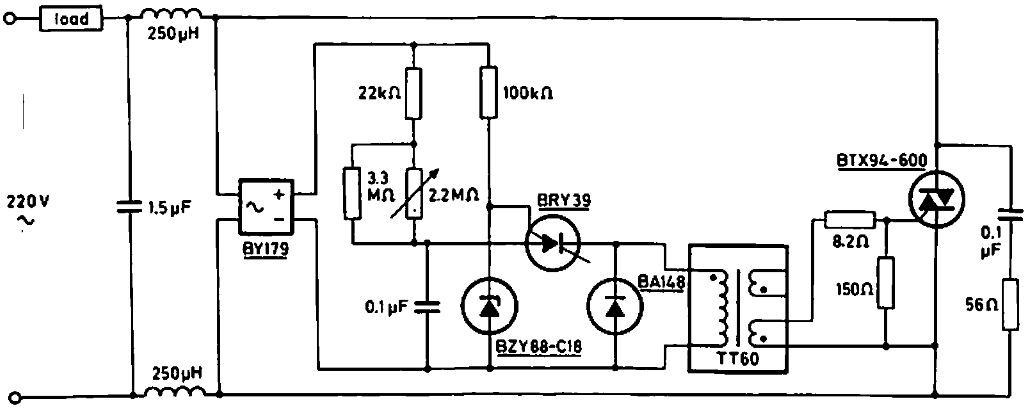

UNIVERSAL MOTOR
R1
10K
1/2W
P1
250K
1/2W
117 V_AC
SCR 1
GE C22B
DIAC
GE ST2
C1
.1μf
100V

HALF-WAVE CONTROL WITHOUT FEEDBACK—Diac-triggered scr, for speed control of universal a-c/d-c motor, has wide control range, although absence of feedback signal makes motor slow down as load is increased. When load is removed, motor runs at no-load speed for setting of P1.—A. A. Adem, Speed Controls for Universal Motors, General Electric, Syracuse, N.Y., No. 200.47, 1966, p 3.

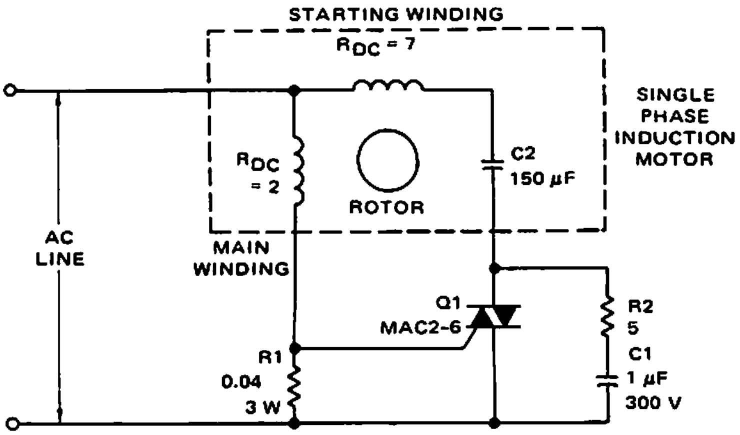

B+
Detector and switch
1
2
3
4
B+
Oscillator
B+
B+
3
4
1
2
From capacitor commutator
To motor windings
Q3
Q4
Q1
Q2
R7
R8
R5
R6
CR1
CR2
C1
C2
R3
R2
R1
R4

Q_1, Q_2	2N718
Q_3, Q_4	2N1804
CR_1, CR_2	1N750
R_1, R_2	4.7K
R_3, R_4	4.7K
R_5, R_6	470 Ω
R_7, R_8	100K
C_1, C_2	0.1 μF

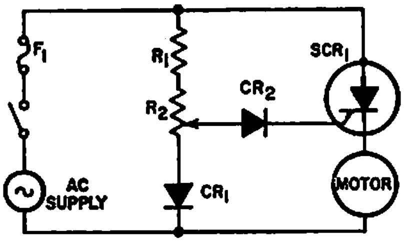
CAPACITIVE SWITCHING OF WOUND POLES—Can be used wherever d-c motors or a-c synchronous motors without brushes must operate with minimum maintenance. One set of four capacitor stator plates is provided for each wound pole of motor, and switching is accomplished by mounting capacitor rotor on motor shaft so it passes between stacked stator plates. Rotor plates should be insulated from shaft, and require no electrical connection because they merely serve to couple stator sections. Modulated output from stator is detected and used to switch appropriate wound poles of permanent-magnet motor. Amplitude of modulation is independent of speed, which means that capacitor system performs equally well for motor starting, running, and restarting from stall. D-c supply is 100 V and oscillator is 100-kHz sine-wave.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 70.


load
250μH
22kΩ
100kΩ
3.3 MΩ
2.2MΩ
220V ~
1.5μF
BY179
BRY39
BTX94-600
8.2Ω
150Ω
0.1 μF
56Ω
0.1μF
BZY88-C18
BA148
TT60
250μH

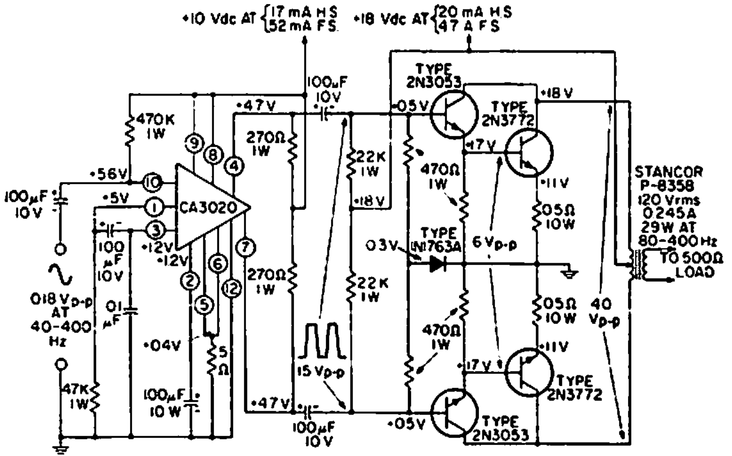
BASIC SCS CONTROL FOR TRIAC—Uses BRY39 silicon controlled switch with triac for controlling power to low-inductance loads such as lamps, heaters, and squirrel-cage fan motors. Control range is 20 to 170 deg. Large changes in line voltage affect trigger angle excessively for certain applications.—Triacs—Operation and Use, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1969.


STARTING WINDING
R_{DC} = 7
SINGLE PHASE INDUCTION MOTOR
AC LINE
R_{DC} = 2
ROTOR
C2 150 µF
MAIN WINDING
Q1 MAC2-6
R2 5
C1 1 µF 300 V
R1 0.04 3 W

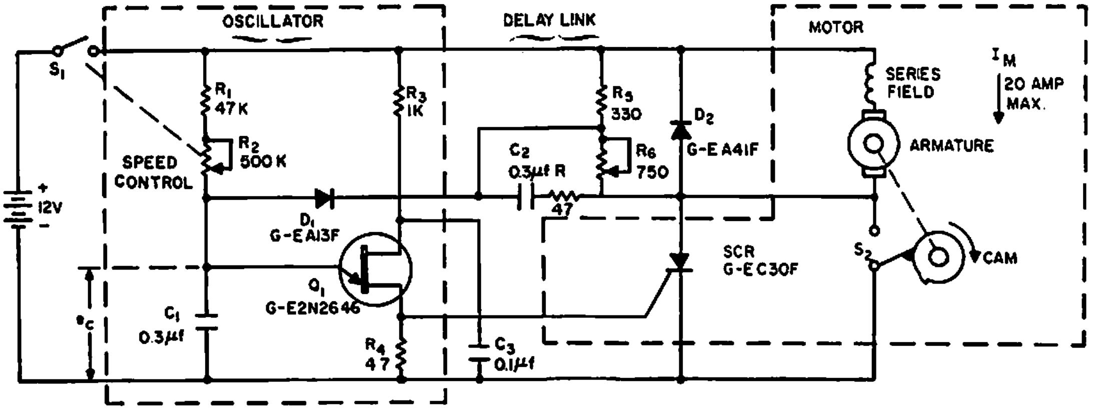
TRIAC MOTOR-STARTING SWITCH—Used to control starting winding of ½-V single-phase 115-V induction motor. Eliminates need for centrifugal switch that would cut out winding when rotor reaches about 75% of full-load speed. Operation is based on starting current in main winding being several times running current. Triac Q1 is triggered by drop across R1 whenever main-winding current exceeds threshold level. Values shown are for motor having peak starting current of 40 A and peak running current of 8 A, with triac triggering on only for currents above 12 A. Current drops below 12 A after about 12 cycles.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–5.


F_1
R_1
R_2
CR_2
SCR_1
AC SUPPLY
CR_1
MOTOR

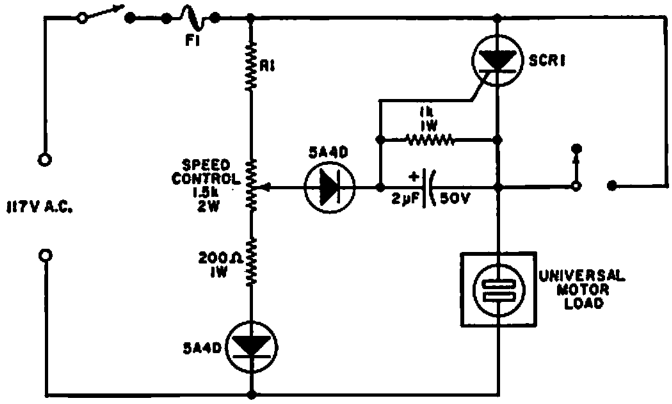
HALF-WAVE SCR WITH REGULATION—Highly effective for speed control of universal motors. Counter emf, which is function of speed, determines point in each positive half-cycle at which scr fires. Skip-cycling may occur at low speed settings of R2, making motor speed erratic. Uses 1N3755 for both diodes for motors drawing up to 25 A from 120-V a-c line. Book gives values of R1 and R2 for eight different scr types.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 244.


+10 Vdc AT {17 mA HS / 52 mA FS
+18 Vdc AT {20 mA HS / 47 A FS
470K 1W
100µF 10V
+56V
+5V
+12V
CA3020
100 µF 10V
01 µF
018 Vp-p AT 40-400 Hz
47K 1W
+04V
5 Ω
100µF 10 W
+47V
270Ω 1W
100µF 10V
15 Vp-p
22K 1W
+18 V
TYPE 2N3053
+05V
TYPE 2N3772
+17V
470Ω 1W
+11V
05Ω 10W
03V
TYPE 1N1763A
6 Vp-p
40 Vp-p
STANCOR P-8358 120 Vrms 0245A 29W AT 80-400 Hz
TO 500Ω LOAD

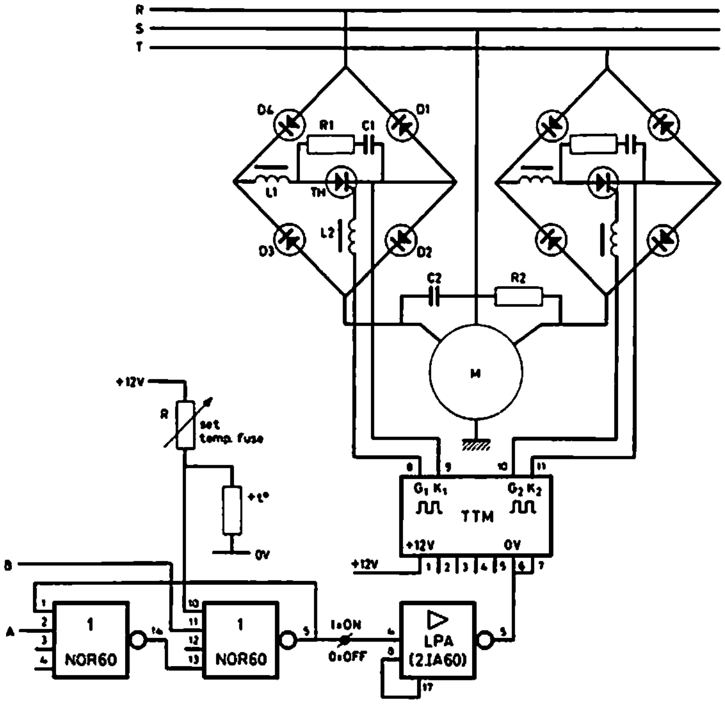
40–400 HZ CONTROL—Uses wideband IC amplifier to drive 500-ohm load through transformer and four-transistor power amplifier. May also be used as servo amplifier. Delivers 29 W.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 274.


OSCILLATOR
DELAY LINK
MOTOR
S_1
R_1 47K
R_2 500 K
SPEED CONTROL
+ 12V -
R_3 1K
D_1 G-E A13F
Q_1 G-E2N2646
C_1 0.3µf
e_c
R_4 47
C_2 0.3µf
R 47
C_3 0.1µf
R_5 330
R_6 750
D_2 G-E A41F
SCR G-E C30F
SERIES FIELD
I_M 20 AMP MAX.
ARMATURE
S_2
CAM

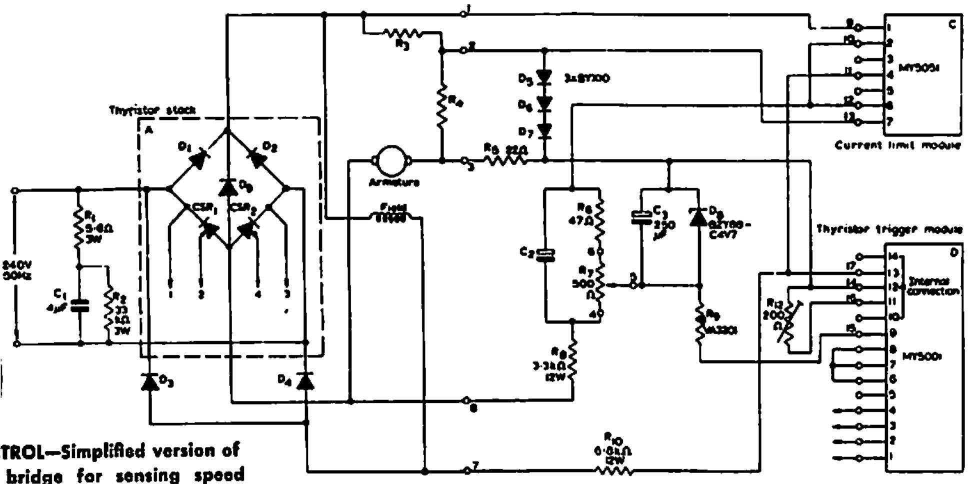
UJT-SCR CONTROL FOR SERIES MOTOR—Relaxation oscillator Q1 generates periodic pulses that trigger scr carrying motor current. At one or more points in rotation of motor shaft, cam bypasses current around scr to make it turn off (commutate). Time between turn-on by ujt and turn-off by scr depends on motor load. Arrangement provides high starting torque at any speed below desired synchronous speed that would otherwise require a-c synchronous motor. Use of cam switch gives simplicity and low cost.—E. K. Howell, Precise Speed Control, High Torque Can Now be Combined in DC Motors, *Electronic Design*, Dec. 6, 1965, p 20–25.


F1
R1
SCR1
1k
1W
5A4D
SPEED CONTROL 1.5k 2W
+
2μF 50V
117V A.C.
200Ω 1W
UNIVERSAL MOTOR LOAD
5A4D

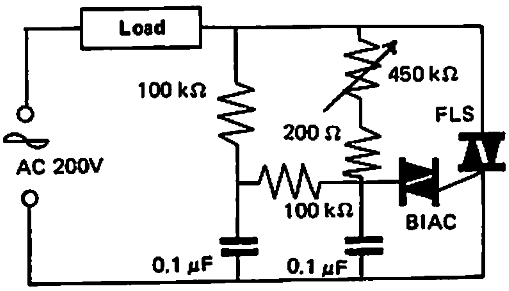
SPEED CONTROL—For 2-A universal motors use 2N1774 for SCR1, 3 A for F1, and 10K for R1. For 5-A motor use 2N685 for SCR1, 10 A for F1, and 5K for R1.—D. Cooper, SCR's and Triacs—the Revolution Continues, *Electronics World*, Aug. 1968, p 25–28.


R
S
T
D4
R1
C1
D1
L1
TH
L2
D3
D2
C2
R2
M
+12V
R
set temp. fuse
+t°
0V
G1 K1
G2 K2
TTM
+12V
0V
B
A
1
NOR60
1
NOR60
1:ON
0:OFF
LPA
(2.IA60)

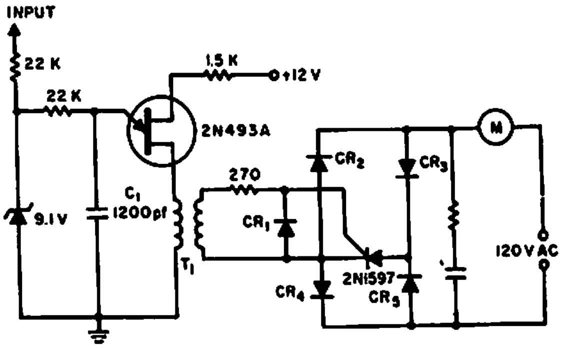
SWITCHING 3-PHASE MOTOR—Philips IC NOR circuits, power amplifier, and TTM thyristor trigger module, when connected to bridge circuits as shown, will switch on 3-hp 3-phase motor M when 1-level pulse is applied to input A, and will switch motor off when 1-level is applied to B. Temperature-sensitive PTC resistor provides overload protection. Values are: R1 22; R2 10; C1-C2 1 μF at 1,000 V; all diodes are BYX25/800R; thyristor TH is BTX12/600R. Thyristor bridges are identical.—C. Rosiello, "Control System Design Manual for 60-Series Norbits," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1968, p 147.


Thyristor stack
A
D1
D2
D9
CSR1
CSR2
R1 5·6Ω 3W
R2 33 kΩ 3W
C1 4μF
240V 50Hz
D3
D4
Armature
Field
R3
R4
D5 3×BY100
D6
D7
R5 22Ω
R6 47Ω
C2
R7 500 Ω
C3 250 μF
D8 BZY88-C4V7
R8 3·3kΩ 12W
R9
R10 0·6kΩ 12W
R12 200 Ω
Current limit module
C
MY5051
Thyristor trigger module
D
Internal connection
MY5001

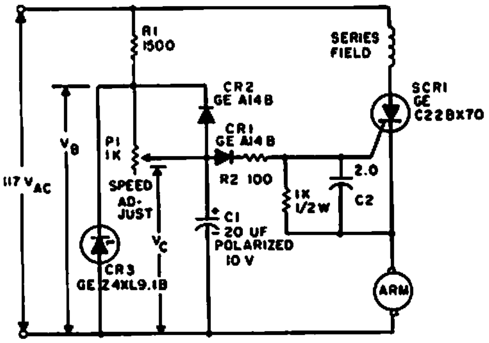
SIMPLE SPEED CONTROL—Simplified version of armature voltage bridge for sensing speed provides economical control for d-c shunt motor. R7 sets speed. Uses Mullard thyristor stack rated at twice motor full-load current, plus two other Mullard modules. Diodes D3 and D4 are Mullard BYX22-80, C2 is 20 μF, and R3 and R4 depend on armature resistance. Report gives complete design information.—J. Merrett, Thyristor Speed Control Circuit Design for D. C. Shunt Motors Supplied from A. C. Mains, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 438, 1967.


Load
100 kΩ
450 kΩ
200 Ω
FLS
AC 200V
100 kΩ
BIAC
0.1 µF
0.1 µF

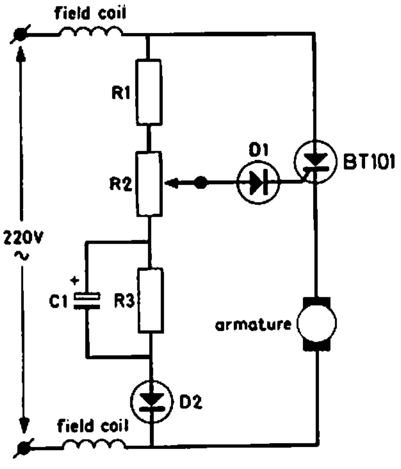
20-A MOTOR SPEED CONTROL—New five-layer FQO½ switching thyristor triggered by biac provides smooth wide-angle control of speed for a-c motors rated at up to 20 A. Will also handle lamp or heater loads. Speed control is 450K pot.—FLS Five-Layer Switch (Hitachi ad), *Journal of Asia Electronics Union*, No. 1, 1970, p 32.


INPUT
22 K
22 K
1.5 K
+12 V
2N493A
9.1 V
C1
1200pf
T1
270
CR1
CR2
CR3
CR4
2N1597
CR5
M
120VAC

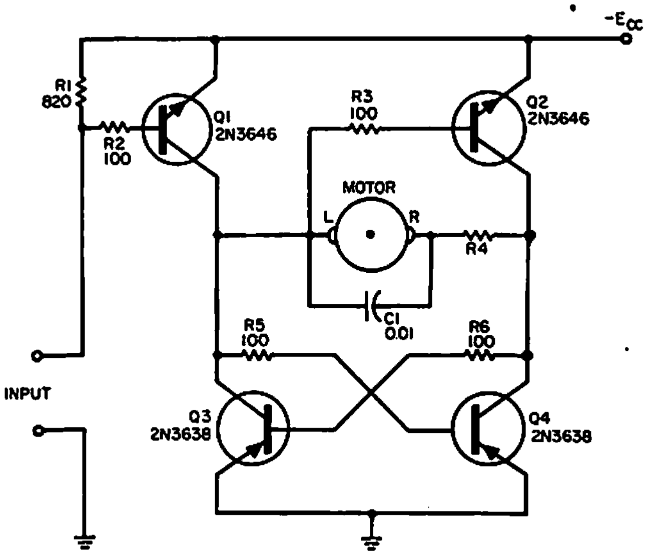
ELIMINATING SNEAK-PATHS—Provides electrical isolation between d-c control circuit and a-c line, without resorting to bulky isolation transformer. With bias as shown, ujt relaxation oscillator starts when C1 charges to 7 V. When input control voltage is increased above 7 V d-c to increase speed of motor, pulse repetition rate increases up to prr corresponding to zener limit of 9.1 V. T1 couples pulses to scr, to provide full-wave control of a-c motor through five-diode bridge. Series resistor and capacitor across bridge suppress motor-produced transients.—S. Steckler, Motor Control System Isolates AC Lines from DC Circuits, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 217.


R1
1500
SERIES FIELD
CR2
GE A14B
SCR1
GE
C228X70
CR1
GE A14B
VB
P1
1K
117 VAC
SPEED ADJUST
R2 100
1K
1/2W
2.0
C2
C1
20 UF
POLARIZED
10 V
VC
CR3
GE Z4XL9.1B
ARM

SLOW-SPEED HALF-WAVE WITH FEEDBACK—Gives stable operation at all speeds. Motor residual field provides speed feedback signal. Circuit permits very short scr conduction time, for stable operation at low speeds. Need for separate armature and field connections to motor is possible drawback.—A. A. Adem, Speed Controls for Universal Motors, General Electric, Syracuse, N.Y., No. 200.47, 1966, p 5.

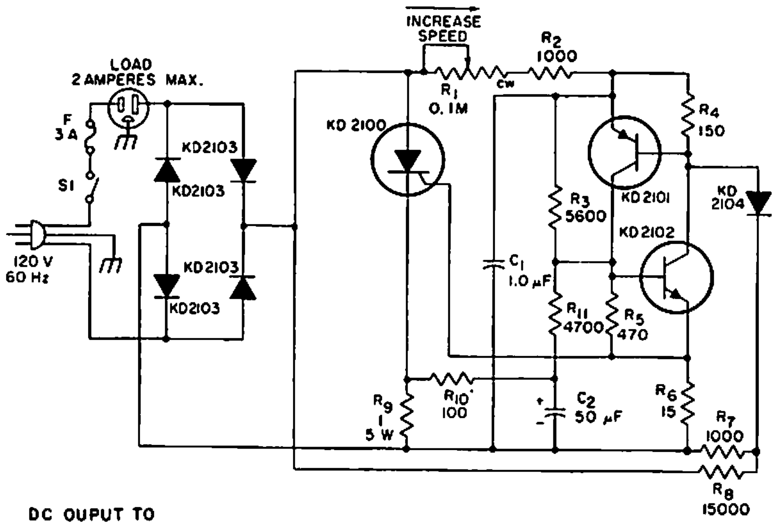

field coil
R1
R2
D1
BT101
220V
~
C1
+
R3
armature
D2
field coil

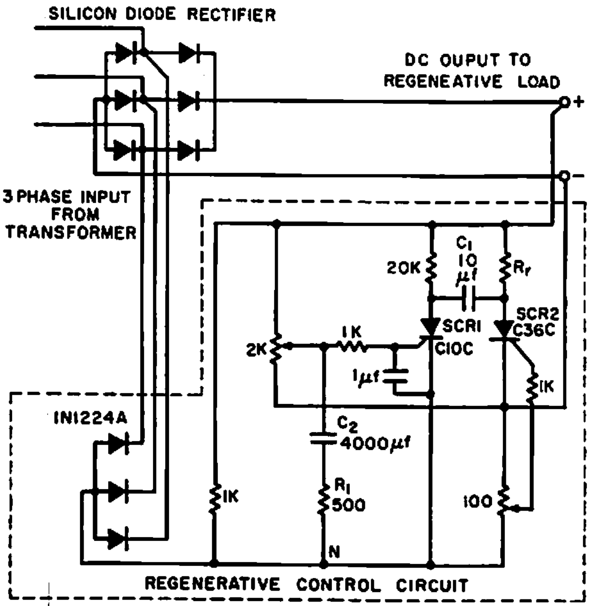
ELECTRIC DRILL SPEED CONTROL—Uses low-cost thyristor and minimum of other components to provide smooth continuous speed control above minimum speed setting determined by values of R3 and C1, which are typically 270 ohms and 16 µF. R1 is 5.6K, R2 is 1K, and diodes are BYX10. Developed for use with a-c series universal motors in hand drills, food mixers, and similar appliances.—Simple Speed Control for Small A. C. Series Motors, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1968.


-ECC
R1
820
R2
100
Q1
2N3646
R3
100
Q2
2N3646
MOTOR
L
R
R4
C1
0.01
R5
100
R6
100
INPUT
Q3
2N3638
Q4
2N3638

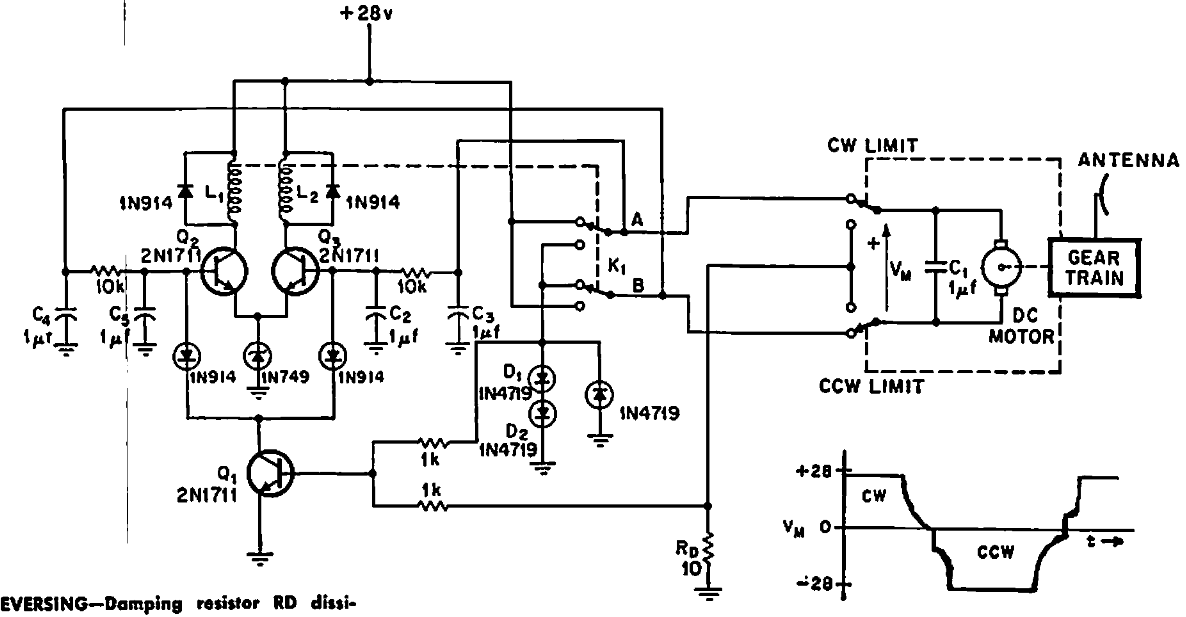
REVERSING SWITCH—With input open, permanent-magnet d-c motor runs in one direction. When input is shorted by ordinary switch, switching transistor, or other means, motor reverses. Closing switch makes Q1 and Q4 conduct, turning off Q2 and Q3. Applications include reversal of battery-powered tape recorders.—C. B. Smith, SPST Switch Reverses PM DC Motor Rotation, *Electronic Design*, April 26, 1967, p 245.

2-A UNIVERSAL FOR POWER TOOLS—Provides full-wave control over entire speed range, with essentially constant speed for any given setting of R1 under changing load conditions. Operates smoothly at low speeds, but motor may overheat because built-in fan cannot provide sufficient cooling air at low speeds. Intended only for universal series-wound motor, but can be used for dimming lamps up to 240-W.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 53.

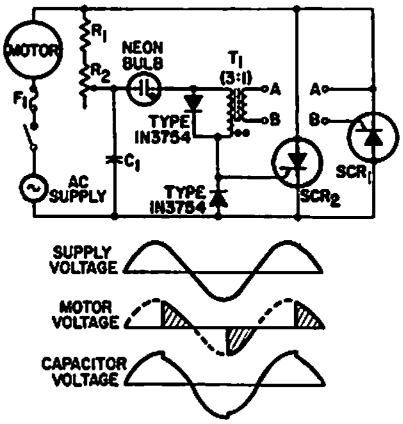

INCREASE SPEED
LOAD 2 AMPERES MAX.
F 3 A
S1
120 V 60 Hz
KD2103
KD2103
KD2103
KD2103
KD 2100
R1 0.1M
CW
R2 1000
R4 150
R3 5600
KD2101
KD2102
KD 2104
C1 1.0 μF
R11 4700
R5 470
R9 1 5 W
R10 100
C2 50 μF
R6 15
R7 1000
R8 15000


SILICON DIODE RECTIFIER
DC OUPUT TO REGENEATIVE LOAD
+
−
3 PHASE INPUT FROM TRANSFORMER
20K
C1 10 μf
Rr
SCR1 C10C
SCR2 C36C
2K
1K
1μf
1K
1N1224A
C2 4000μf
R1 500
1K
100
N
REGENERATIVE CONTROL CIRCUIT

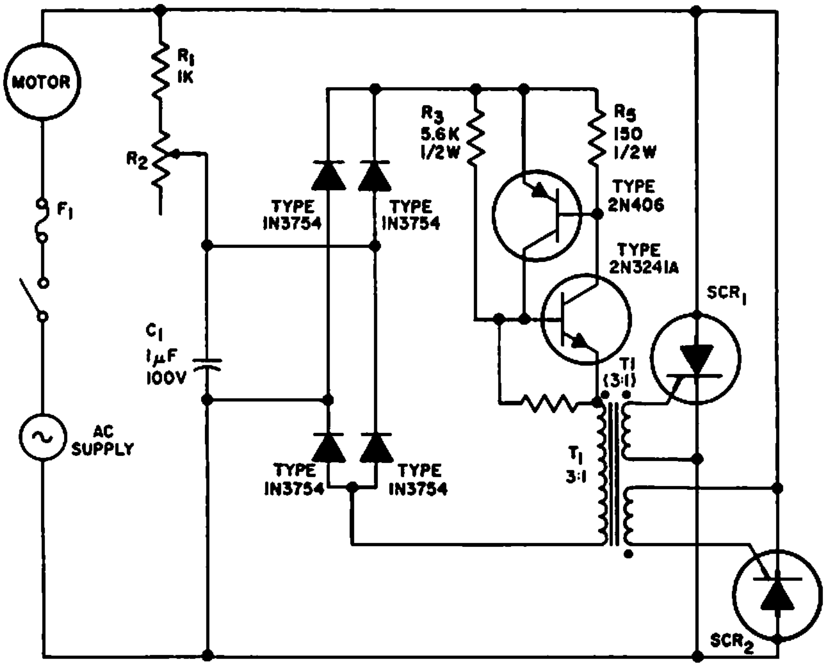
REGENERATIVE-LOAD POWER ABSORBER—Uses scr's in regenerative control circuit to absorb energy from regenerative loads such as elevator and crane motors. Is quiet, has adjustable time delay, and has long life. A-c line variations do not affect set point. Circuit values are for 1.5-kW regenerative control unit having 220 V at no-load. Regenerative load is picked up at 230 V and dropped out at 220 V.—S. P. Leo, Regenerative Load Energy Absorbed by SCR Circuit, *Electronic Design*, May 11, 1964, p 87–89.


+28v
1N914
L1
L2
1N914
Q2 2N1711
Q3 2N1711
10k
10k
C4 1μf
C5 1μf
C2 1μf
C3 1μf
1N914
1N749
1N914
A
K1
B
D1 1N4719
D2 1N4719
1N4719
Q1 2N1711
1k
1k
RD 10
CW LIMIT
ANTENNA
+
VM
C1 1μf
GEAR TRAIN
DC MOTOR
CCW LIMIT
+28
CW
VM 0
CCW
t
−28

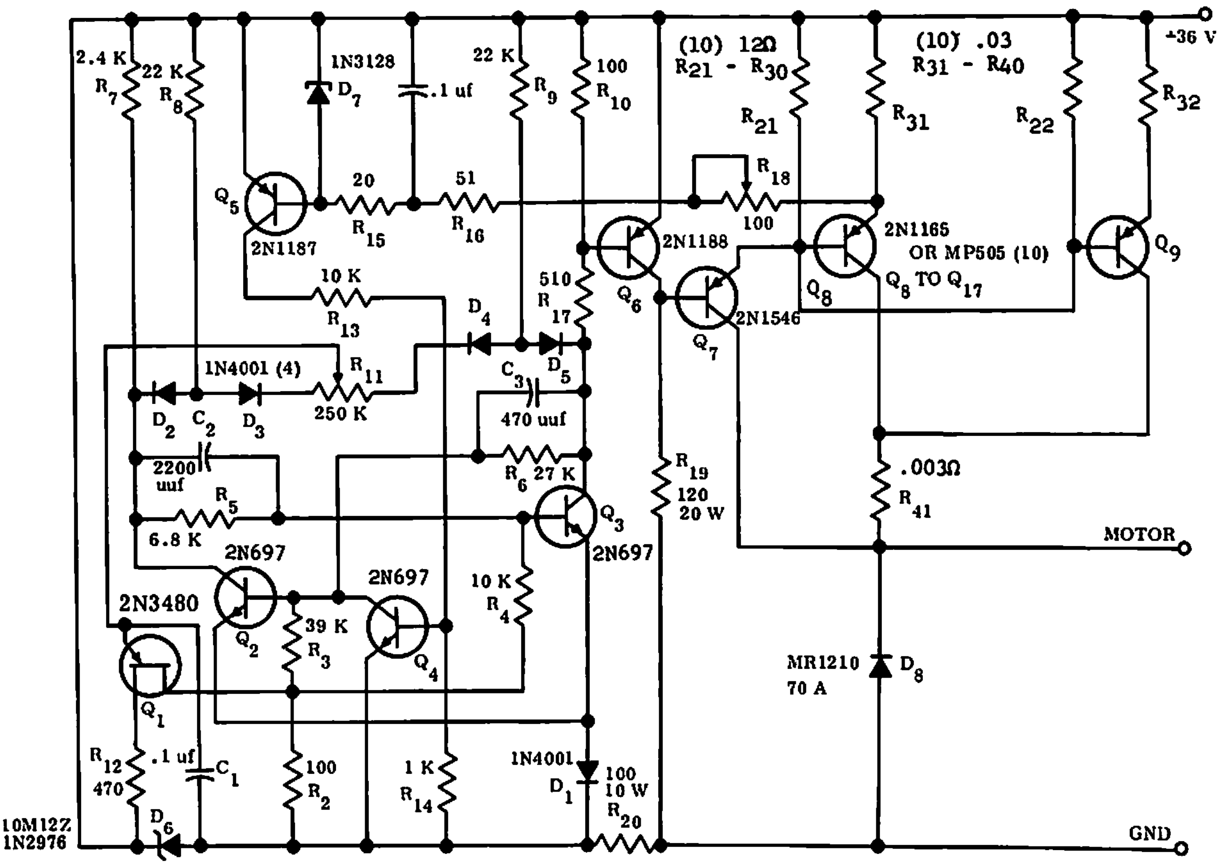
SELF-REVERSING—Damping resistor RD dissipates initial energy of motor when power is removed, and develops signal that turns on Q1 as motor is slowing down. When motor stops, Q3 turns on and pulses latching relay L to reverse motor connections. Can be used to reverse scan direction of motor-driven antenna when limit switch operates.—J. E. Bjornholt, Dynamic Braking EMF Signals Motor To Reverse, *Electronics*, June 22, 1970, p 84.


MOTOR
R1
R2
NEON BULB
T1 (3:1)
A
B
F1
TYPE 1N3754
C1
AC SUPPLY
TYPE 1N3754
SCR1
SCR2
SUPPLY VOLTAGE
MOTOR VOLTAGE
CAPACITOR VOLTAGE

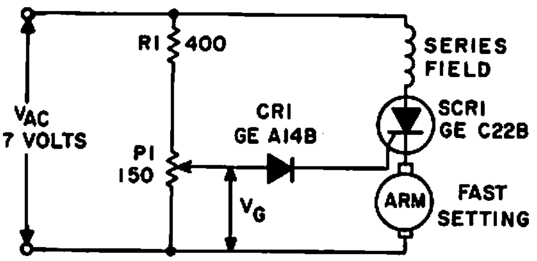
FULL-WAVE SCR WITHOUT REGULATION—Simple full-wave proportional control uses a-c phase shifting to provide gate phase-angle control. Small pulse transformer provides isolation. Conduction angle range is 30 to 150 deg. Book gives values of all components for eight different types of scr used with both 120-V and 240-V a-c lines.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 248.


MOTOR
R1 1K
R2
F1
C1 1μF 100V
AC SUPPLY
TYPE 1N3754
TYPE 1N3754
TYPE 1N3754
TYPE 1N3754
R3 5.6K 1/2W
R5 150 1/2W
TYPE 2N406
TYPE 2N3241A
T1 (3:1)
T1 3:1
SCR1
SCR2

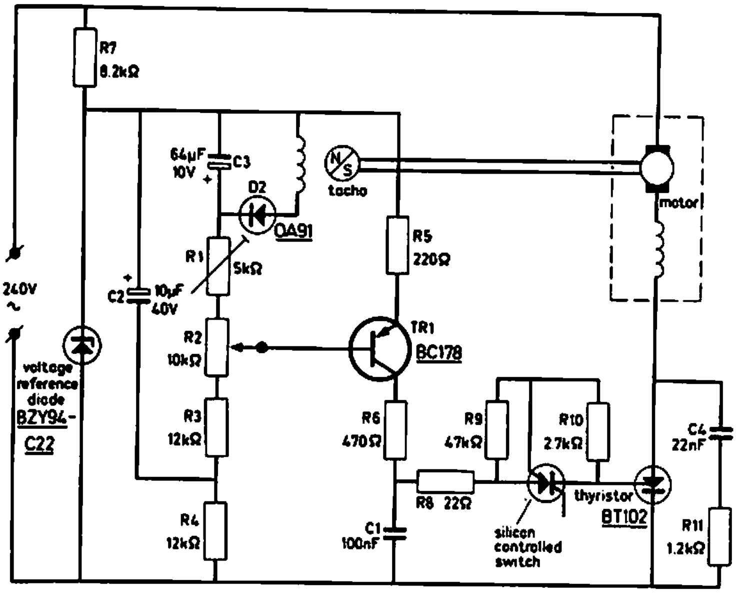
FULL-WAVE SCR UNREGULATED WITH 5–170 DEG CONDUCTION RANGE—Large conduction angle range is more desirable when higher power is to be controlled. For 120-V a-c supply, R2 is 75K and scr's depend on motor current rating. For 240-V a-c, R2 is 150K.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 249.


2.4 K R7
22 K R8
Q5
2N1187
1N3128 D7
.1 uf
20 R15
51 R16
22 K R9
100 R10
(10) 12Ω R21 - R30
(10) .03 R31 - R40
+36 V
R21
R31
R22
R32
R18 100
2N1188 Q6
2N1546 Q7
Q8
2N1165 OR MP505 (10) Q8 TO Q17
Q9
10 K R13
510 R17
D4
D5
C3
470 uuf
1N4001 (4)
R11 250 K
D2 C2 D3
2200 uuf
R5 6.8 K
R6 27 K
Q3 2N697
R19 120 20 W
.003Ω R41
MOTOR
2N697
2N697
10 K R4
2N3480
Q2
39 K R3
Q4
Q1
MR1210 70 A D8
R12 470
.1 uf C1
100 R2
1 K R14
1N4001 D1
100 10 W R20
10M12Z 1N2976
D6
GND

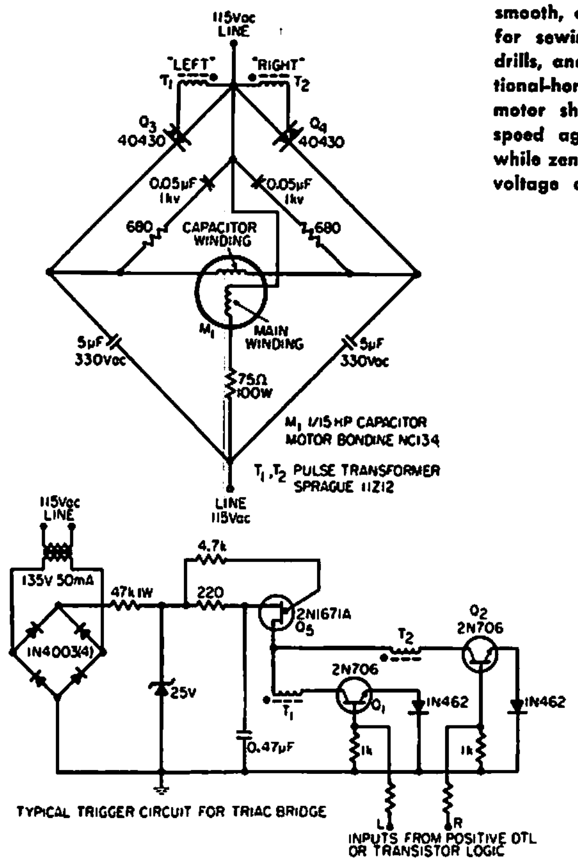
PWM CONTROL FOR 36-V GOLF CART—Handles up to 200 A under stall or starting conditions by using ten transistors in parallel for control of series d-c motor. Book tells how pulse width modulation is used to control speed.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 6–4–8.


R1 400
SERIES FIELD
V_{AC} 117 VOLTS
CR1 GE A14B
SCR1 GE C22B
P1 150
V_G
ARM
FAST SETTING

HALF-WAVE WITH FEEDBACK—Uses feedback by motor residual field to induce back emf in armature proportional to speed. Scr is located between armature and series field winding. When load on motor is increased, feedback action automatically advances firing angle of scr, thereby increasing motor torque while maintaining essentially constant speed. Chief drawback is 25-W power dissipation in R1-P1. Operation is unstable at low speeds. —A. A. Adem, Speed Controls for Universal Motors, General Electric, Syracuse, N.Y., No. 200.47, 1966, p 4.

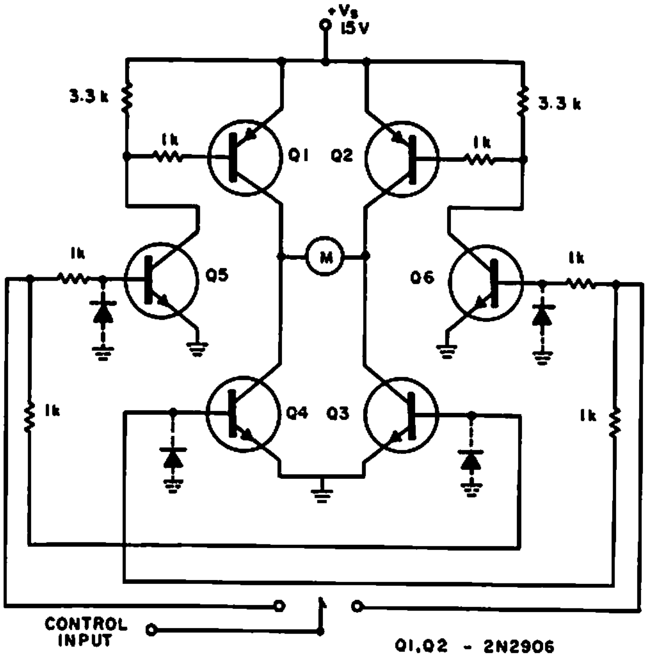

R7 8.2kΩ
64μF 10V C3
D2 OA91
tacho
motor
R1 5kΩ
R5 220Ω
240V ~
C2 10μF 40V
R2 10kΩ
TR1 BC178
voltage reference diode BZY94-C22
R3 12kΩ
R6 470Ω
R9 47kΩ
R10 2.7kΩ
C4 22nF
R8 22Ω
thyristor BT102
R4 12kΩ
C1 100nF
silicon controlled switch
R11 1.2kΩ

LOW-COST THYRISTOR CONTROL OF SMALL FHP MOTOR—Philips BT102 thyristor makes smooth, continuous speed control economical for sewing machines, food mixers, electric drills, and other appliances using small fractional-horsepower motors. Tachometer on motor shaft provides feedback to stabilize speed against variations in motor loading, while zener provides stabilization against line voltage changes. Thyristor is triggered by scs at point in each half-cycle corresponding to setting of speed control R2, to give 7:1 speed range. Tachometer is disk of ceramic magnetic material mounted on motor shaft, inducing pulses in coil wound on suitably shaped stator.—Series Motor Speed Control Systems with Tachometer, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 6, 1968.


115Vac LINE
"LEFT"
"RIGHT"
T_1
T_2
Q_3 40430
Q_4 40430
0.05μF 1kv
0.05μF 1kv
680
CAPACITOR WINDING
680
M_1
MAIN WINDING
5μF 330Vac
5μF 330Vac
75Ω 100W
M_1 1/15 HP CAPACITOR MOTOR BONDINE NC134
T_1,T_2 PULSE TRANSFORMER SPRAGUE 11Z12
LINE 115Vac
115Vac LINE
135V 50mA
47k 1W
4.7k
220
2N1671A Q_5
IN4003(4)
T_2
Q_2 2N706
2N706
Q_1
T_1
25V
IN462
IN462
0.47μF
1k
1k
L
R
INPUTS FROM POSITIVE DTL OR TRANSISTOR LOGIC

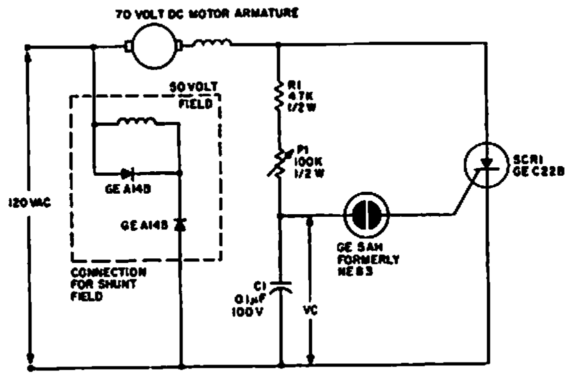
TYPICAL TRIGGER CIRCUIT FOR TRIAC BRIDGE

TRIACS REVERSE CAPACITOR MOTOR—Simple triac bridge controls direction of rotation for fractional-horsepower capacitor-start motor. Power is obtained from a-c motor line. Left and right rotation command signals are obtained from trigger circuit (shown also) through transformers T1 and T2, with trigger in turn controlled by low-level logic from flip-flop or other source.—High-Voltage Triacs Reverse Capacitor Motor, "Electronic Circuit Design Handbook," Tab Books, Blue Ridge Summit, Pa., p 33–34.

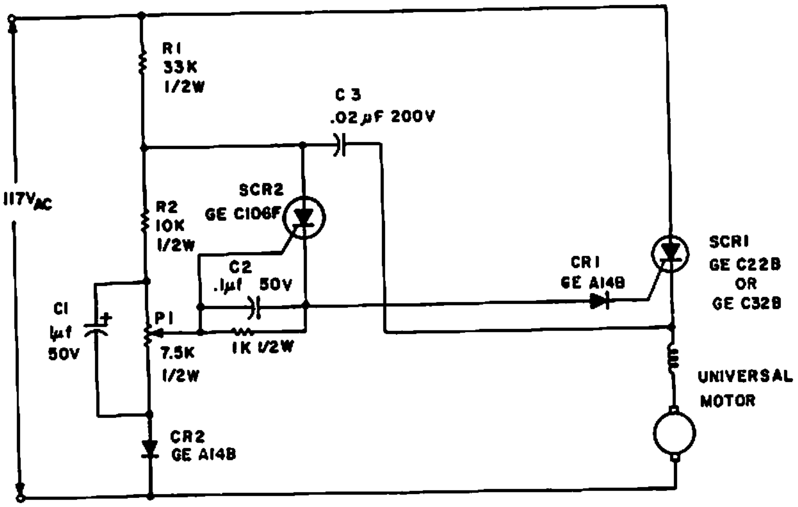

$+V_s$ 15V
3.3 k
3.3 k
1k
Q1
Q2
1k
1k
M
1k
Q5
Q6
1k
Q4
Q3
1k
CONTROL INPUT

Q1,Q2 - 2N2906
Q3-Q6 - 2N2222
DIODES - IN647

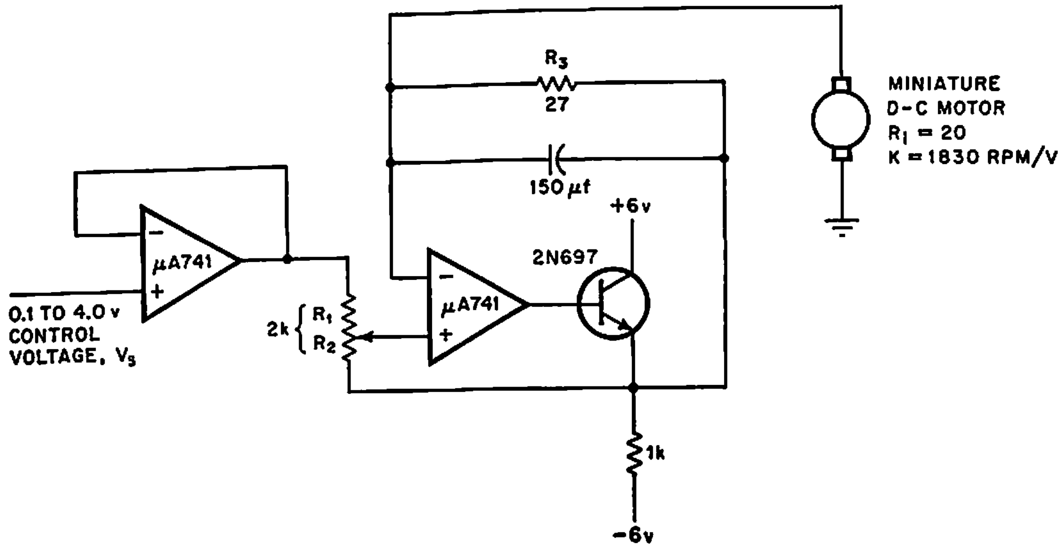
PROPORTIONAL D-C CONTROL—Drives 15-V d-c permanent-magnet motor rated at 100 mA. Bridge-type proportional control amplifier Q1-Q4 is driven by common-emitter stages Q5-Q6. Motor voltage varies from 9.5 to 14.7 V when control input voltage is increased from 0.8 to 2.5 V, with proportional change in speed. Control switch determines direction of rotation.—J. Ayer, Proportional DC Motor Control Requires Low-Level Inputs, *Electronic Design*, Aug. 15, 1968, p 236.


70 VOLT DC MOTOR ARMATURE
50 VOLT FIELD
R1 47K 1/2W
P1 100K 1/2W
SCR1 GE C22B
120 VAC
GE A14B
GE A14B
CONNECTION FOR SHUNT FIELD
GE 5AH FORMERLY NE 83
C1 0.1μF 100V
VC

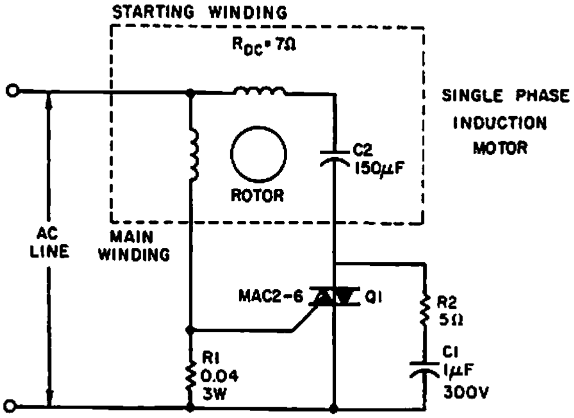
HALF-WAVE NEON-TRIGGERED—Simplest and lowest-cost speed control for universal, shunt, or p-m motors. Uses one scr and minimum number of components. Series network R1-P1-C1 supplies phase-shift signal to neon that triggers scr on at varying times in positive a-c half-cycles.—"SCR Manual," 4th Edition, General Electric, 1967, p 215.


R1 33K 1/2W
C3 .02μF 200V
117V$_{AC}$
SCR2 GE C106F
R2 10K 1/2W
C2 .1μf 50V
CR1 GE A14B
SCR1 GE C22B OR GE C32B
C1 1μf 50V
P1 7.5K 1/2W
1K 1/2W
UNIVERSAL MOTOR
CR2 GE A14B

HALF-WAVE WITH IMPROVED SPEED REGULATION—Reliable and economical circuit with excellent performance at low speed is achieved by using ramp charge on C1 to provide stable triggering point for SCR2, which in turn delivers pulse rather than continuous current for triggering gate of SCR1.—A. A. Adem, Speed Controls for Universal Motors, General Electric, Syracuse, N.Y., No. 200.47, 1966, p 8.

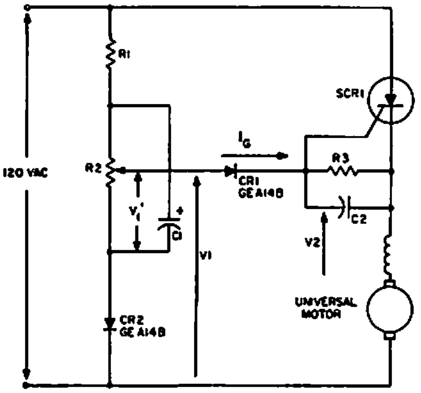

R3
27
150μf
MINIATURE D-C MOTOR
R$_1$ = 20
K = 1830 RPM/V
+6v
2N697
μA741
μA741
0.1 TO 4.0v CONTROL VOLTAGE, V$_S$
2k
R$_1$
R$_2$
1k
-6v

CONSTANT SPEED WITHIN 2%—Negative impedance in series with motor makes speed essentially independent of load. Opamp connected with both positive and negative feedback serves as negative impedance converter. Capacitor prevents circuit from oscillating.—S. Ben-Yaakov, Negative Impedance Stabilizes Motor's Speed, *Electronics*, Mar. 30, 1969, p 94.

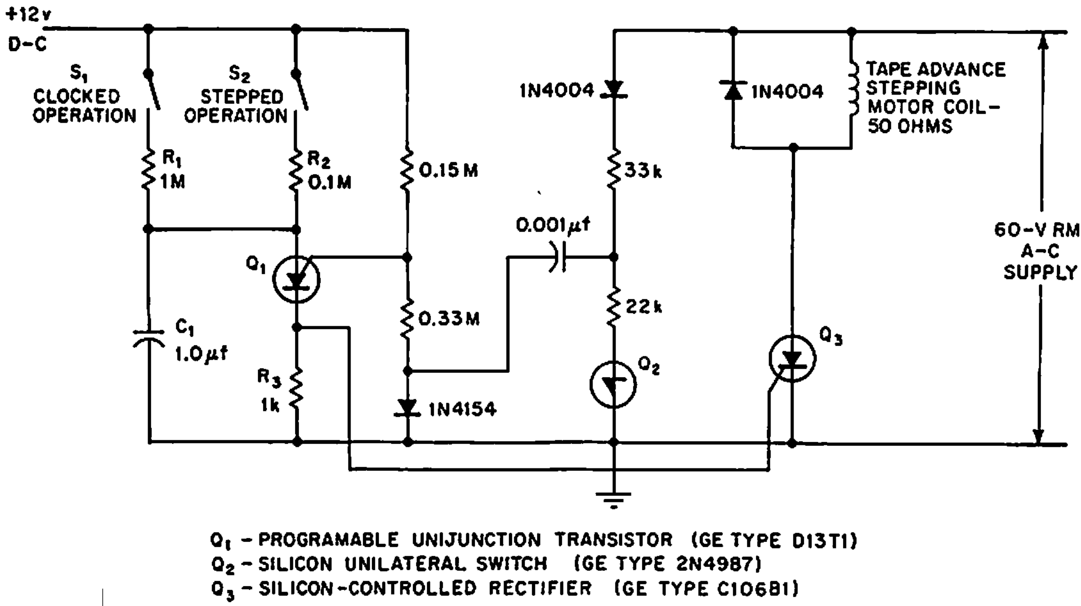

STARTING WINDING
R_{DC} = 7Ω
SINGLE PHASE INDUCTION MOTOR
C2
150μF
ROTOR
AC LINE
MAIN WINDING
MAC2-6
Q1
R2
5Ω
C1
1μF
300V
R1
0.04
3W

TRIAC STARTER FOR ½-HP INDUCTION—Replaces mechanical centrifugal switch in disconnecting start winding when motor reaches about 75% of full-load speed. Voltage across R1, proportional to current in main winding, gates triac; use slide-wire resistor initially to select correct trigger level.—G. V. Fay, Reliable Semiconductor Replaces Centrifugal Motor Starting Switch, *Electronic Design*, Aug. 16, 1969, p 248.

HALF-WAVE UNIVERSAL SERIES MOTOR CONTROL—Used in blenders, hand tools, vacuum cleaners, mixers, and light industrial applications. Gives equivalent of infinitely variable tap on motor. For full-speed operation with half-wave circuit, 80-V motor must be used. Article gives theory of operation in detail. Table gives values of components required for three different sizes of motors.—"SCR Manual," 4th Edition, General Electric, 1967, p 210–211.

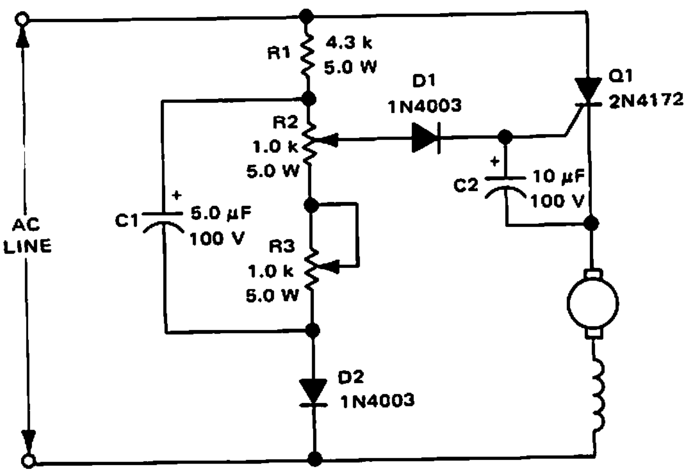

120 VAC
R1
R2
V_1'
C1
V1
I_G
CR1
GE A14B
SCR1
R3
C2
V2
UNIVERSAL MOTOR
CR2
GE A14B

	LOW UP TO 1 AMP NAMEPLATE	MEDIUM UP TO 3 AMP NAMEPLATE	HIGH UP TO 15 AMP NAMEPLATE
R2	10K 1W	1K 2W	1K 2W
R1	47K 1/2 W	3.3K 2W	3.3K 2W
R3	1K 1/2 W	150K 1/2 W OPTIONAL	150K 1/2 W OPTIONAL
C1	0.5μf 50V	10μf 50V	10μf 50V
C2	0.1μf 10V	0.1μf 10V OPTIONAL	0.1μf 10V OPTIONAL
SCR1	GE C106B	GE C22BX70	GE C33B

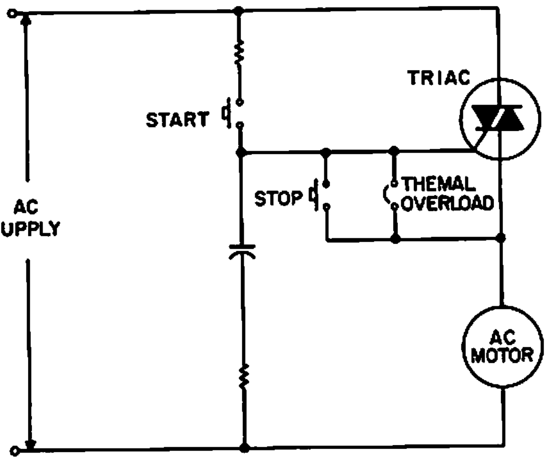

+12v D-C
S_1
CLOCKED OPERATION
S_2
STEPPED OPERATION
1N4004
1N4004
TAPE ADVANCE STEPPING MOTOR COIL-50 OHMS
R_1
1M
R_2
0.1M
0.15 M
33k
0.001μf
60-V RMS A-C SUPPLY
Q_1
22k
C_1
1.0μf
0.33M
Q_3
Q_2
R_3
1k
1N4154

Q_1 – PROGRAMABLE UNIJUNCTION TRANSISTOR (GE TYPE D13T1)
Q_2 – SILICON UNILATERAL SWITCH (GE TYPE 2N4987)
Q_3 – SILICON-CONTROLLED RECTIFIER (GE TYPE C106B1)

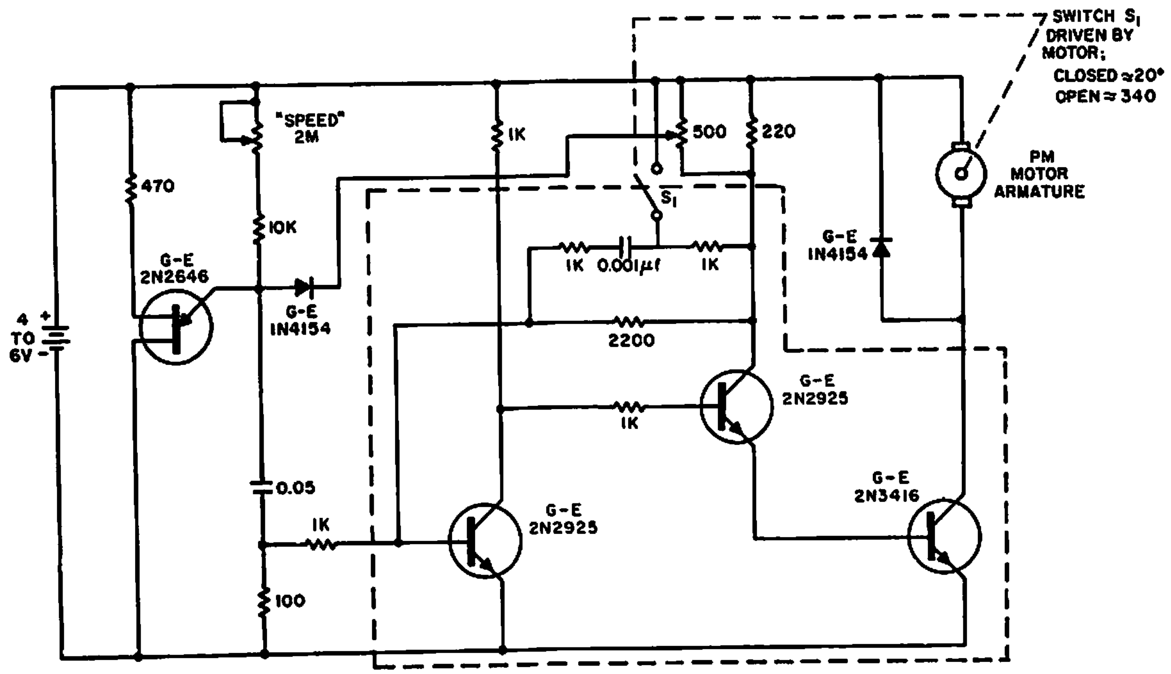
PROGRAM-TAPE STEPPER—Inadvertent advance of d-c stepping motor by supply noise is minimized if motor is activated by a-c signal. Tape advance signal closes either S1 or S2, depending on mode of operation chosen. Closing S2 charges C1 to breakover point of programmable ujt Q1. When Q1 fires, scr Q3 is turned on during positive half-cycles of a-c supply voltage, energizing stepping motor that indexes tape. Sus Q2 ensures that scr is gated on at beginning of each positive half-cycle. In clocked mode, S1 opens and closes at prescribed time intervals of about 1 s, depending on time constant R1-C1.—J. H. Silverman, A-C Source Drives Tape-Stepping Motor, *Electronics*, Nov. 24, 1969, p 109.


AC LINE
R1 4.3 k 5.0 W
D1 1N4003
Q1 2N4172
R2 1.0 k 5.0 W
C2 + 10 µF 100 V
C1 + 5.0 µF 100 V
R3 1.0 k 5.0 W
D2 1N4003

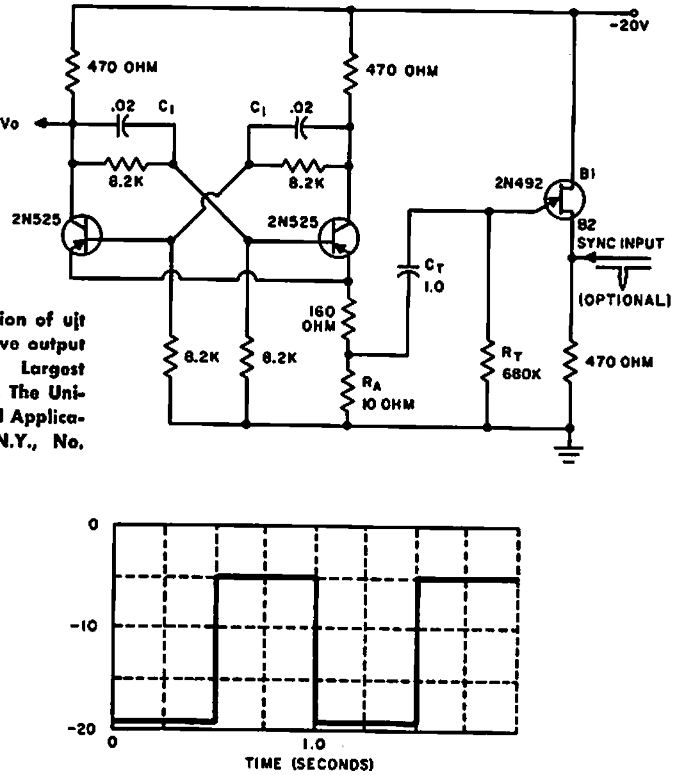
COMPENSATED HALF-WAVE DRIVE—Speed regulation is much better than for uncompensated drive. Back emf of motor provides feedback when scr is off, to compensate for changes in load. Used with 1/15th-hp 5,000-rpm 115-V d-c motor on 120-V a-c line.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–19.


AC SUPPLY
START
STOP
TRIAC
THEMAL OVERLOAD
AC MOTOR

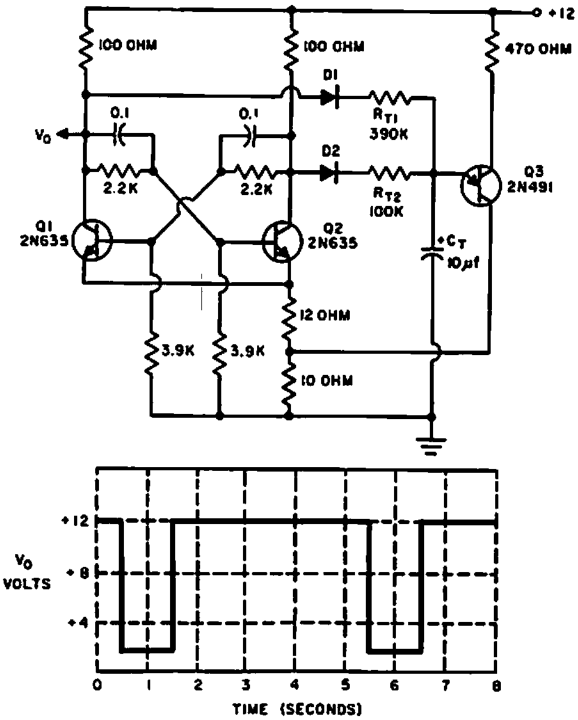
A-C MOTOR STARTER—Momentary closing of start button latches triac on and starts motor. Momentary closing of stop button, closing of thermal overload contact, or loss of line voltage stops motor. Resistor and capacitor values are given in specifications for triac chosen to match motor rating.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1., 1965, p 8.


SWITCH S1 DRIVEN BY MOTOR;
CLOSED≈20°
OPEN≈340
PM MOTOR ARMATURE
"SPEED" 2M
1K
500
220
470
10K
S1
1K
0.001µf
1K
G-E 2N2646
G-E 1N4154
2200
G-E 1N4154
G-E 2N2925
1K
4 TO 6V
0.05
1K
G-E 2N2925
G-E 2N3416
100

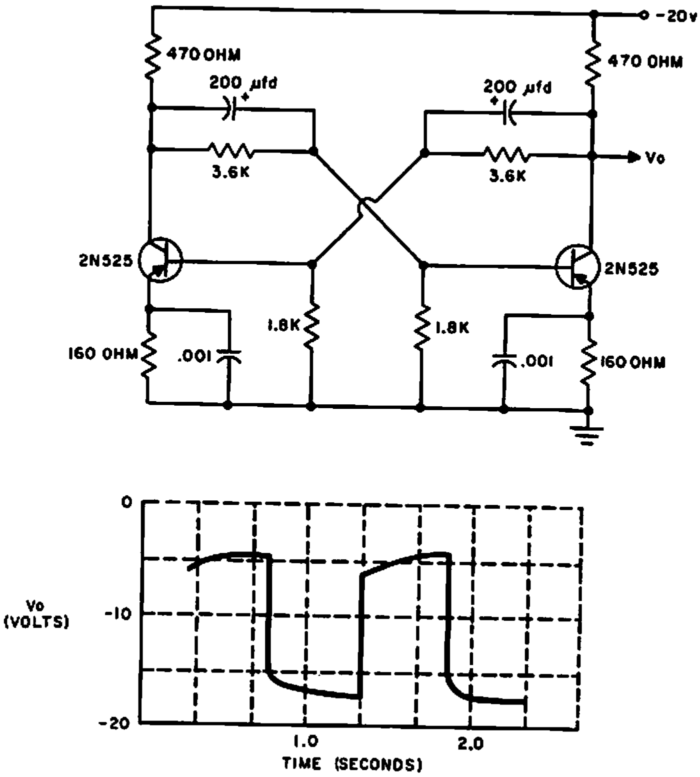
UJT CONTROL FOR P-M MOTOR—Ujt relaxation oscillator drives flip-flop to energize small battery-operated permanent-magnet motor. Rotation of motor shaft closes S1, reversing flip-flop and turning motor off. At low speeds, cam on motor shaft should close S1 several times per revolution. Motor speed can be changed in discrete octave steps by changing switch closures per revolution from 1 to 2 to 4 to 8, etc., either mechanically or electrically. Speed is synchronously related to oscillator frequency.—E. K. Howell, Precise Speed Control, High Torque Can Now be Combined in DC Motors, *Electronic Design*, Dec. 6, 1965, p 20–25.


-20V
470 OHM
470 OHM
Vo
.02 C1
C1 .02
8.2K
8.2K
2N525
2N525
2N492
B1
B2
SYNC INPUT
(OPTIONAL)
CT 1.0
160 OHM
8.2K
8.2K
RA 10 OHM
RT 680K
470 OHM
0
-10
-20
0
1.0
TIME (SECONDS)

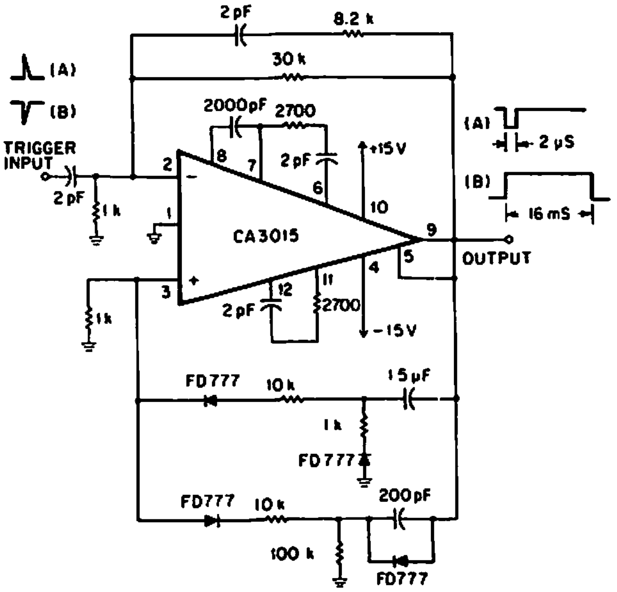
HYBRID SYMMETRICAL MVBR—Addition of ujt gives perfect symmetrical square-wave output without need for balance control. Largest capacitor is only 1 μF.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 52.


+12
100 OHM
100 OHM
470 OHM
D1
RT1 390K
D2
RT2 100K
0.1
0.1
Vo
2.2K
2.2K
Q1 2N635
Q2 2N635
Q3 2N491
+CT 10μf
12 OHM
3.9K
3.9K
10 OHM
+12
+8
+4
Vo VOLTS
0
1
2
3
4
5
6
7
8
TIME (SECONDS)

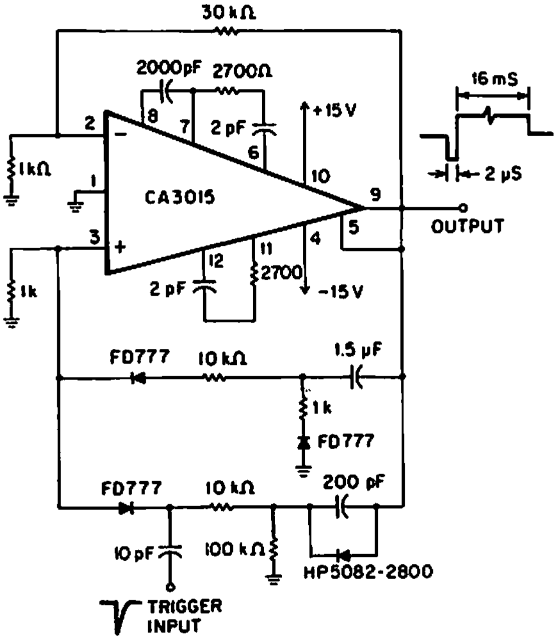
HYBRID UNSYMMETRICAL MVBR—Uses npn transistor flip-flop with ujt. Waveform shown is for values specified for RT; with potentiometers here, lengths of two parts of timing period can be adjusted over range of up to 1,000 to 1. Protective 3K resistors should then be in series with each pot.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 53.


-20v
470 OHM
470 OHM
200 μfd
200 μfd
3.6K
3.6K
Vo
2N525
2N525
1.8K
1.8K
160 OHM
.001
.001
160 OHM
0
-10
-20
Vo (VOLTS)
1.0
2.0
TIME (SECONDS)

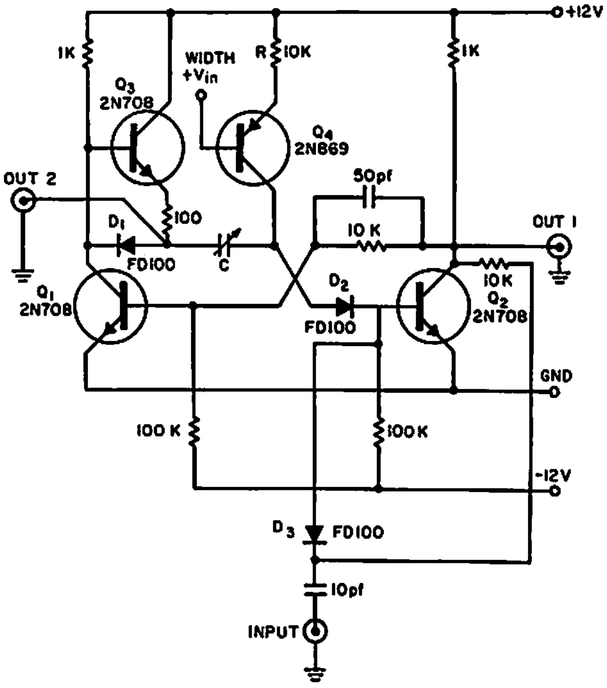
BASIC TWO-TRANSISTOR CIRCUIT—Included for comparison, because output waveform deviates considerably from ideal square wave. —T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 51.


2 pF
8.2 k
30 k
(A)
(B)
TRIGGER INPUT
2 pF
1 k
2000pF
2700
2 pF
+15 V
8
7
6
10
2
1
CA3015
9
3
12
11
4
5
2 pF
2700
1 k
-15 V
(A)
2 μS
(B)
16 mS
OUTPUT
FD777
10 k
1.5 μF
1 k
FD777
FD777
10 k
200pF
100 k
FD777

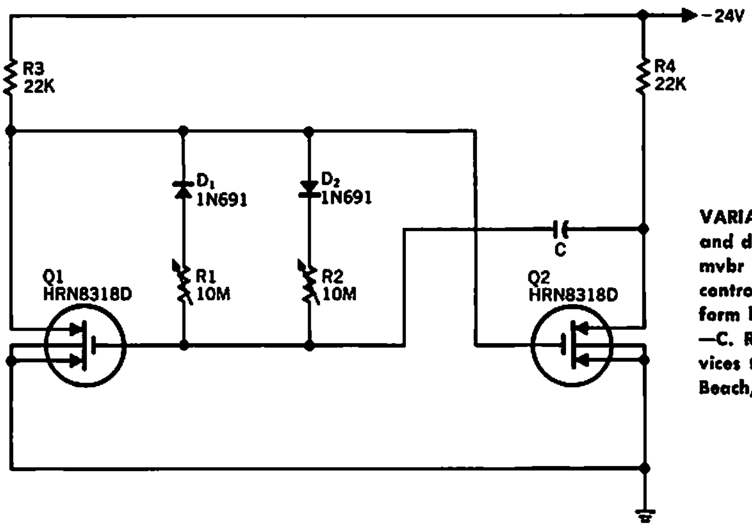
CONTROLLED BIPOLAR—Positive trigger input gives negative output pulse, while negative trigger gives positive pulse. Durations of both pulses are independently adjustable.—G. T. Flynn, Sequential Bipolar Multivibrator, *EEE,* April 1969, p 122–123.


30 kΩ
2000pF
2700Ω
2 pF
+15 V
8
7
6
10
2
1kΩ
1
CA3015
9
3
1k
12
11
4
5
2 pF
2700
-15V
16 mS
2 μS
OUTPUT
FD777
10 kΩ
1.5 μF
1 k
FD777
FD777
10 kΩ
200 pF
10 pF
100 kΩ
HP5082-2800
TRIGGER INPUT

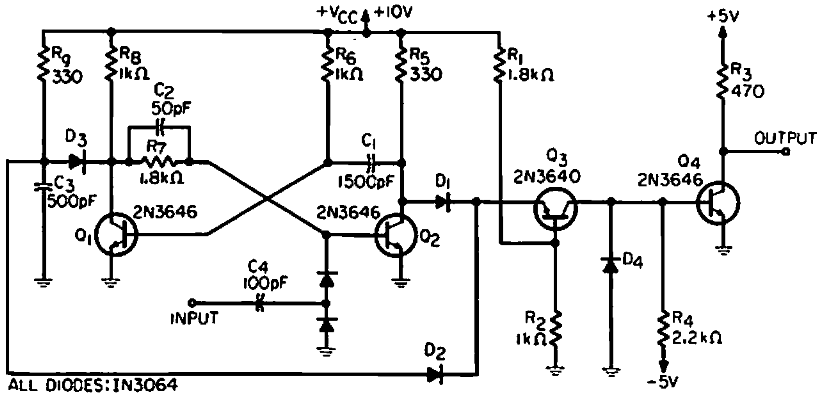
SEQUENTIAL BIPOLAR—Generates 2-μs negative pulse followed by 16-ms positive pulse, each time circuit is triggered. Will trigger as often as once every 20 ms. Output amplitudes are −7 and +7 V. Duration of each pulse is independently adjustable over wide range by changing circuit values.—G. T. Flynn, Sequential Bipolar Multivibrator, *EEE,* April 1969, p 122–123.


+12V
1K
WIDTH +Vin
R
10K
1K
Q3 2N708
Q4 2N869
OUT 2
50pf
OUT 1
100
D1
FD100
C
10 K
D2
10K
Q1 2N708
FD100
Q2 2N708
GND
100 K
100K
-12V
D3
FD100
10pf
INPUT

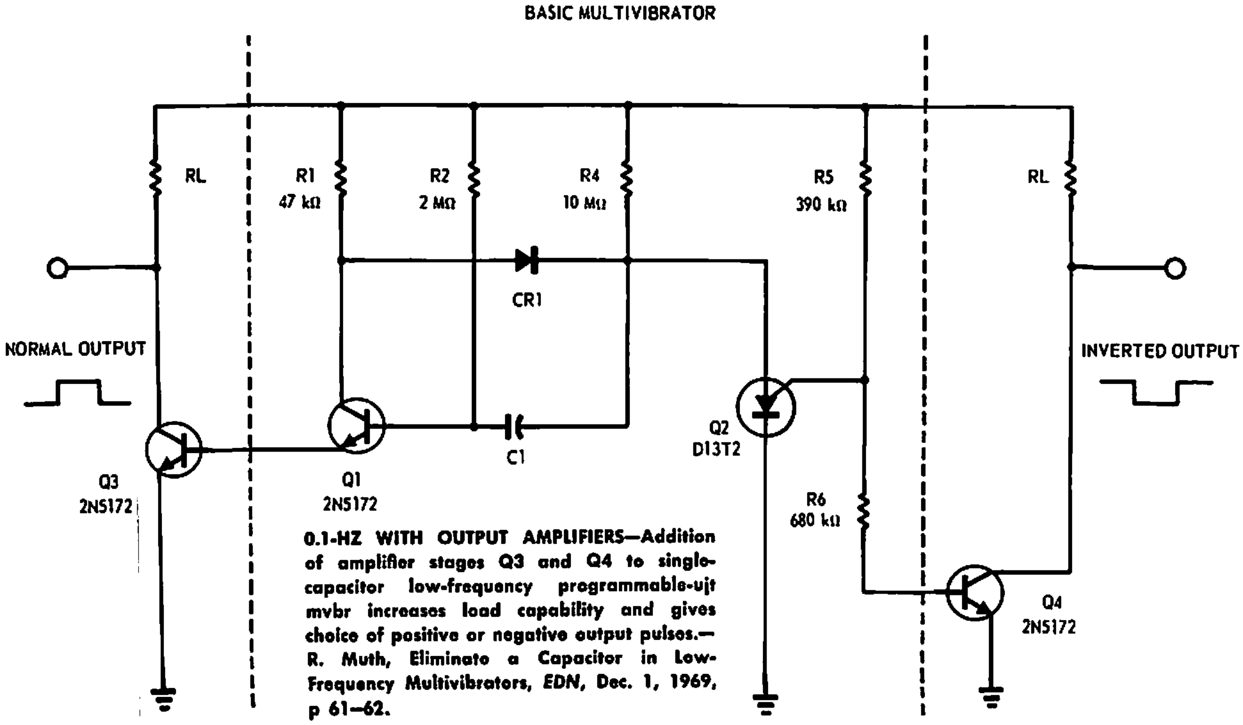
FAST-RECOVERY ONE SHOT—Pulse width of four-transistor mvbr is determined by d-c voltage applied to base of Q4.—G. Marosi, Four-Transistor Monostable Multi Shortens Recovery Time, *Electronic Design,* Aug. 17, 1964, p 201–202.


-24V
R3
22K
R4
22K
D1
1N691
D2
1N691
C
Q1
HRN8318D
R1
10M
R2
10M
Q2
HRN8318D

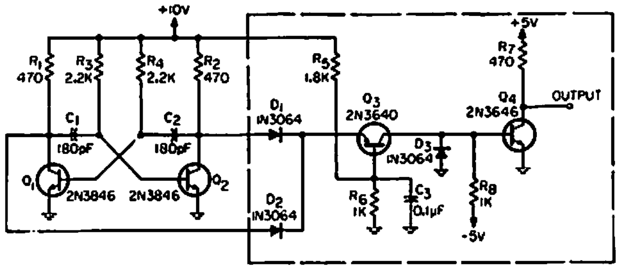
VARIABLE WIDTH AND DUTY CYCLE—Isolating and dividing timing resistor of astable mosfet mvbr into two controls gives independent control over pulse width and duty cycle, to form basis for highly flexible pulse generator.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 24.


+VCC +10V
+5V
R9
330
R8
1kΩ
C2
50pF
R7
1.8kΩ
D3
C3
500pF
2N3646
Q1
R6
1kΩ
R5
330
C1
1500pF
2N3646
Q2
D1
R1
1.8kΩ
Q3
2N3640
Q4
2N3646
R3
470
OUTPUT
C4
100pF
INPUT
D2
R2
1kΩ
D4
R4
2.2kΩ
-5V
ALL DIODES:IN3064

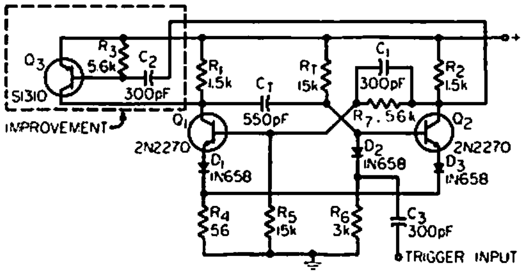
TWO PULSES PER TRIGGER—Pulse duration and interval are independently adjustable. Performance is equivalent to that of three one-shots.—D. R. Hoppe, Two-Pulse Monostable, *EEE*, May 1967, p 84.


BASIC MULTIVIBRATOR
RL
R1
47 kΩ
R2
2 MΩ
R4
10 MΩ
R5
390 kΩ
RL
CR1
NORMAL OUTPUT
INVERTED OUTPUT
Q3
2N5172
Q1
2N5172
C1
Q2
D13T2
R6
680 kΩ
Q4
2N5172

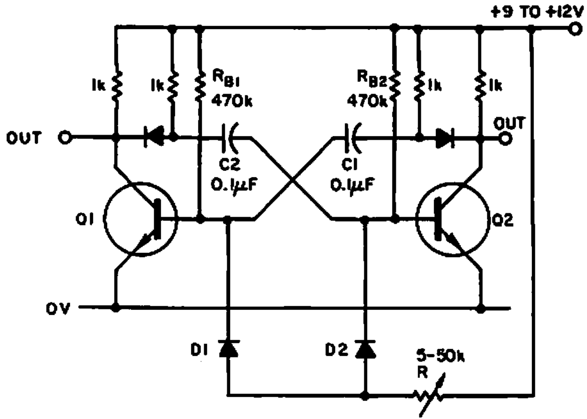
0.1-HZ WITH OUTPUT AMPLIFIERS—Addition of amplifier stages Q3 and Q4 to single-capacitor low-frequency programmable-ujt mvbr increases load capability and gives choice of positive or negative output pulses.—R. Muth, Eliminate a Capacitor in Low-Frequency Multivibrators, *EDN*, Dec. 1, 1969, p 61–62.


+10V
R1 470
R3 2.2K
R4 2.2K
R2 470
C1 180pF
C2 180pF
Q1 2N3846
2N3846 Q2
D1 IN3064
D2 IN3064
+5V
R5 1.8K
Q3 2N3640
D3 IN3064
R6 1K
C3 0.1µF
R7 470
Q4 2N3646
OUTPUT
R8 1K
-5V

DOUBLER FOR MVBR—Circuit in dashed rectangle doubles output frequency of astable mvbr Q1—Q2 to extend operating range. May also be used with most other relaxation oscillators. Wiht values shown, output frequency is 5.5 MHz, pulse width 86 ns, rise time 15 ns, and fall time 5 ns.—D. R. Hoppe, Frequency Doubler for Relaxation Oscillators, *EEE*, Feb. 1967, p 147—148.

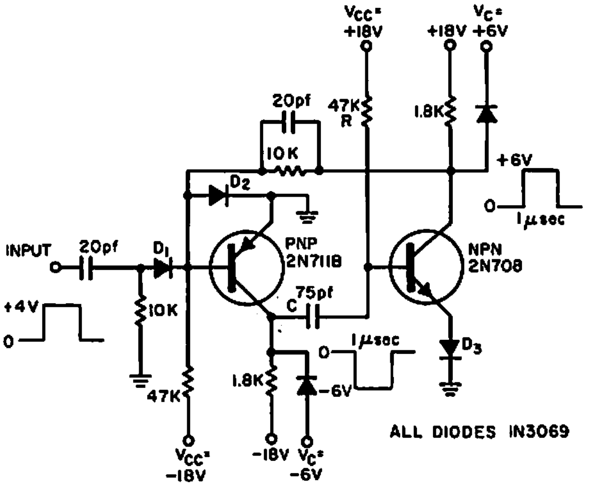

Q3
S1310
R3 5.6k
C2 300pF
IMPROVEMENT
+Vcc
R1 1.5k
CT 550pF
RT 15k
C1 300pF
R7 56k
R2 1.5k
Q1 2N2270
Q2 2N2270
D1 IN658
D2 IN658
D3 IN658
R4 56
R5 15k
R6 3k
C3 300pF
TRIGGER INPUT

FAST-RECOVERY ONE-SHOT—Simple modification (dashed rectangle) cuts recovery time to 50 ns, as compared to about 6 µs for basic one-shot. Modification also improves output waveform and reduces dynamic output impedance.—M. Felcheck and W. Kirschner, Improved One-Shot with Fast Recovery, *EEE*, Oct. 1967, p 142—143.


+9 TO +12V
1k
1k
RB1 470k
RB2 470k
1k
1k
OUT
OUT
C2 0.1µF
C1 0.1µF
Q1
Q2
0V
D1
D2
5-50k R

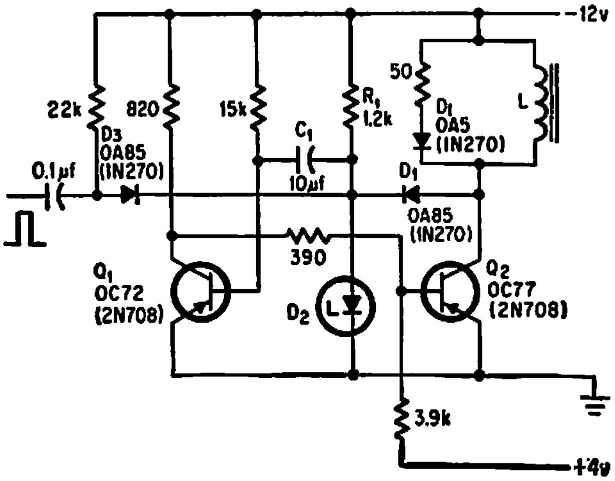
ALL DIODES - 15940
Q1,Q2 - 2N5305 DARLINGTON PAIR OR TWO 2N3705

140—1,400 HZ ASTABLE—Wide frequency range is achieved simply by adding D1, D2, and R to standard mvbr. Mark-space ratio is constant. Range shown for R covers entire frequency range of mvbr.—S. H. Dolding, 3 Extra Parts Give Astable Multi a Wide Frequency Range, *Electronic Design*, July 5, 1969, p 82 and 84.

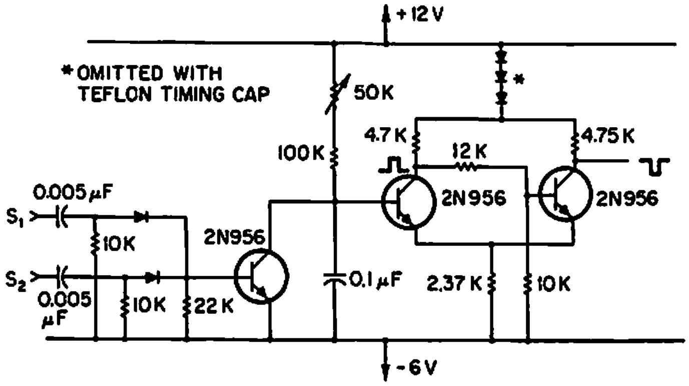

Vcc= +18V
+18V
Vc= +6V
20pf
47K R
1.8K
10K
+6V
1µsec
D2
INPUT
20pf
D1
PNP 2N7118
NPN 2N708
+4V
0
10K
C 75pf
0
1µsec
-6V
D3
1.8K
47K
Vcc= -18V
-18V
Vc= -6V

ALL DIODES IN3069

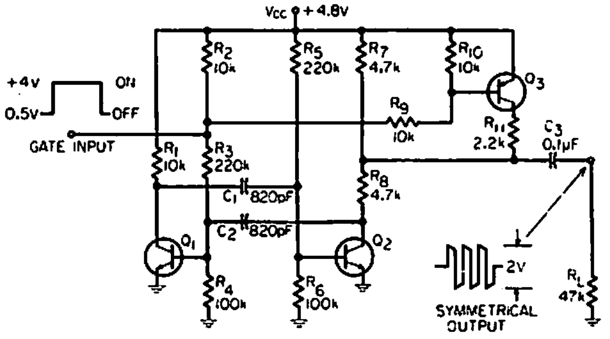
REGENERATIVE SHARPENING OF RISE TIME—Complementary transistors, connected as shown, speed transition time of monostable mvbr enough to make it indistinguishable from 40-ns rise and fall times of transistors themselves. Pulse repetition frequency is 960 kHz with values shown.—G. Klein, Monostable Multivibrator Has a Sharp Rise Time, *Electronic Design*, Feb. 17, 1964, p 88—89.


-12v
22k
820
15k
R1 1.2k
50
L
D3 OA85 (IN270)
D1 OA5 (IN270)
0.1µf
C1 10µf
D1 OA85 (IN270)
390
Q1 OC72 (2N708)
D2
Q2 OC77 (2N708)
3.9k
+4v

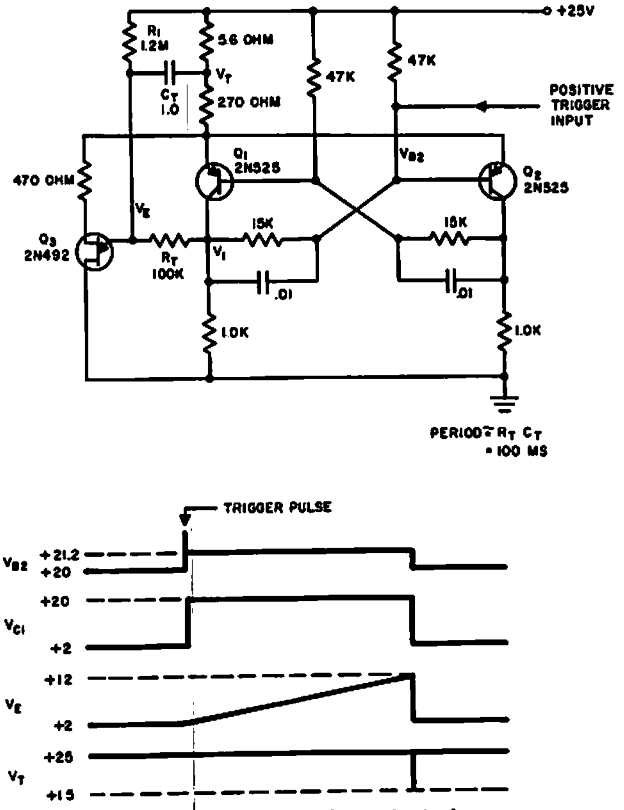
ZENER BLOCKS STRAY PULSES—Zener D2 acts with three conventional diodes in mvbr to block pulses from power supply and inductive load, and thereby prevent premature triggering.—R. Ilic, Diodes Provide Noise Immunity for Monostable Multivibrators, *Electronics*, Jan. 9, 1967, p 106—107.


+12V
*OMITTED WITH
TEFLON TIMING CAP
50K
*
4.7K
12K
4.75K
100K
0.005μF
S1
S2
10K
10K
22K
2N956
2N956
2N956
0.1μF
2.37K
10K
0.005 μF
-6V

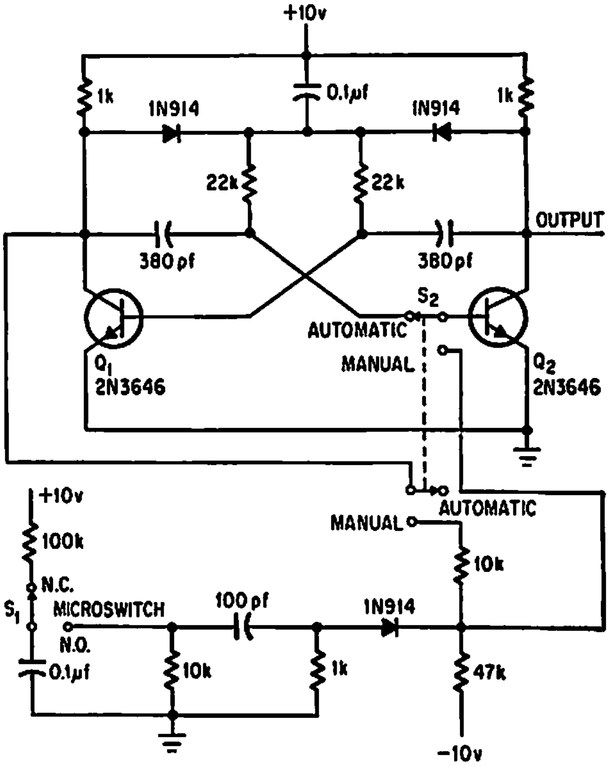
TRIGGERABLE-ANYTIME MONO—Consists of modified Schmitt trigger and one additional stage that performs function of mono without having its drawback of ignoring input triggers during output pulse. Circuit may be retriggered at any time from any number of sources. Triggers occurring during output pulse simply resaturate first transistor, discharging 0.1-μF capacitor to negative supply voltage and initiating normal pulse period. Values shown give 5-ms pulse width.—B. Pearl, A Retriggerable Pseudo-Mono, *EEE*, Dec. 1966, p 78–79.


Vcc +4.8V
+4V
0.5V
ON
OFF
GATE INPUT
R2 10k
R5 220k
R7 4.7k
R10 10k
Q3
R9 10k
R11 2.2k
C3 0.1μF
R1 10k
R3 220k
C1 820pF
C2 820pF
R8 4.7k
Q1
Q2
R4 100k
R6 100k
2V
SYMMETRICAL OUTPUT
RL 47k

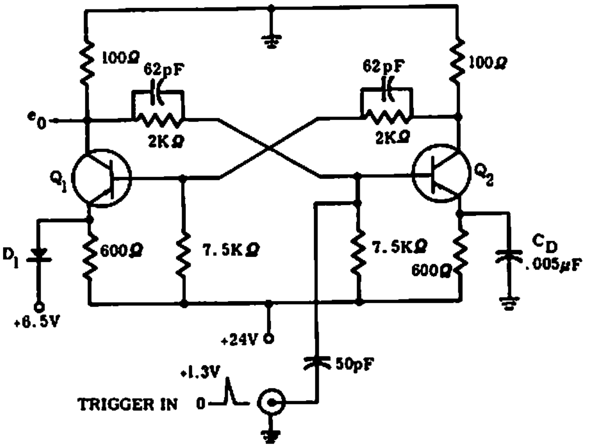
SYMMETRICAL A-C OUTPUT—Addition of Q3 to keyed mvbr eliminates d-c level shift of output that would cause severe distortion in a-c coupled load. Another advantage is that circuit starts instantly with full-width first pulse. Astable mvbr Q1-Q2 is keyed by switching charging voltage of C2. Mvbr oscillates at about 3 kHz for +4 V gate input, and is turned off when gate is below 1 V.—M. Converse, Keyed Multivibrator Produces Symmetrical A-C Output, *EEE*, Nov. 1968, p 141.


+25V
R1 1.2M
56 OHM
VT
CT 1.0
270 OHM
47K
47K
POSITIVE TRIGGER INPUT
470 OHM
Q1 2N525
VB2
Q2 2N525
Q3 2N492
VE
RT 100K
V1
15K
15K
.01
.01
1.0K
1.0K
PERIOD ≈ RT CT • 100 MS
TRIGGER PULSE
VB2
+21.2
+20
VC1
+20
+2
VE
+12
+2
VT
+25
+15

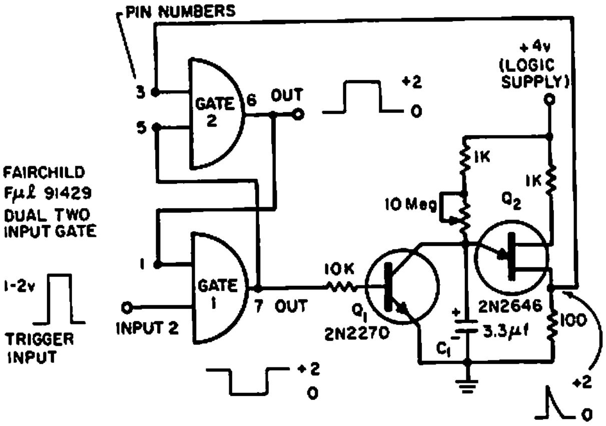
HYBRID ONE-SHOT—With basic circuit shown, all voltages return to initial values at end of timing cycle, so timing period is independent of trigger rate and duty cycle.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 55.


+10v
1k
1N914
0.1μf
1N914
1k
22k
22k
OUTPUT
380pf
380pf
S2
AUTOMATIC
MANUAL
Q1 2N3646
Q2 2N3646
+10v
100k
N.C.
S1
MICROSWITCH
N.O.
0.1μf
10k
100pf
1k
1N914
AUTOMATIC
MANUAL
10k
47k
-10v

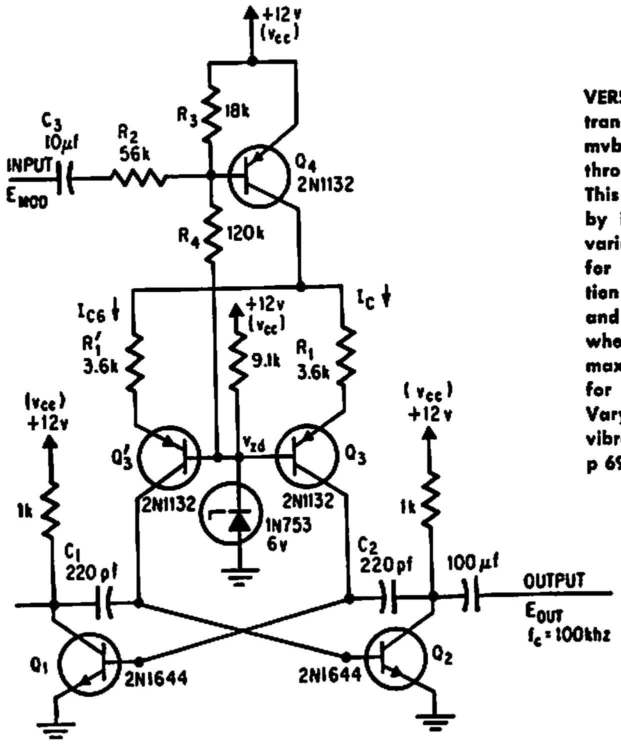
ASTABLE-MONO SWITCH—With S2 in automatic position, circuit runs as unsymmetrical astable mvbr generating 1.5-μs pulses at 150-kHz repetition rate, for testing counter and logic circuits at high switching speeds. Manual position gives one-shot action.—D. Haggen, Switch Converts Multivibrator from Astable to One-Shot, *Electronics*, Nov. 28, 1966, p 80.


100Ω
62pF
62pF
100Ω
e_0
2KΩ
2KΩ
Q_1
Q_2
D_1
600Ω
7.5KΩ
7.5KΩ
600Ω
C_D
.005μF
+6.5V
+24V
+1.3V
TRIGGER IN 0
50pF

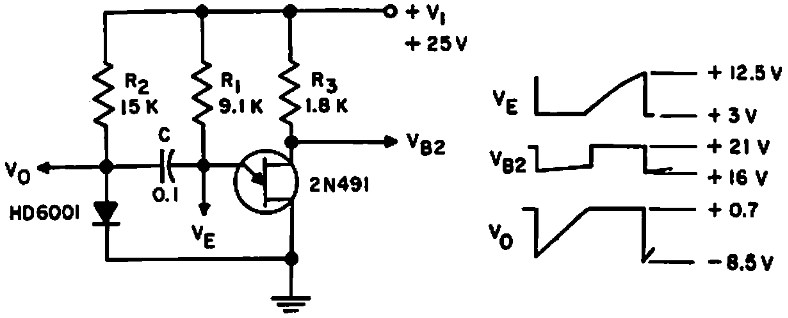
CURRENT-MODE MONO—Maximum repetition rate is 1MHz. Timing interval or delay in returning from quasi-stable to steady state is almost comparable to recovery time of capacitor.—"High Speed Switching Transistor Handbook," Motorola, Phoenix, Ariz., 1969, p 280.


PIN NUMBERS
3
5
GATE 2
6 OUT
+2
0
+4v (LOGIC SUPPLY)
FAIRCHILD FμL 91429 DUAL TWO INPUT GATE
1K
1K
10 Meg
Q_2
1
GATE 1
7 OUT
10K
Q_1
2N2270
2N2646
3.3μf
100
C_1
1-2v
TRIGGER INPUT
INPUT 2
+2
0
+2
0

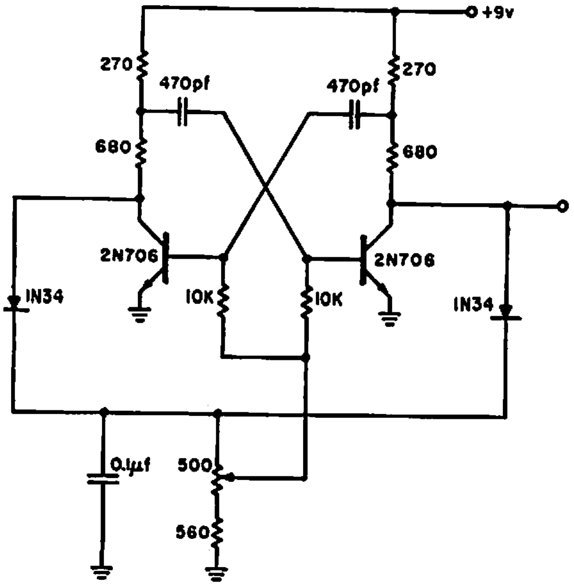
WIDE-RANGE ONE-SHOT—Combining two cross-coupled NAND gates with ujt gives stable, wide-range one-shot mvbr having complementary outputs, with delays of 100 ms to 20 s, in minimum space.—A. C. Ward, NAND Gates and UJT Form Stable Hybrid Monostable Multi, *Electronic Design*, April 26, 1965, p 45–46.


+12v (V_{cc})
C_3 10μf
R_2 56k
INPUT
E_{MOD}
R_3 18k
Q_4 2N1132
R_4 120k
I_{C6}
I_C
R_1' 3.6k
+12v (V_{cc})
9.1k
R_1 3.6k
(V_{cc}) +12v
(V_{cc}) +12v
Q_3'
V_{zd}
Q_3
2N1132
1N753 6v
2N1132
1k
1k
C_1 220pf
C_2 220pf
100μf
OUTPUT
E_{OUT}
f_c = 100khz
Q_1
2N1644
2N1644
Q_2

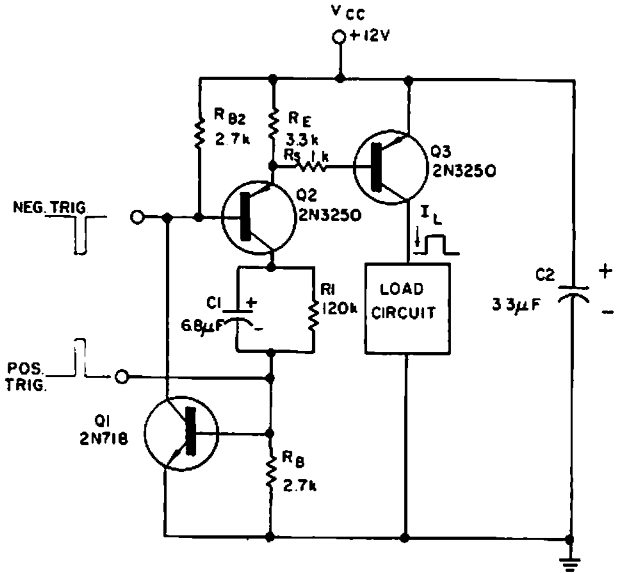
VERSATILE MVBR CONTROL—Constant-current transistors Q3 and Q3′ control frequency of mvbr Q1-Q2 by controlling charging current through cross-coupling capacitors C1 and C2. This charging current is, in turn, determined by input voltage on Q4 acting as voltage-variable resistor. Circuit works equally well for sine, sawtooth, or square-wave modulation on Q4. For d-c control, C3 is shorted and R2, R3, and R4 adjusted so Q4 is off when input is zero. With values shown, maximum linear swing of 20 kHz is obtained for 100-kHz output carrier.—D. H. Reese, Jr., Varying Capacitor Charge-Up Controls Multivibrator's Range, *Electronics*, Dec. 25, 1967, p 69.


+ V_1
+ 25V
R_2 15 K
R_1 9.1 K
R_3 1.8 K
C
0.1
V_{B2}
V_O
HD6001
V_E
2N491
V_E
+ 12.5 V
+ 3 V
V_{B2}
+ 21 V
+ 16 V
V_O
+ 0.7
− 8.5 V

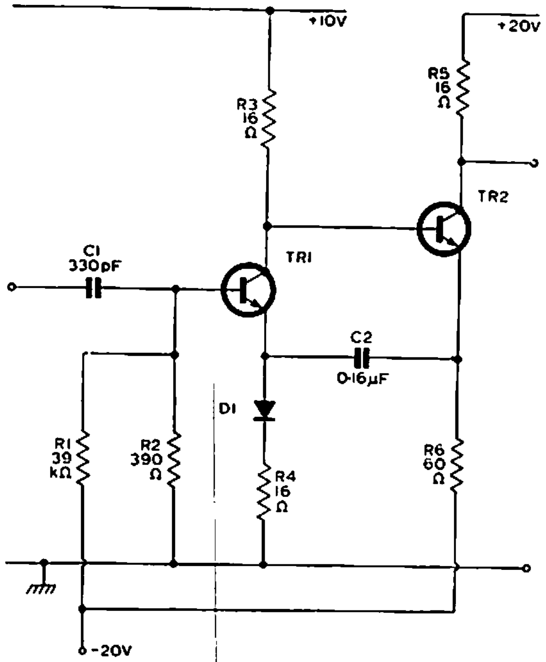
SINGLE-UJT MVBR—Frequency is about 1 kHz. Article gives equations for calculating times for the two periods shown in waveforms.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 74.


+9v
270
470pf
470pf
270
680
680
2N706
2N706
IN34
10K
10K
IN34
0.1μf
500
560

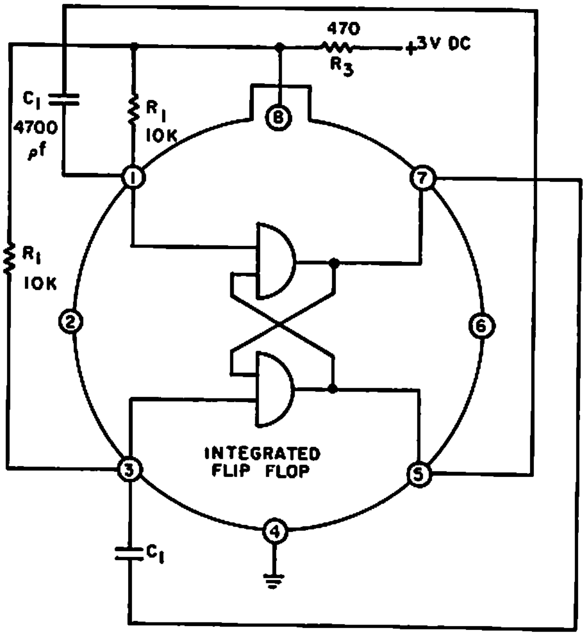
200—300 KHZ TUNABLE—Frequency is changed with 500-ohm pot. Base bias is obtained through diode network to ensure reliable starting.—M. W. Egerton, Tunable Multivibrator Starts Reliably, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 184.


Vcc
+12V
RB2
2.7k
RE
3.3k
RS 1k
Q3
2N3250
NEG. TRIG
Q2
2N3250
IL
C1
6.8μF
R1
120k
LOAD CIRCUIT
C2
3.3μF
POS. TRIG.
Q1
2N718
RB
2.7k

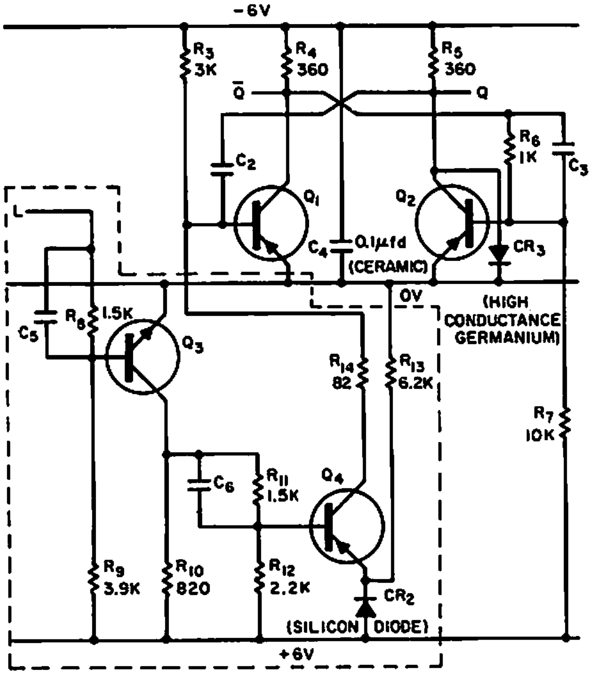
ONE-SHOT SWITCH—Three-transistor equivalent of scr applies power to d-c load when triggered by either positive or negative pulse. Circuit draws negligible standby current. Article gives equation for determining time load current is cut off.—D. Bron, Three-Transistor Circuit Functions as a One-Shot SCR, *Electronic Design*, March 1, 1970, p 81—83.


+10V
+20V
R5 16 Ω
R3 16 Ω
TR2
C1 330pF
TR1
C2 0·16μF
D1
R1 39 kΩ
R2 390 Ω
R4 16 Ω
R6 60 Ω
-20V

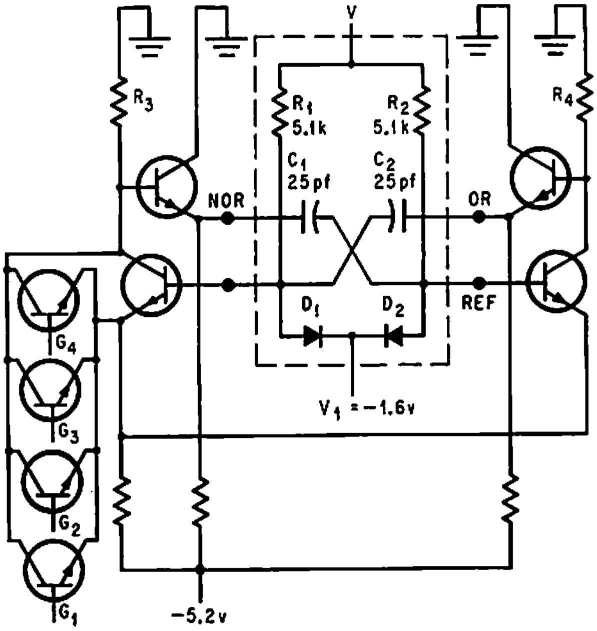
EMITTER-COUPLED MONO—Delivers 500-mA output pulse having duration of 1.25 μs. Transistors are BFY50, and diode is AAZ12.—Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


470
+3V DC
R3
C1 4700 pf
R1 10K
R1 10K
1
2
3
4
5
6
7
8
INTEGRATED FLIP FLOP
C1

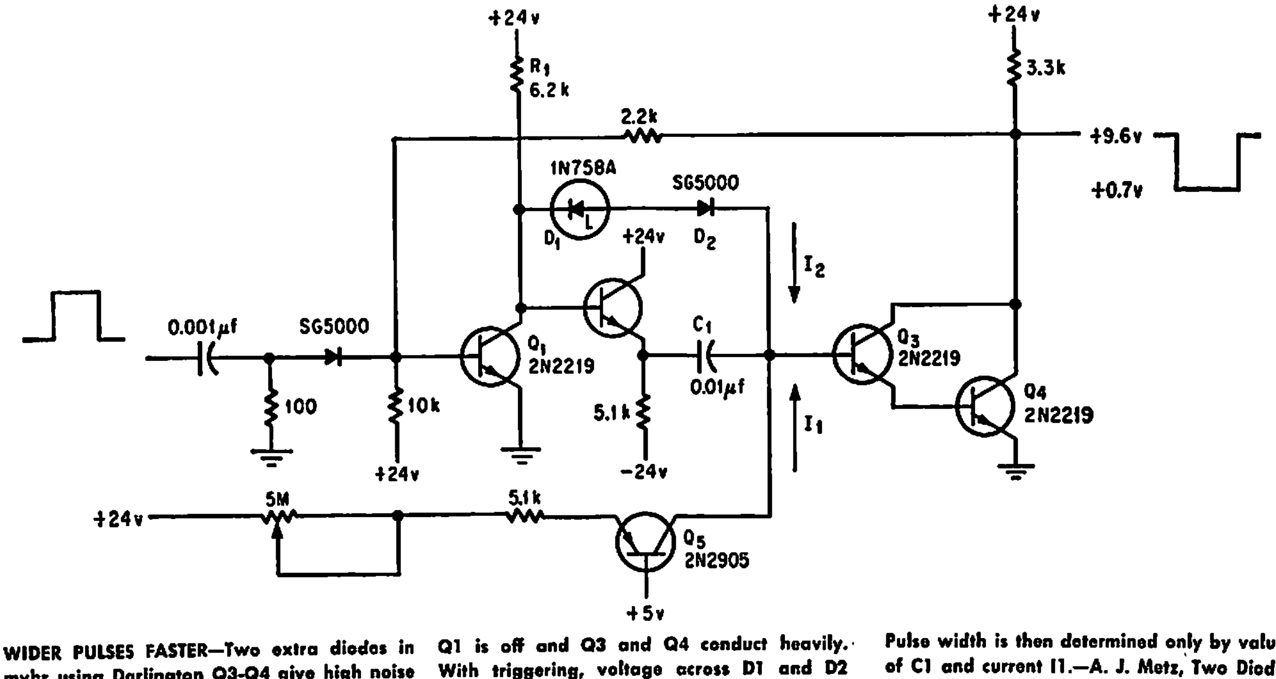
FREE-RUNNING IC FLIP-FLOP—Only five external components are needed to convert standard Fairchild or Amelco IC flip-flop to astable or free-running mvbr. R3 makes circuit self-starting. Article gives frequency equation.—G. Demjanenko, External Connection Converts Integrated Flip-Flop To Monostable, *Electronic Design*, Aug. 17, 1964, p 198—200.


-6V
R3 3K
R4 360
R5 360
Q̄
Q
C2
R6 1K
C3
Q1
Q2
C4
0.1μfd (CERAMIC)
CR3
L
OV
(HIGH CONDUCTANCE GERMANIUM)
C5
R8
1.5K
Q3
R14 82
R13 6.2K
R7 10K
C6
R11 1.5K
Q4
R9 3.9K
R10 820
R12 2.2K
CR2
(SILICON DIODE)
+6V

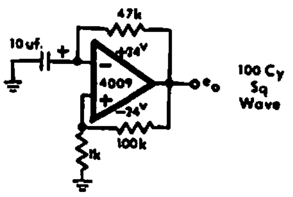
BACKWARD MONO—Changing capacitively coupled input of conventional monostable mvbr to direct coupling permits selecting one pulse from series of pulses, providing signal whenever pulse is missing from pulse train, and indicating null in servo system. Article describes each application in detail, with waveforms. Cost of parts is only a few dollars, even for 0.1-μs rise and fall times.—R. A. Karlin, The Backward Monostable: A Time-Delay Switch, *Electronic Design*, Jan. 4, 1965, p 58–61.


V
R3
R1 5.1k
R2 5.1k
R4
C1 25pf
C2 25pf
NOR
OR
REF
D1
D2
V1 = -1.6v
G4
G3
G2
G1
-5.2v

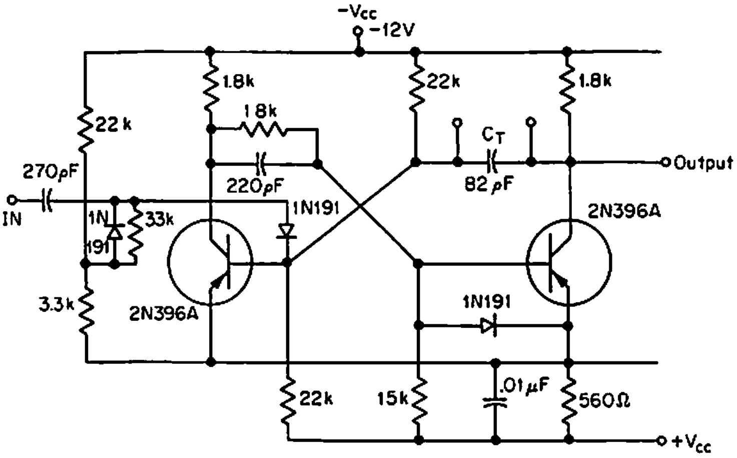
MULTI-INPUT ASTABLE IC—Components outside dashed box are on Motorola MC301 IC having emitter-coupled logic. Connection shown gives gated astable mvbr in which frequency is determined by values of components and supply voltage V. Oscillations stop when any one of the four input levels is high. Features include fast operation, externally controlled repetition rate, and multi-input start-stop control of operation.—A. Tojo, High Speed Multivibrator Controlled By Single ECL, *Electronics*, Sept. 18, 1967, p 109–110.


+24v
R1 6.2 k
2.2k
+24v
3.3k
+9.6v
+0.7v
1N758A
D1
SG5000
D2
+24v
I2
0.001μf
SG5000
Q1 2N2219
C1
0.01μf
Q3 2N2219
Q4 2N2219
100
10k
+24v
5.1k
-24v
I1
+24v
5M
5.1k
Q5 2N2905
+5v

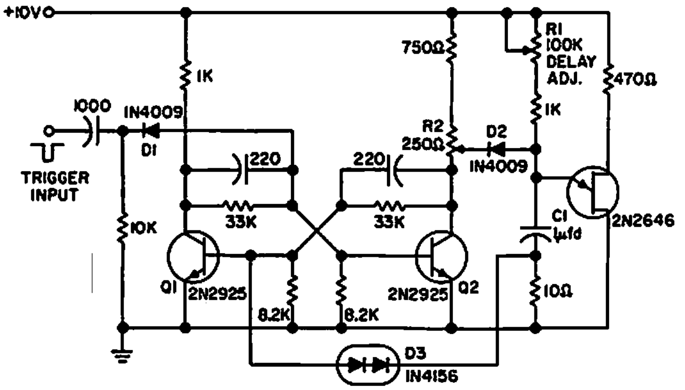
WIDER PULSES FASTER—Two extra diodes in mvbr using Darlington Q3-Q4 give high noise immunity and fast recovery time without limiting width of output pulse. In stable state, Q1 is off and Q3 and Q4 conduct heavily. With triggering, voltage across D1 and D2 falls below zener voltage and high resistance of D1 has effect of opening this diode path. Pulse width is then determined only by values of C1 and current I1.—A. J. Metz, Two Diodes Remove Pulse-Width Limitation, *Electronics*, June 12, 1967, p 105.


47k
10uf
+
+24V
4009
-24V
100k
1k
100 Cy
Sq
Wave

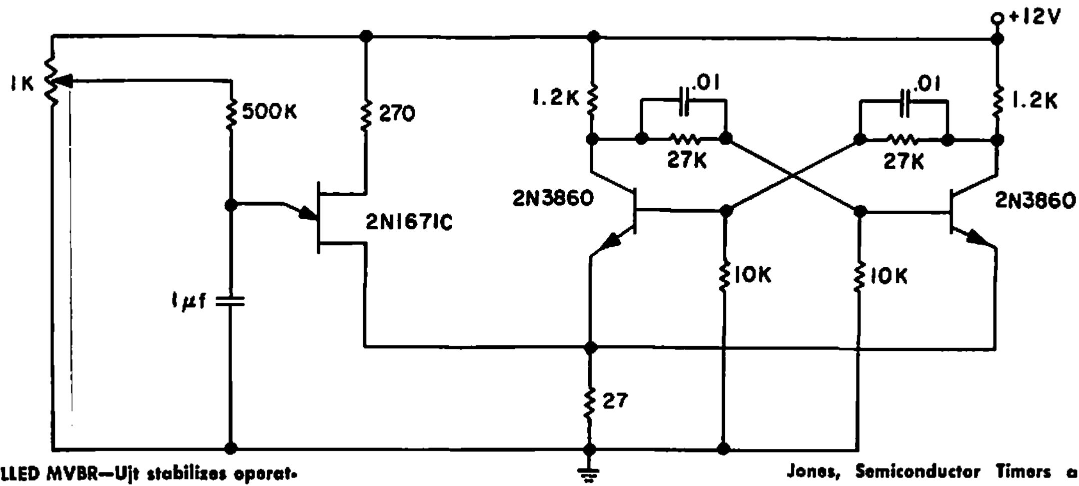
100-HZ SQUARE-WAVE OPAMP—Uses Model 4009 d-c opamp with only four external components. Positive feedback loop sets trigger threshold level of opamp, while R-C time constant in negative feedback loop sets charging time constant. Varying negative feedback resistor gives wide range of frequencies.—B. J. Losmandy, Operational Amplifier Applications for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.


-Vcc
-12V
1.8k
22k
1.8k
1.8k
22k
270pF
IN
220pF
CT
82pF
Output
1N191
1N 191
33k
2N396A
2N396A
1N191
3.3k
22k
15k
.01μF
560Ω
+Vcc

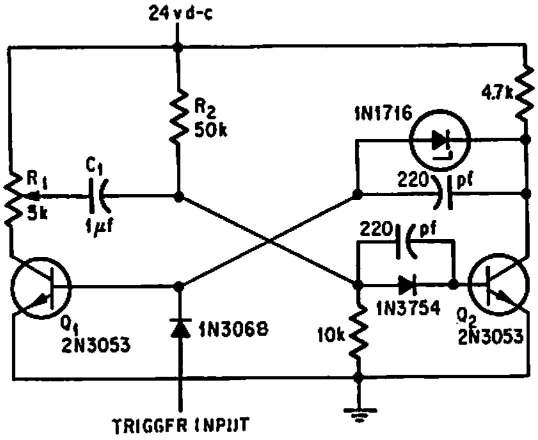
COMMERCIAL MONO—Input pulse of correct polarity and amplitude will make OFF transistor turn on and remain in this unstable state for period of time determined largely by value of CT. Circuit was developed by General Electric Co.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 220.


+10V
1K
750Ω
R1
100K
DELAY
ADJ.
470Ω
1K
1000
IN4009
D1
TRIGGER
INPUT
220
220
R2
250Ω
D2
IN4009
33K
33K
10K
C1
1μfd
2N2646
Q1
2N2925
8.2K
8.2K
2N2925
Q2
10Ω
D3
IN4156

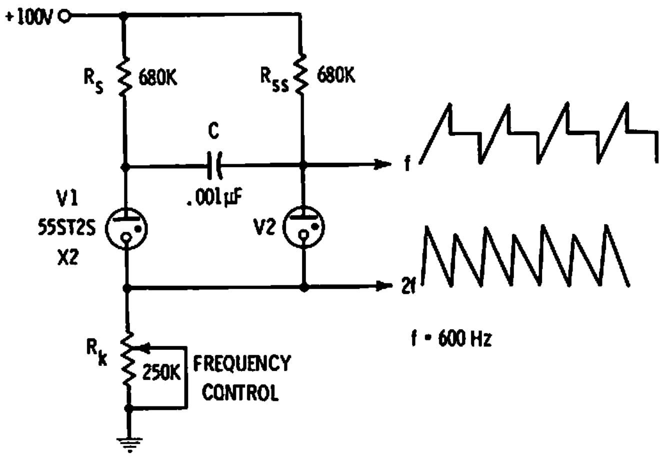
FAST-RECOVERY ONE-SHOT—Provides extremely wide range of duty cycles, good timing stability, and clean waveforms while using only low-cost components. Circuit can be retriggered immediately after completing timing cycle, without loss of timing accuracy.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 5.


+12V
1K
500K
270
1.2K
.01
.01
1.2K
27K
27K
2N3860
2N3860
2N1671C
1μf
10K
10K
27

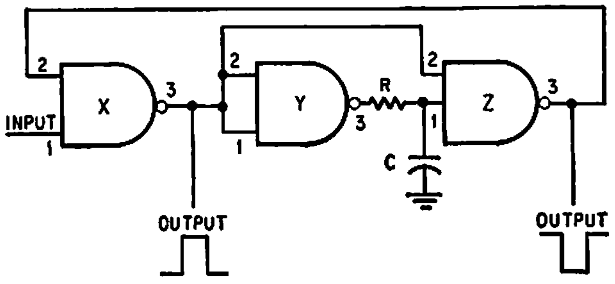
UJT-CONTROLLED MVBR—Ujt stabilizes operating frequency, making mvbr produce good 1-Hz square waves despite changes in supply voltage and ambient temperature.—D. V. Jones, Semiconductor Timers and Low Frequency Oscillators, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 16.


24 vd-c
R2
50k
1N1716
4.7k
C1
R1
3k
1μf
220 pf
220 pf
Q1
2N3053
1N3068
1N3754
10k
Q2
2N3053
TRIGGER INPUT

WIDER PULSES—By adjusting capacitor charging voltage as well as RC time constant in monostable mvbr, range of variation in output pulse width can be greater than 1,000:1. R1 adjusts charging voltage and R2 adjusts time constant.—P. Schiff, Voltage Adjustment Extends Multivibrator's Pulse Width, *Electronics*, Sept. 30, 1968, p 82–83.

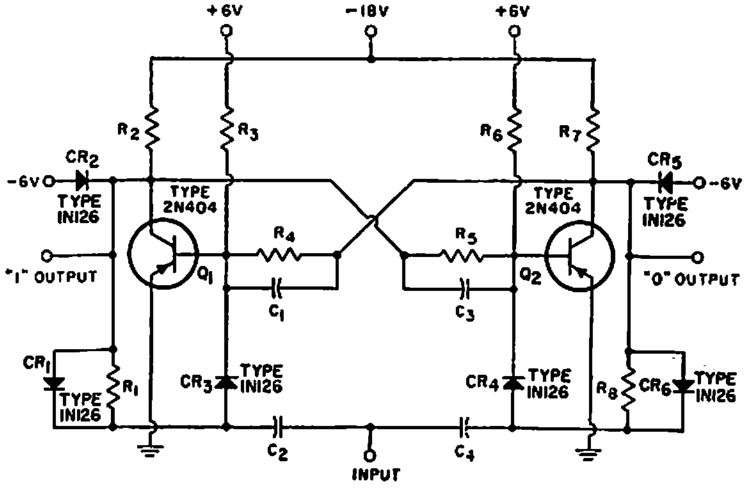

+100V
RS 680K
RSS 680K
C
.001μF
V1
5SST2S
X2
V2
f
2f
f = 600 Hz
Rk
250K
FREQUENCY CONTROL

CATHODE-COUPLED ASTABLE NEON—600-Hz fundamental frequency is available, as well as alternate waveform at 1,200 Hz. Amplitudes of high-frequency signal are equal only on alternate cycles.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 46.


2
X
3
INPUT
1
2
Y
3
1
R
2
Z
3
1
C
OUTPUT
OUTPUT

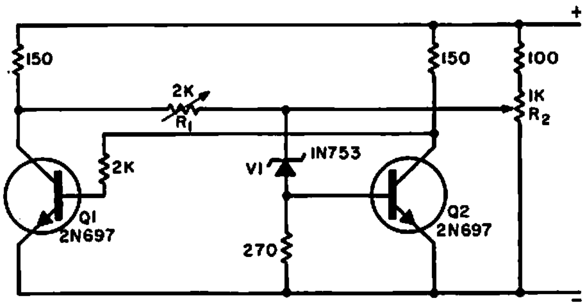
X,Y and Z are 3 of the
4 gates of a Sylvania SG223

CONSTANT PULSE WIDTH—Combining three NAND gates as shown gives fast monostable mvbr in which width of output pulse is independent of supply voltage and input pulse width. With 4 V for 1 level and less than 0.45 V for 0 level, period of monostable is 1.4 RC. To avoid gate overload, R should be below 220 ohms.—P. Sandland, Integrated Gates Form Fast Monostable Multivibrator, *Electronics*, June 26, 1967, p 108–109.

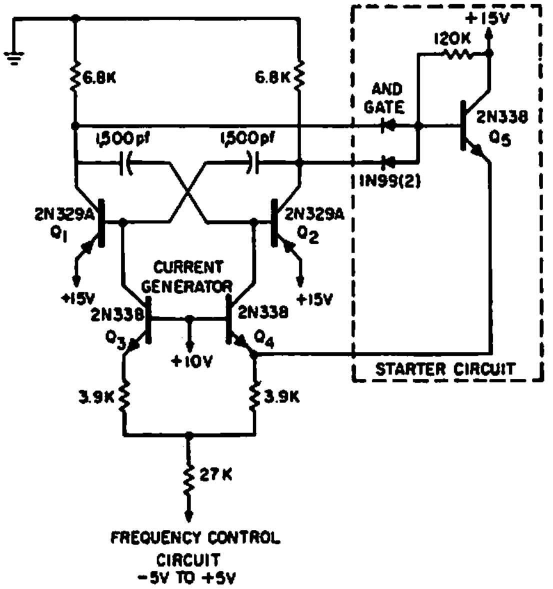

+6V
−18V
+6V
R2
R3
R6
R7
CR2
−6V
TYPE 1N126
TYPE 2N404
R4
R5
TYPE 2N404
CR5
−6V
TYPE 1N126
"1" OUTPUT
Q1
C1
C3
Q2
"0" OUTPUT
CR1
TYPE 1N126
R1
CR3
TYPE 1N126
CR4
TYPE 1N126
R8
CR6
TYPE 1N126
C2
INPUT
C4

1-MHZ BISTABLE—Can be used for generating binary outputs for computer applications, or as electronic switch. Circuit is in stable state when either transistor is conducting and other transistor is cut off. States are switched each time positive trigger pulse is applied to input terminal at bottom center. Output, which may be taken from either stage, or both, is unit step voltage for single trigger and square wave for continuous periodic triggering of input. Frequency division of 2:1 is thereby obtained. Values: R1, R8 5.1K; R2, R7 1.2K; R3, R6 11K; R4, R5 2.7K; C1, C3 180 pF; C2, C4 430 pF.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 534.

SWITCHING BY SUPPLY VOLTAGE CHANGE—Insertion of zener in one coupling arm of bistable mvbr gives switching simply by changing d-c supply voltage. Can be used in overvoltage alarms, trigger circuits, and protective circuits.—A. R. Hayes, Multivibrator Switches With Supply Voltage Change, *Electronic Design*, April 13, 1964, p 74–75.

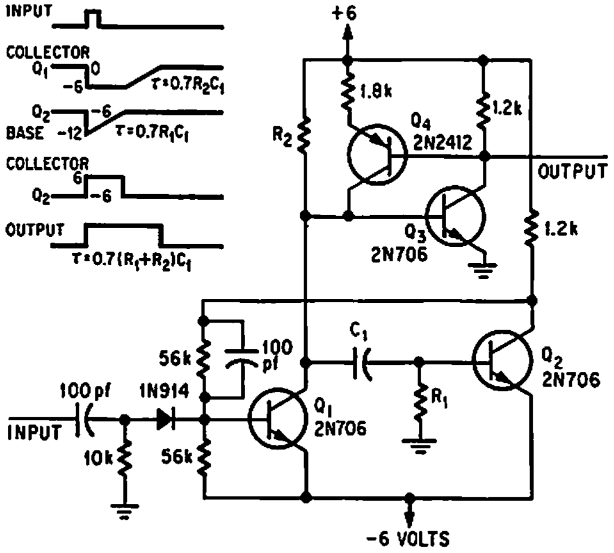


+
150
150
100
2K
R1
1K
R2
2K
V1
1N753
Q1
2N697
Q2
2N697
270
−



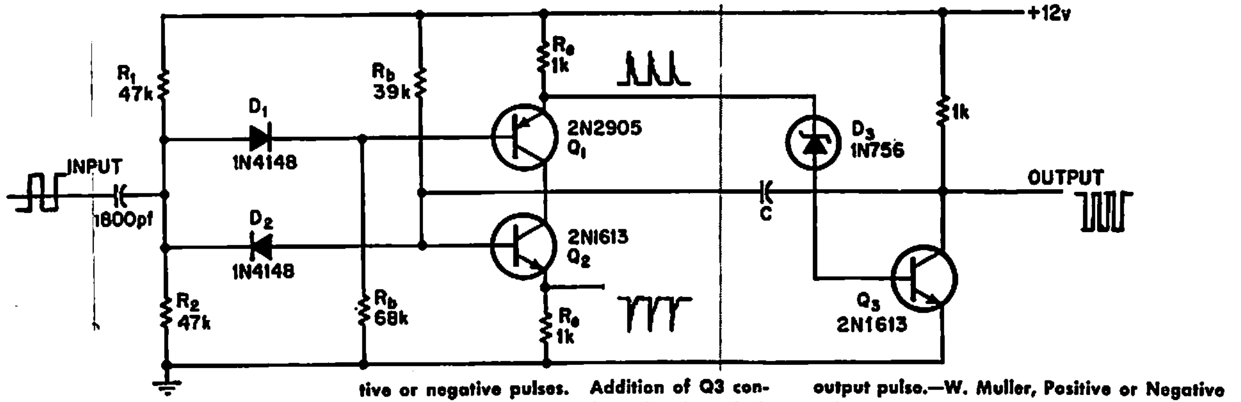
+15V
120K
6.8K
6.8K
AND GATE
2N338
Q5
1500pf
1500pf
1N99(2)
2N329A
Q1
2N329A
Q2
CURRENT GENERATOR
+15V
+15V
2N338
2N338
Q3
Q4
+10V
STARTER CIRCUIT
3.9K
3.9K
27K
FREQUENCY CONTROL CIRCUIT
-5V TO +5V

GATE PREVENTS TURN-ON STALL—Use of AND-gate starter (dashed rectangle) with symmetrical free-running mvbr provides protection from stalling at turn-on, without interfering with normal balanced operation.—M. T. Pett, Starter Circuit Prevents Stall of Free-Running Multi, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 63.



INPUT
COLLECTOR
Q1
0
-6
τ=0.7R2C1
Q2
BASE
-6
-12
τ=0.7R1C1
COLLECTOR
Q2
6
-6
OUTPUT
τ=0.7(R1+R2)C1
+6
1.8k
1.2k
R2
Q4
2N2412
OUTPUT
Q3
2N706
1.2k
C1
56k
100 pf
Q2
2N706
100pf
1N914
R1
INPUT
Q1
2N706
10k
56k
-6 VOLTS

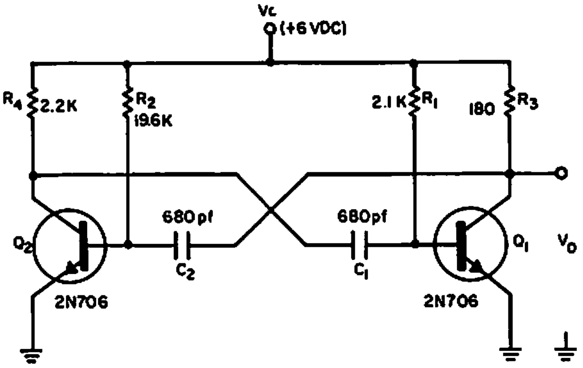
IMMEDIATE RETRIGGERING—Modification of single-shot mvbr gives timing capacitor C1 extra job of setting up circuit to receive next trigger pulse instantly, by reducing recovery time of circuit to zero. Duty cycle thus becomes essentially 100%. Values of R1, R2, and C1 are selected to give desired output pulse width.—J. L. Shagena and A. Mall, Single-Shot Multivibrator Has Zero Recovery Time, *Electronics*, Nov. 27, 1967, p 83.

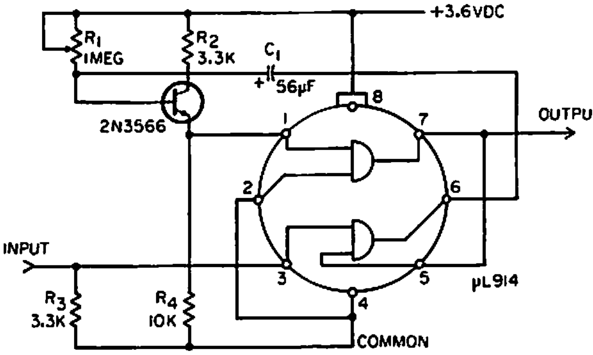


+12v
R1
47k
Rb
39k
Re
1k
D1
1N4148
2N2905
Q1
D3
1N756
1k
INPUT
1800pf
C
OUTPUT
D2
1N4148
2N1613
Q2
R2
47k
Rb
68k
Re
1k
Q3
2N1613

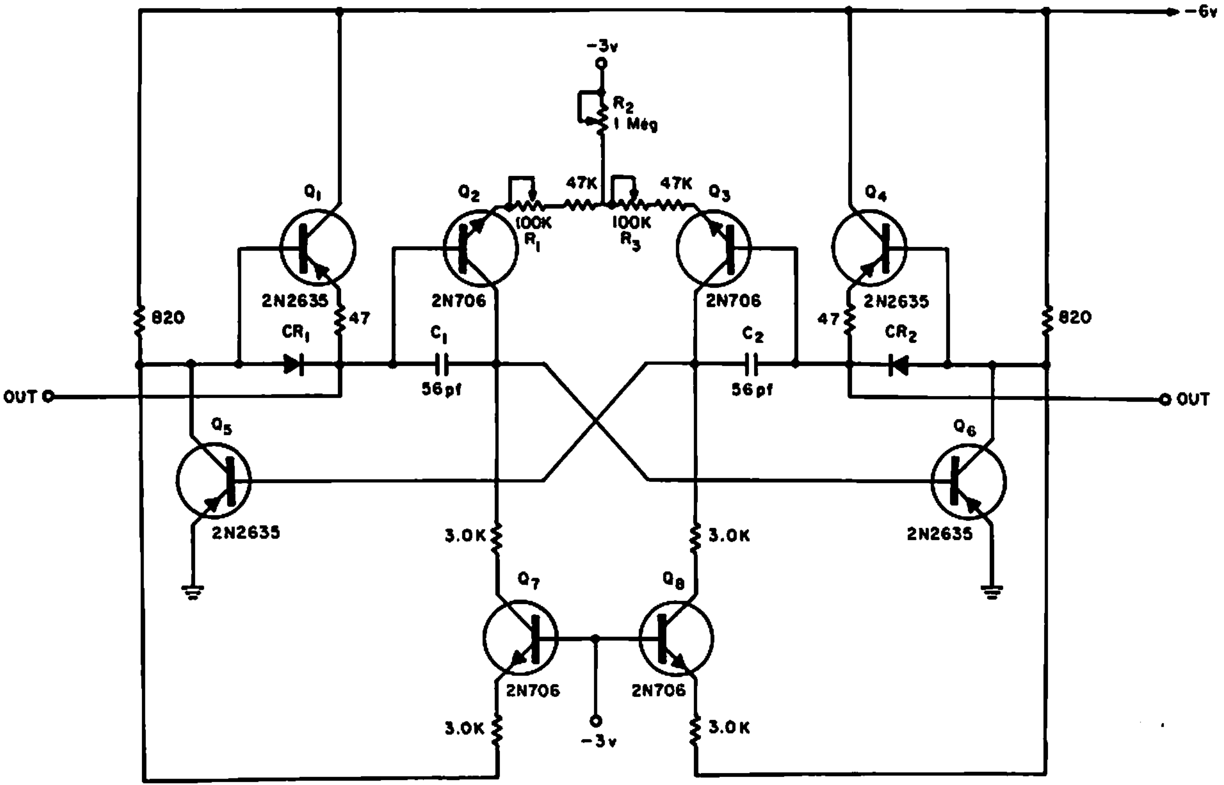
BIPOLAR ONE-SHOT—Use of complementary transistors permits triggering by either positive or negative pulses. Addition of Q3 converts circuit to monostable mvbr, for which single rectangular input pulse gives double output pulse.—W. Muller, Positive or Negative Pulses Trigger One-Shot Multivibrator, *Electronics*, Aug. 18, 1969, p.94.

OPTIMUM ASTABLE DESIGN WITH GRAPHS—Article contains design equations, graphs, and step-by-step procedure for optimizing ten design criteria for generating square-wave or unsymmetrical pulses with fastest possible rise time. Circuit shown is worked out as example, for 100-kHz pulses with width of 1 μs.—C. W. Davis, Plotting Produces Total Astable Design, *Electronic Design*, Sept. 13, 1965, p 60–63.


Vc
(+6 VDC)
R4 2.2K
R2 19.6K
2.1 K R1
180 R3
680 pf
C2
680 pf
C1
Q2
2N706
Q1
2N706
Vo


+3.6VDC
R1 1MEG
R2 3.3K
C1
56μF
2N3566
8
1
7
OUTPUT
2
6
INPUT
3
5
4
μL914
R3 3.3K
R4 10K
COMMON

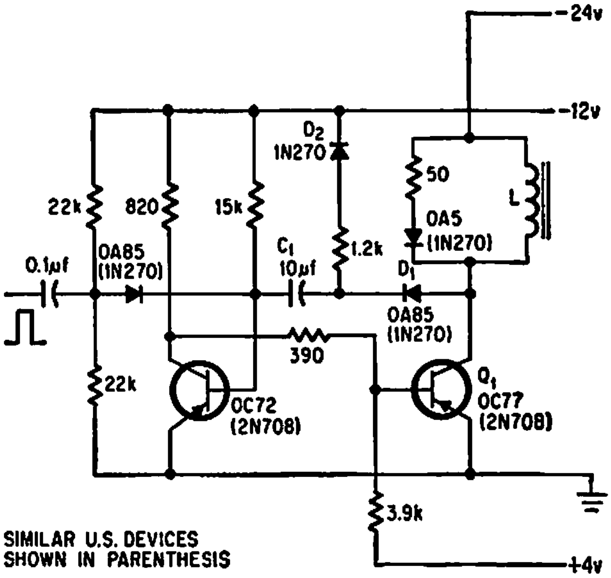
75-S ONE-SHOT FOR $3.50—Long-duration one-shot uses low-cost components, including dual-gate IC. Operates on supply as low as 2.6 V d-c. Input and output levels are compatible with standard micrologic.—R. W. Walton, Long-Duration One-Shot Uses Integrated Circuit, *EEE*, Oct. 1966, p 140.


-6v
-3v
R2
1 Meg
Q1
Q2
47K
47K
Q3
Q4
100K
R1
100K
R3
2N2635
2N706
2N706
2N2635
820
CR1
47
C1
47
C2
CR2
820
56pf
56pf
OUT
OUT
Q5
Q6
2N2635
2N2635
3.0K
3.0K
Q7
Q8
2N706
2N706
3.0K
3.0K
-3v

EIGHT TRANSISTORS GIVE WIDE RANGE—Additional transistors prevent locking of conventional mvbr into stable state, to give frequency range from 8 kHz to 3 MHz. Article tells how circuit works.—A. Marosi, Wide-Range Multivibrator Varies Frequency from 8 Kc to 3 Mc, *Electronic Design*, April 12, 1965, p 50.

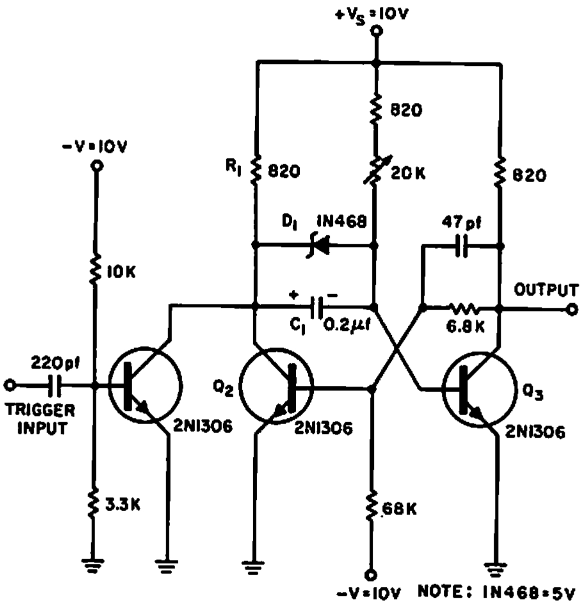
NOTE:

DIODES ARE IN662

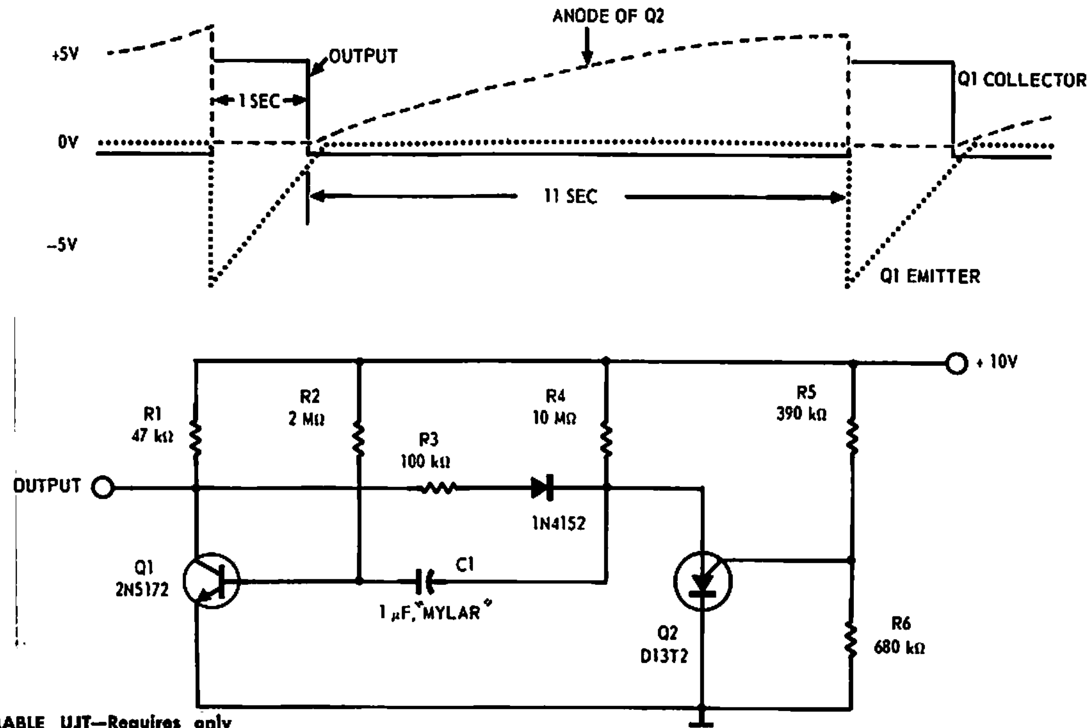

-24v
-12v
D2
1N270
50
OA5
(1N270)
L
22k
820
15k
C1
10μf
1.2k
D1
0.1μf
OA85
(1N270)
OA85
(1N270)
390
22k
OC72
(2N708)
Q1
OC77
(2N708)
3.9k
+4v

SIMILAR U.S. DEVICES SHOWN IN PARENTHESIS

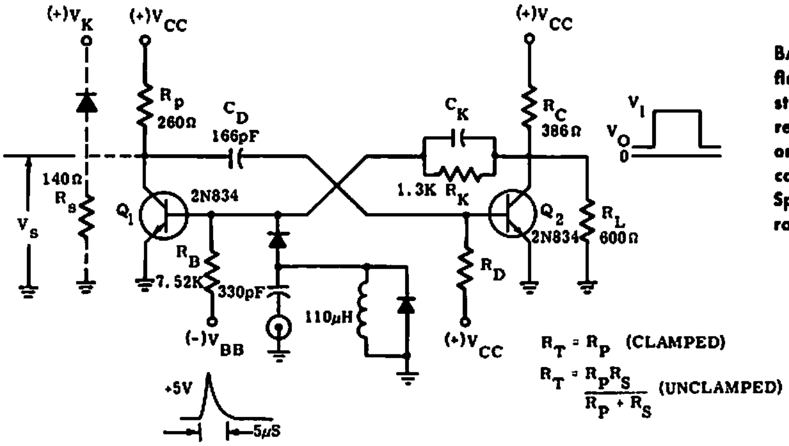
DIODES BLOCK STRAY PULSES—Arrangement prevents relay or other inductive load from affecting stability of mbvr, and at same time provides immunity to pulses coming from common power supply.—R. Ilic, Diodes Provide Noise Immunity for Monostable Multivibrators, *Electronics*, Jan. 9, 1967, p 106–107.


+VS=10V
820
-V=10V
R1
820
20K
820
D1 1N468
47pf
10K
C1 0.2μf
OUTPUT
6.8K
220pf
TRIGGER INPUT
Q2
Q3
2N1306
2N1306
2N1306
3.3K
68K
-V=10V
NOTE: 1N468=5V

ZENER STABILIZES DELAY—Use of zener D1 across timing capacitor makes time delay independent of whether mono mvbr is triggered by random pulse pattern or by first pulse in burst of uniformly spaced pulses. Article tells how zener changes time delay equation.—G. Carsner, Zener Diode Stabilizes Monostable Delay Time, *Electronic Design*, Dec. 21, 1964, p 59–60.

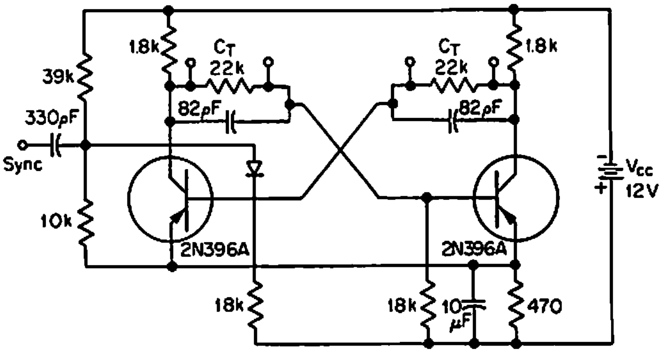

ANODE OF Q2
+5V
OUTPUT
1 SEC
Q1 COLLECTOR
0V
11 SEC
-5V
Q1 EMITTER
+10V
R1
47 kΩ
R2
2 MΩ
R3
100 kΩ
R4
10 MΩ
R5
390 kΩ
OUTPUT
1N4152
Q1
2N5172
C1
1 μF, MYLAR
Q2
D13T2
R6
680 kΩ

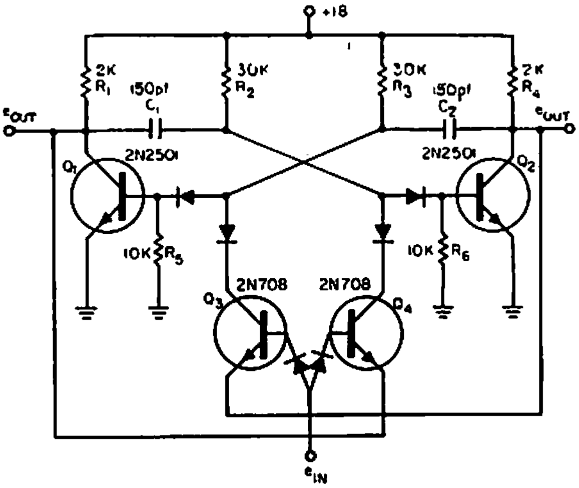
0.1-HZ PROGRAMMABLE UJT—Requires only one large and expensive film capacitor for operation well below 1 Hz. Changing value of C1 changes duration of OFF period. Load must be at least 50K.—R. Muth, Eliminate a Capacitor in Low-Frequency Multivibrators, *EDN*, Dec. 1, 1969, p 61–62.


(+)V_K
(+)V_CC
R_P
260Ω
C_D
166pF
C_K
(+)V_CC
R_C
386Ω
V_I
V_O
0
140Ω
R_S
V_S
Q_1
2N834
1.3K R_K
Q_2
2N834
R_L
600Ω
R_B
7.52K
330pF
110μH
R_D
(-)V_BB
(+)V_CC
+5V
5μS
R_T = R_P (CLAMPED)
R_T = R_P R_S / (R_P + R_S) (UNCLAMPED)

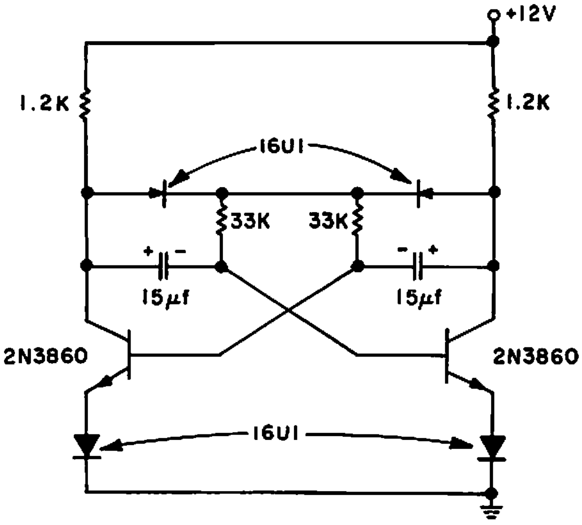
BASIC MONO—Also called one-shot or delay flop. Has one stable state, and one quasi-stable state into which it must be triggered, returning to stable state after given relaxation or delay time. Book gives procedure for calculating values of components.—"High-Speed Switching Transistor Handbook," Motorola, Phoenix, Ariz., 1969, p 235.

VOLTAGE-DIVIDER ASTABLE—Uses voltage divider in bias network. Frequency of operation is approximately equal to 1,000,000 divided by (0.025C + 2.5), where C is value of cross-coupling capacitor in pF, or about 375 kHz for values shown.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 213.

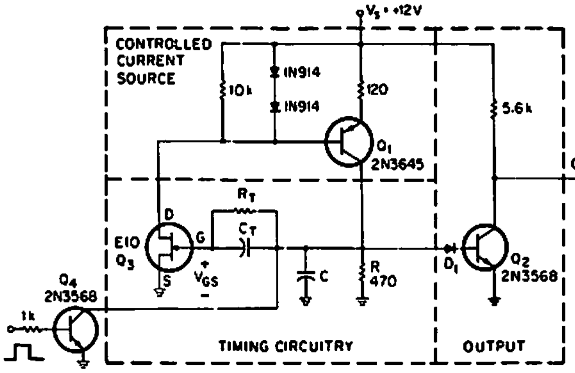

1.8k
C_T
22k
C_T
22k
1.8k
39k
82pF
82pF
330pF
Sync
Vcc
12V
10k
2N396A
2N396A
18k
18k
10 μF
470


+18
2K R_1
150pf C_1
30K R_2
30K R_3
150pf C_2
2K R_4
e_OUT
e_OUT
Q_1
2N2501
2N2501
Q_2
10K R_5
10K R_6
2N708
2N708
Q_3
Q_4
e_IN

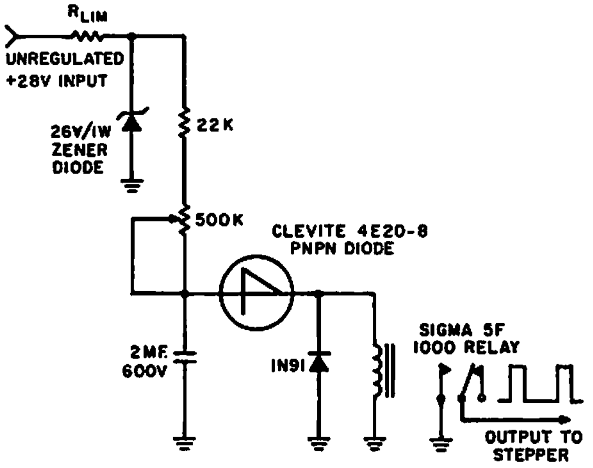
360-KHZ ASTABLE-BISTABLE—Addition of gating transistors Q3-Q4 to feedback paths of basic astable mvbr gives bistable operation. Circuit is free-running up to 360 kHz for fixed input, or changes state in binary fashion when input is pulsed.—T. Saunders, Modified Astable Multivibrator Also Operates in Bistable Mode, *Electronic Design*, Dec. 20, 1965, p 48–49.


+12V
1.2K
1.2K
16U1
33K
33K
+ -
- +
15μf
15μf
2N3860
2N3860
16U1

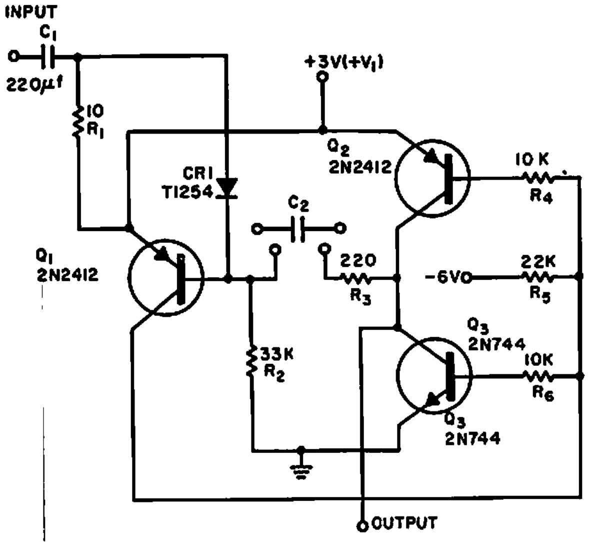
LOW-COST ASTABLE—Provides periods of 0.5 to 1 s. Upper 16U1 dual-diode assures startup by preventing lockup due to saturation of both transistors. Lower dual-diode protects transistors.—D. V. Jones, Semiconductor Timers and Low Frequency Oscillators, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 16.


V_s = +12V
CONTROLLED CURRENT SOURCE
10k
1N914
1N914
120
5.6k
Q_1 2N3645
OUTPUT
R_T
C_T
D
G
S
E10 Q_3
V_{GS}
C
R 470
D_1
Q_2 2N3568
Q_4 2N3568
1k
TIMING CIRCUITRY
OUTPUT

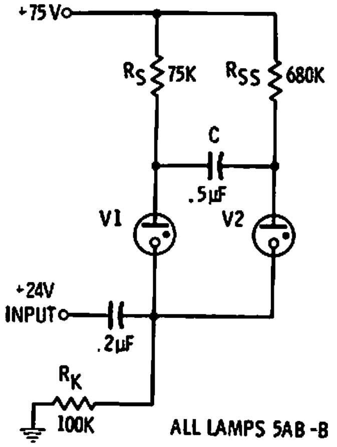
FALSE TRIGGERING—Current source isolates line noise from timing circuitry of one-shot mvbr, to prevent false triggering by line noise when using long time constants. Q1 and capacitor C provide required isolation. RT should be much larger than R, with 10K as minimum; this means that minimum pulse duration is about 50 μs. With 10 meg for RT and 330 μF for CT, time duration is 1 hr.—G. L. Schaffer, Current Source Improves Immunity of One-Shot, *EEE*, March 1969, p 126 and 128.


R_{LIM}
UNREGULATED +28V INPUT
26V/1W ZENER DIODE
22K
500K
CLEVITE 4E20-8 PNPN DIODE
2MF 600V
IN91
SIGMA 5F 1000 RELAY
OUTPUT TO STEPPER

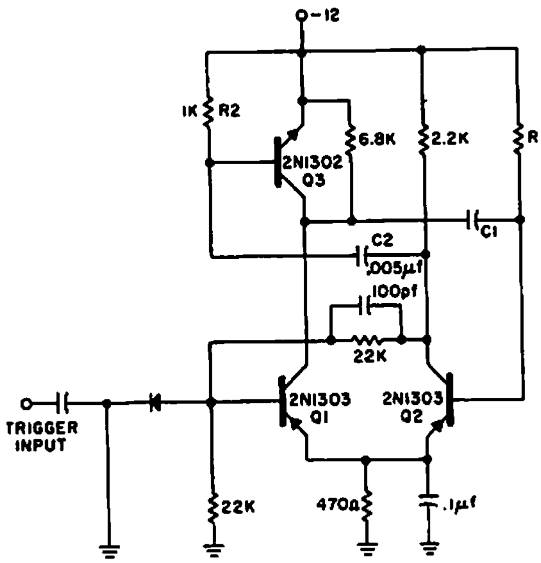
0.5–10 HZ WITH NOISE IMMUNITY—Shockley pnpn diode connected as free-running mvbr is unaffected by radiated noise of relays and other devices. Used to drive stepper relays at rate determined by setting of pot. Zener regulator prevents supply voltage changes from affecting frequency.—M. E. T. Swinnen, Multivibrator Immune to Radiated Noise, *Electronic Design*, Dec. 7, 1964, p 71–73.


INPUT
C_1
220μf
10 R_1
CR1 T1254
+3V(+V_1)
Q_2 2N2412
10 K R_4
C_2
Q_1 2N2412
220 R_3
-6V
22K R_5
33K R_2
Q_3 2N744
10K R_6
Q_3 2N744
OUTPUT

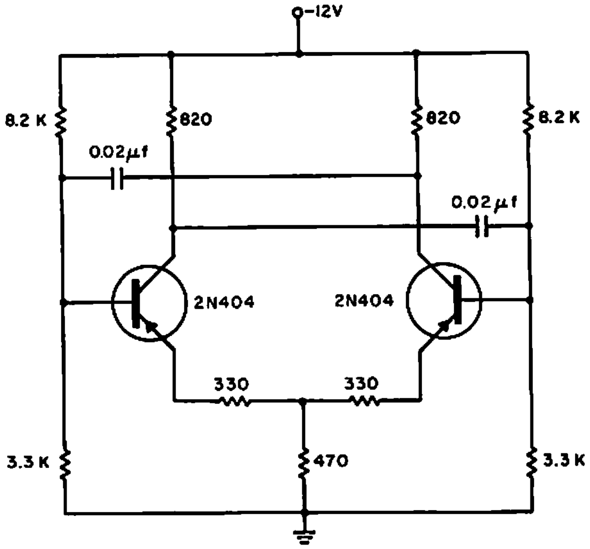
FAST-RECOVERY ONE-SHOT—At rest, Q1 and Q2 are ON, Q2 is OFF, and output is at ground. Positive input pulse changes all transistors, driving output to about 3 V positive. Value of coupling capacitor C2, acting with R2, determines holding time before circuit returns to original state. For 0.01 μF, output pulse is about 280 μs. Pulse width remains constant for duty cycles well above 90%.—D. Colin, Monostable Configuration Provides Unusually Fast Recovery Time, *Electronic Design*, Aug. 3, 1964, p 43.


+75V
R_S 75K
R_{SS} 680K
C
.5μF
V1
V2
+24V INPUT
.2μF
R_K
100K
ALL LAMPS 5AB-B

MONOSTABLE NEON—V1 is normally on but is extinguished by 24-V input pulse which permits V2 to ignite. However, voltage across 100K resistor is not sufficient to keep V1 from firing, so circuit returns to stable state. Time V2 is on depends on time constant of 0.5-μF capacitor and two anode resistors.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 50.

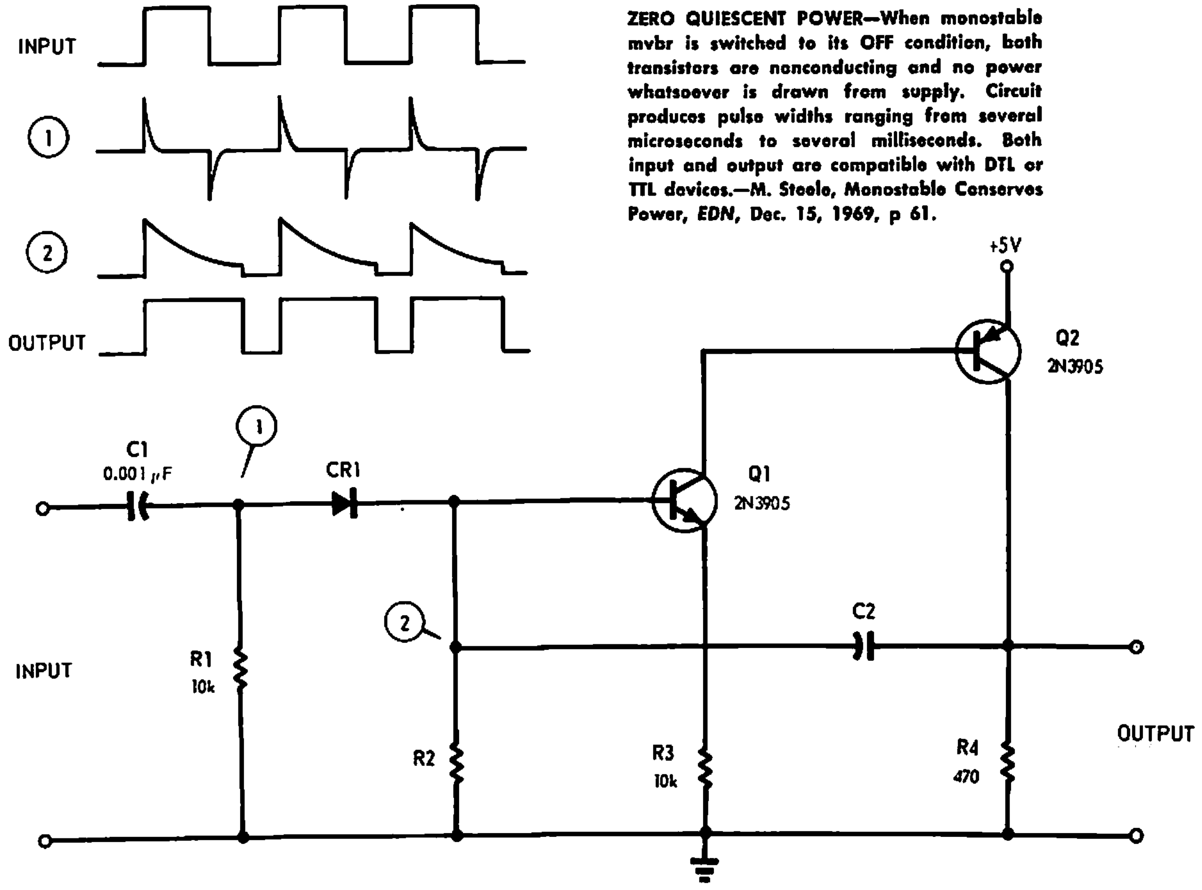

-12
1K
R2
2N1302
Q3
6.8K
2.2K
R1
C1
C2
.005μf
100pf
22K
2N1303
Q1
2N1303
Q2
TRIGGER INPUT
22K
470Ω
.1μf

TRANSISTOR SPEEDS CAPACITOR DISCHARGE—Addition of Q3 to monostable mvbr provides regenerative discharging of timing capacitor at end of pulse period. Circuit has given fall times as short as 0.1 μs on pulse widths of 1 μs to 15 ms.—R. W. Allington, Extra Transistor Reduces Turn-Off Time in One-Shot Multi, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N. Y., 1964, p 69.

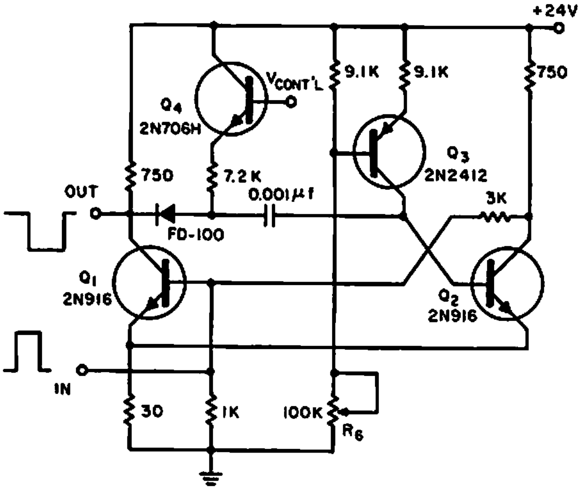

-12V
8.2 K
820
820
8.2 K
0.02μf
0.02μf
2N404
2N404
330
330
3.3 K
470
3.3 K

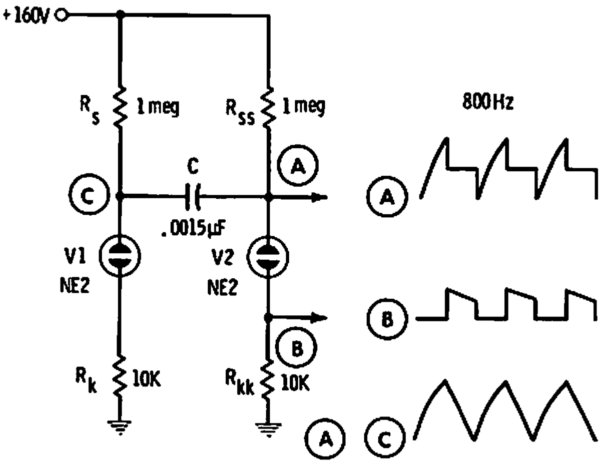
POSITIVE STARTING—Simple modification of standard mvbr, to prevent transistors from saturating, insures oscillation by precluding existence of stable state in which both transistors are on. Values shown give 100-kHz operation over wide temperature range.—N. O. Sokal, Free-Running Multi Has Sure-Fire Starting, *Electronic Design*, Jan. 6, 1964, p 80.

ZERO QUIESCENT POWER—When monostable mvbr is switched to its OFF condition, both transistors are nonconducting and no power whatsoever is drawn from supply. Circuit produces pulse widths ranging from several microseconds to several milliseconds. Both input and output are compatible with DTL or TTL devices.—M. Steele, Monostable Conserves Power, *EDN*, Dec. 15, 1969, p 61.

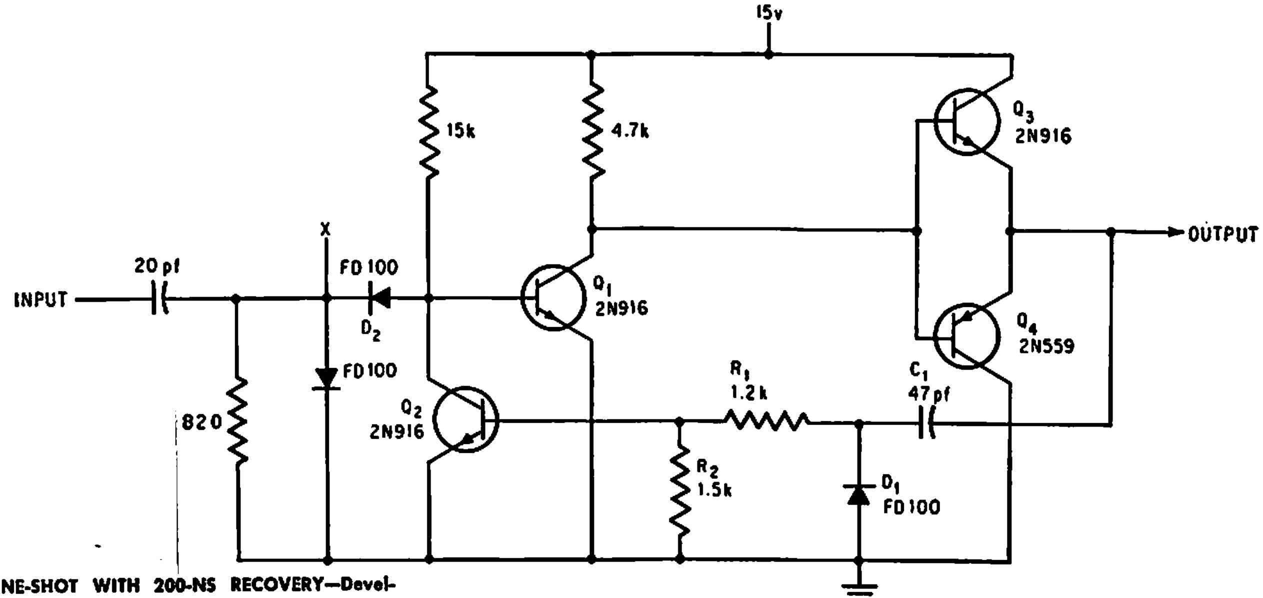

INPUT
①
②
OUTPUT
+5V
Q2
2N3905
C1
0.001 μF
①
CR1
Q1
2N3905
②
C2
INPUT
R1
10k
R2
R3
10k
R4
470
OUTPUT

LINEAR PULSE WIDTH CONTROL—Monostable mvbr provides output pulse whose width varies linearly with respect to control voltage of 0-25 V d-c applied to base of Q4. Article gives equation for period of one-shot. Operation depends on use of emitter-follower constant-current generator. Pulse width range is about 3 to 80 μs.—R. S. Hughes, Pulse Width vs. Control Voltage Made Linear by Generator, *Electronic Design*, Dec. 21, 1964, p 56–58.

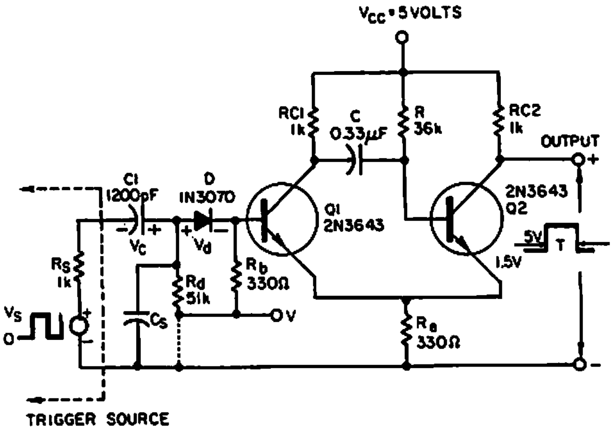

+24V
Q4
2N706H
VCONT'L
9.1K
9.1K
750
750
7.2K
0.001μf
Q3
2N2412
3K
OUT
FD-100
Q1
2N916
Q2
2N916
IN
30
1K
100K
R6


+160V
Rs
1meg
Rss
1meg
800Hz
C
A
C
.0015μF
V1
NE2
V2
NE2
A
B
B
Rk
10K
Rkk
10K
B
A
C

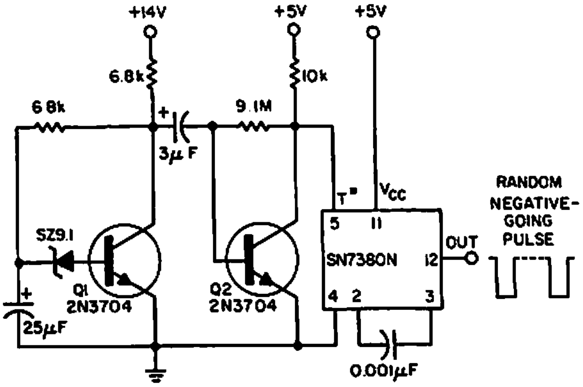
800-HZ ASTABLE NEON—Offers three symmetrical waveshapes by tapping circuit at different points. Square wave at B has 10-μs rise time, and top may be made flat by using diode clipper.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 45.


15v
15k
4.7k
Q3
2N916
OUTPUT
X
20pf
INPUT
FD100
D2
Q1
2N916
FD100
Q2
2N916
820
R1
1.2k
C1
47pf
Q4
2N559
R2
1.5k
D1
FD100

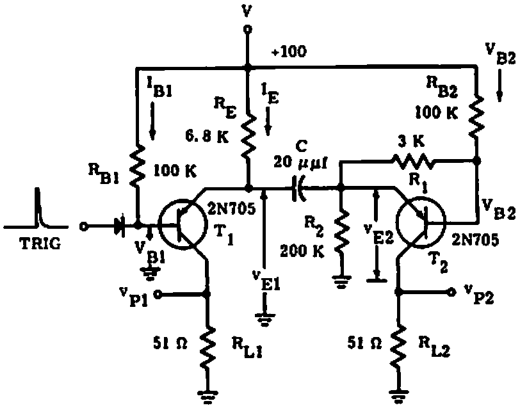
ONE-SHOT WITH 200-NS RECOVERY—Developed for computer and communications applications having very high pulse repetition rate. Has been used as pulse-averaging discriminator in f-m system having 200-kHz deviation of 1-MHz carrier. Input at point X clamps output to positive supply voltage for duration of pulse. Discharging C1 through low-impedance path D1-Q4 gives short recovery time. Pulse width generated is 600 ns.—J. J. Moran and R. M. Gloriosco, Narrow-Pulse One-Shot Recovers Quickly, *Electronics*, Jan. 9, 1967, p 107.


VCC=5VOLTS
RC1 1k
C 0.33μF
R 36k
RC2 1k
OUTPUT
+
C1 1200pF
D IN3070
Q1 2N3643
2N3643 Q2
Vc
Vd
Rs 1k
Rd 51k
Rb 330Ω
Cs
0V
5V
T
1.5V
Re 330Ω
Vs
0
TRIGGER SOURCE
-

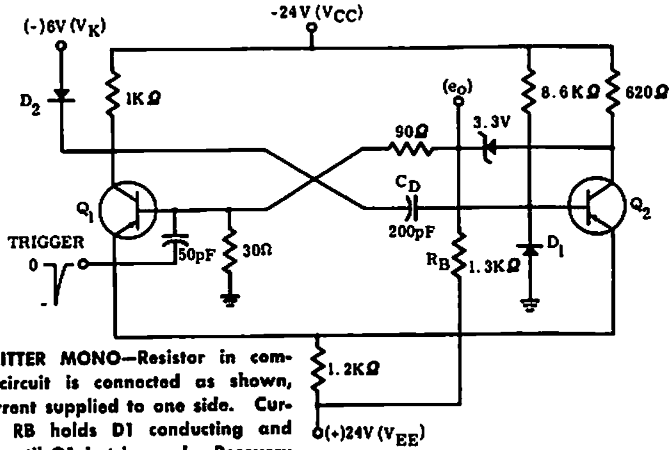
IMPROVED TRIGGERING OF MONO—Shaping of input trigger pulses by differentiating circuit C1-Rd makes performance of emitter-coupled mono more reliable. Will trigger reliably with pulses above 3.9 V for all values of d-c control voltage between 1.1 and 1.8 V, with this controlled range making output pulse duration vary between 1.1 and 8.35 ms. Recovery time is about 1.7 ms.—A. J. Duelm, Wiring Modification Improves Voltage Variable Delay Circuit, *Electronic Design*, Feb. 15, 1970, p 82 and 84.


+14V
+5V
+5V
6.8k
10k
6.8k
9.1M
3μF
T*
VCC
5
11
SN7380N
12
4
2
3
OUT
RANDOM NEGATIVE-GOING PULSE
SZ9.1
Q1 2N3704
Q2 2N3704
25μF
0.001μF

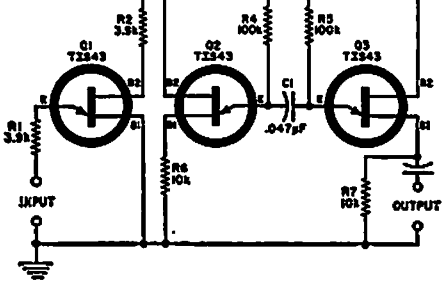
NOISE-TRIGGERED RANDOM PULSES—Provides random pulse spacings ranging from tens of microseconds to milliseconds, for TTL logic-level pulse generator. Uses Schauer SZ9.1 zener with Q1 as broad-spectrum noise generator. Q2 is biased so only higher-level noise spikes drive it to saturation and trigger IC mono mvbr. Varying noise generator supply voltage changes output rate.—R. J. Krusberg, Noise Spikes Trigger Random-Pulse Generator, *Electronic Design*, June 7, 1970, p 102.


V
+100
VB2
IB1
RE
IE
RB2 100 K
6.8 K
C 20 μμf
3 K
R1
RB1
100 K
2N705
T1
R2 200 K
VE2
VB2
2N705
T2
TRIG
VB1
VE1
VP1
VP2
51 Ω
RL1
51 Ω
RL2

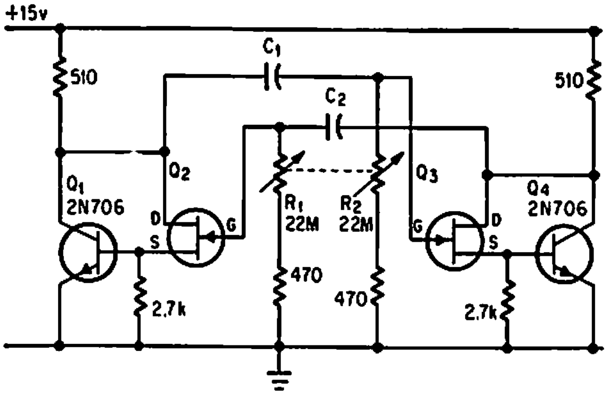
FAST-RISE MONO—Gives essentially square-wave output pulses with rise time of 1 ns, fall time of 2 ns, and duration from 12 ns to several μs. Will produce 12-ns pulses reliably at repetition rate of 20 MHZ.—"High Speed Switching Transistor Handbook," Motorola, Phoenix, Ariz., 1969, p 302.


(-)6V (VK)
-24V (VCC)
D2
1KΩ
(eo)
8.6KΩ
620Ω
90Ω
3.3V
CD
200pF
Q1
Q2
TRIGGER
0
-
50pF
30Ω
RB
1.3KΩ
D1
1.2KΩ
(+)24V (VEE)

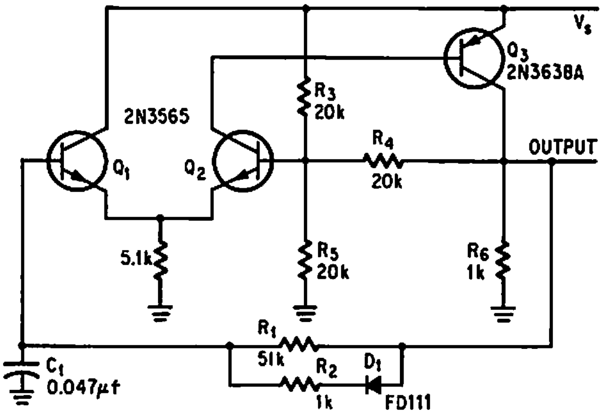
COMMON-EMITTER MONO—Resistor in common-emitter circuit is connected as shown, with base current supplied to one side. Current through RB holds D1 conducting and keeps Q2 on until Q1 is triggered. Recovery of circuit is rapid, permitting duty cycle as high as 80%. Circuit is sensitive to small trigger signals but insensitive to their level, so noise is not a problem.—"High Speed Switching Transistor Handbook," Motorola, Phoenix, Ariz., 1969, p 281.


R3 1k
+9V
R2 3.9k
R4 100k
R5 100k
Q1 T2343
Q2 T2343
Q3 T2343
B2
B2
B2
E
E
E
B1
B1
B1
C1
.047μF
R1 3.9k
R6 10k
R7 10k
INPUT
OUTPUT

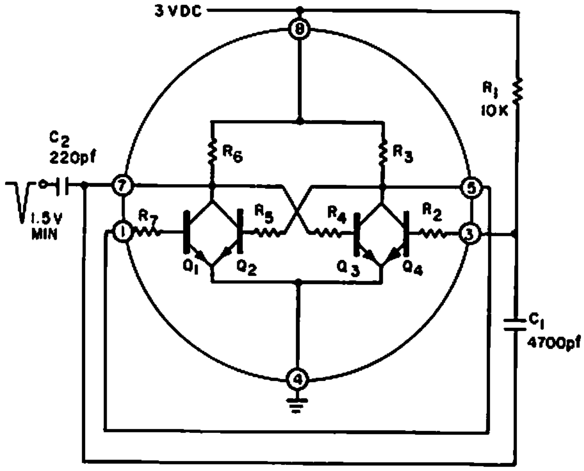
ON AND OFF—Both ujt's of mvbr are normally off. Input ujt Q1 provides rectangular pulse when positive input signal of sufficiently high level arrives, causing Q2 and Q3 to fire in sequence, after which circuit returns to rest. Will handle repetition rates up to 120 pps. Input must be at least 4.5-V positive-going pulse or 3-V rms sine-wave signal.—Ujt Monocycle Multivibrator, *Electronics World*, April 1969, p 61.


+15v
510
C1
C2
510
Q1
2N706
Q2
D
S
G
R1
22M
R2
22M
Q3
G
D
S
Q4
2N706
470
470
2.7k
2.7k

6-MIN PERIOD—Two 2N3436 fet's are connected as source followers, with two npn transistors serving as switches. Action is similar to that of ordinary mvbr and is self-starting. When C1 and C2 are 4 μF, rheostats can vary period over range from 8 ms to 6 min. With 100 pF, frequency range becomes 100 Hz to 3 MHz. Stability is good with long time constants because large electrolytics are not used.—G. Hanus and Y. Martinez, Stable Low Frequencies with FET-Bipolar Pairs, *Electronics*, Jan. 9, 1967, p 105.

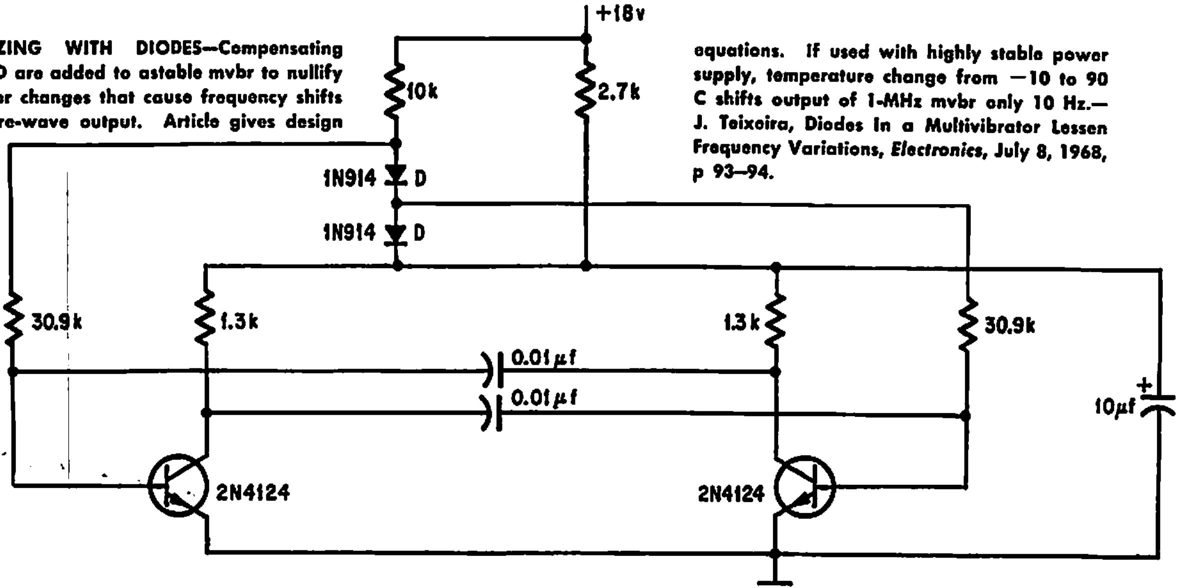

V_s
Q_3
2N3638A
2N3565
R_3
20k
Q_1
Q_2
R_4
20k
OUTPUT
5.1k
R_5
20k
R_6
1k
R_1
51k
R_2
1k
D_1
FD111
C_1
0.047μf

VARIABLE DUTY CYCLE—Switching of diode between two timing networks gives ratio of up to 500 to 1 between on and off times of unsymmetrical free-running mvbr. With values shown, frequency is 600 Hz, rise time 0.3 μs and fall time 4 μs. Article gives design equations. Supply voltage can drop 50% without affecting frequency.—L. Blaser, Waveform Generation Eased By Two Timing Networks, *Electronics*, Sept. 18, 1967, p 110–111.

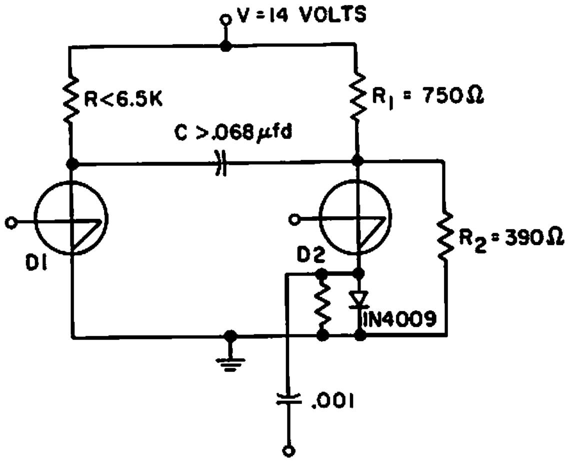

3 VDC
8
R_1
10K
C_2
220pf
1.5V
MIN
R_6
R_3
7
5
R_7
R_5
R_4
R_2
1
3
Q_1
Q_2
Q_3
Q_4
C_1
4700pf
4

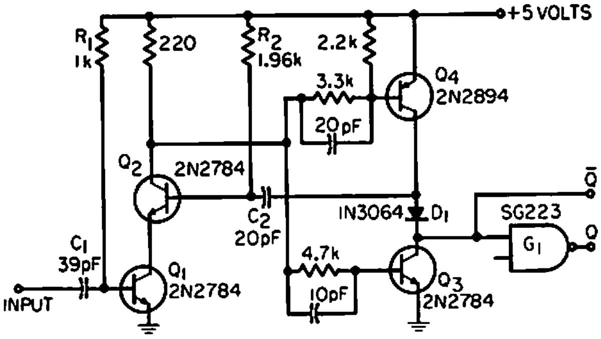
MAKING IC FLIP-FLOP GO MONO—Only two external components are needed to convert standard Fairchild or Amelco IC flip-flop for operation as monostable (one-shot) mvbr. Width of one-shot pulse in seconds is equal to 0.37 R1C1, where R1 is in ohms and C1 in farads. For values shown, width is 18 ms.—G. Demjanenko, External Connection Converts Integrated Flip-Flop To Monostable, *Electronic Design*, Aug. 17, 1964, p 198–200.

STABILIZING WITH DIODES—Compensating diodes D are added to astable mvbr to nullify transistor changes that cause frequency shifts in square-wave output. Article gives design equations. If used with highly stable power supply, temperature change from −10 to 90 C shifts output of 1-MHz mvbr only 10 Hz.—J. Teixeira, Diodes In a Multivibrator Lessen Frequency Variations, *Electronics*, July 8, 1968, p 93–94.


+18v
10k
2.7k
1N914
D
1N914
D
30.9k
1.3k
1.3k
30.9k
0.01μf
0.01μf
10μf
+
2N4124
2N4124

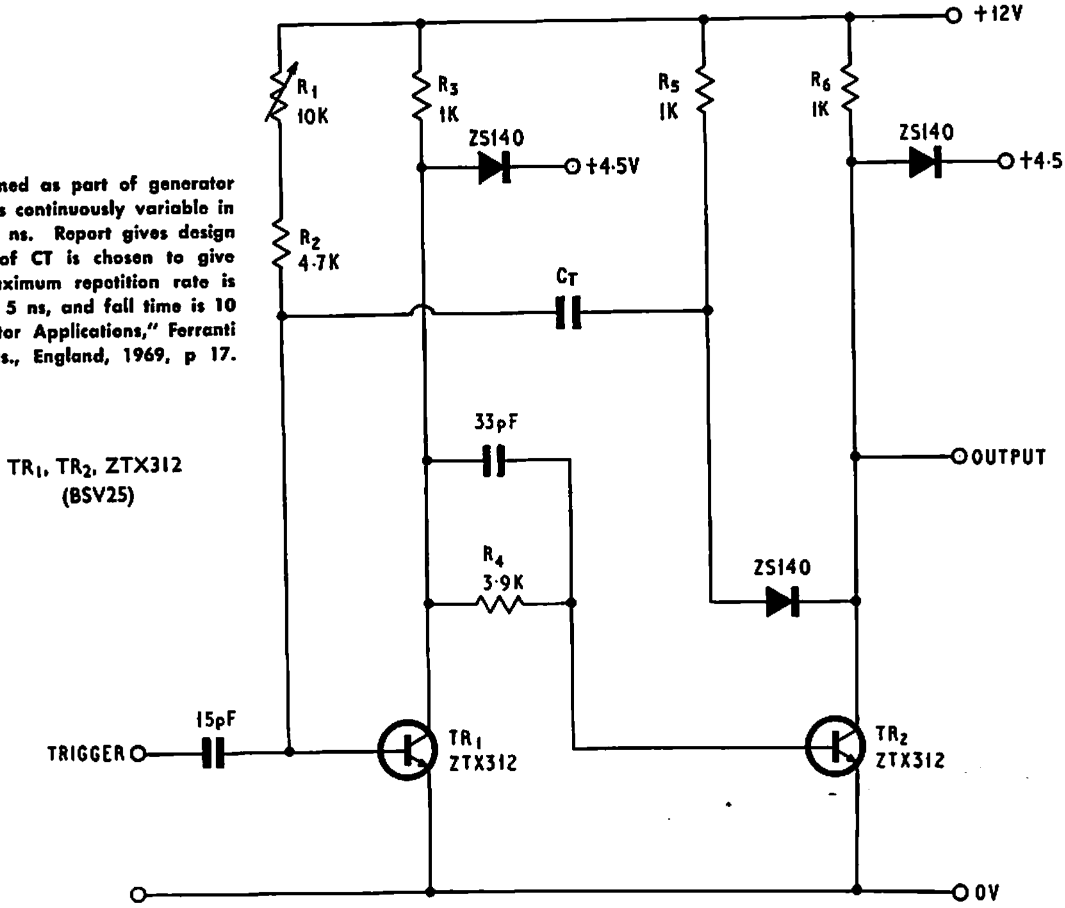
TWO-SUS ONE-SHOT—With silicon unilateral switches, circuit is capable of handling duty cycles above 85%. Requires positive-going switching voltage of 8 V applied to one sus to turn it on. Succeeding positive pulses then have no effect, but first negative-going pulse will turn on other sus and turn off the one that was conducting. After supply voltage is applied, sus having lowest switching voltage will be first to turn on. D1 and D2 are D13P1 sus switches.—W. R. Spofford, Jr., Applications of the New Silicon Bilateral Switch and the Silicon Unilateral Switch, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 4.

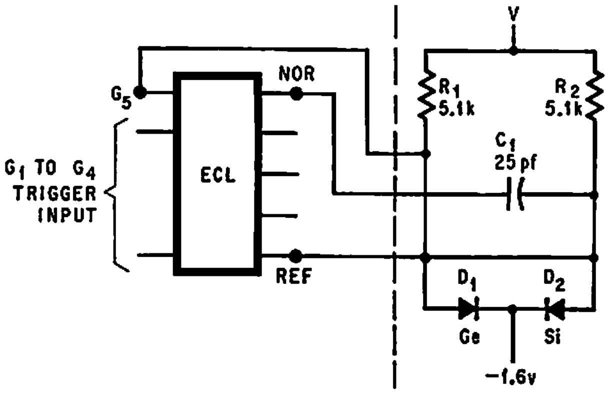

V = 14 VOLTS
R<6.5K
R₁ = 750Ω
C >.068μfd
R₂ = 390Ω
D1
D2
IN4009
.001


+5 VOLTS
R₁ 1k
220
R₂ 1.96k
2.2k
3.3k
20pF
Q4 2N2894
Q₂ 2N2784
C₂ 20pF
IN3064
D₁
SG223
Q̄
Q
G₁
C₁ 39pF
INPUT
Q₁ 2N2784
4.7k
10pF
Q₃ 2N2784

30-NS PULSE WIDTH FROM ONE-SHOT—Improved input trigger circuit permits generation of extremely fast pulses with width independent of trigger duration and amplitude. Requires negative trigger.—D. R. Hoppe, High Speed Saturated-Mode One-Shot, *EEE*, May 1968, p 122–123.

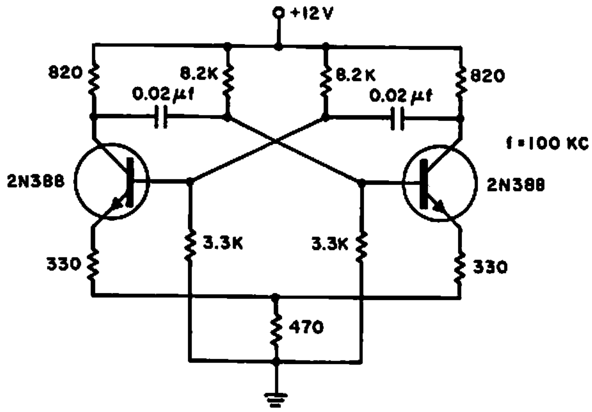
FAST MONO—Designed as part of generator for producing pulses continuously variable in width down to 100 ns. Report gives design procedure. Value of CT is chosen to give desired width. Maximum repetition rate is 5 MHz, rise time is 5 ns, and fall time is 10 ns.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 17.

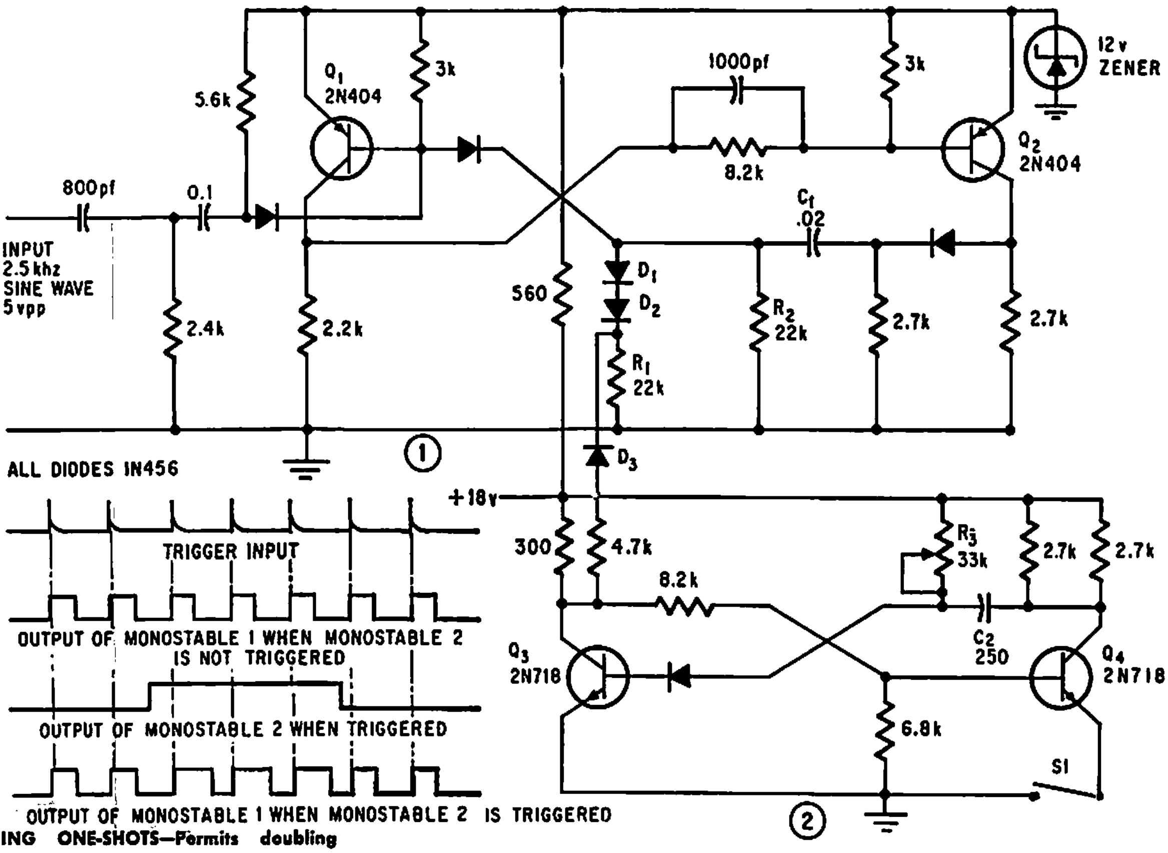

+12V
R₁ 10K
R₃ 1K
R₅ 1K
R₆ 1K
ZS140
+4·5V
ZS140
+4·5V
R₂ 4·7K
CT
33pF
OUTPUT
TR₁, TR₂, ZTX312 (BSV25)
R₄ 3·9K
ZS140
15pF
TRIGGER
TR₁ ZTX312
TR₂ ZTX312
0V


V
NOR
G_5
G_1 TO G_4
TRIGGER
INPUT
ECL
REF
R_1
5.1k
R_2
5.1k
C_1
25 pf
D_1
D_2
Ge
Si
−1.6v

MULTI-INPUT MONO IC—Only five components, at right of dashed line, are needed with Motorola MC301 emitter-coupled logic IC to give monostable mvbr in which trigger signal at any one of the four inputs initiates oscillation. Frequency can be varied remotely by changing V.—T. Tojo, High Speed Multivibrator Controlled By Single ECL, *Electronics*, Sept. 18, 1967, p 109–110.

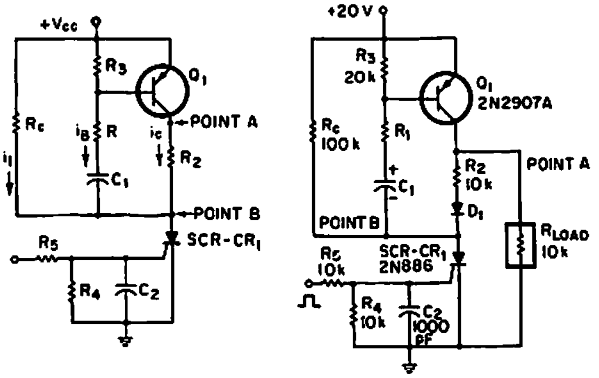
AVOIDING BOTH-ON CONDITION—Free-running mvbr is designed to preclude situation where both transistors are on and saturated, as might occur if both halves of circuit are well matched and power supply voltage comes on slowly. With transistors both in active region when on and with loop gain greater than one, circuit cannot exist stably with both transistors on.—N. O. Sokal, Trouble Spots in Circuits, *Electronic Design*, Nov. 9, 1964, p 32–37.

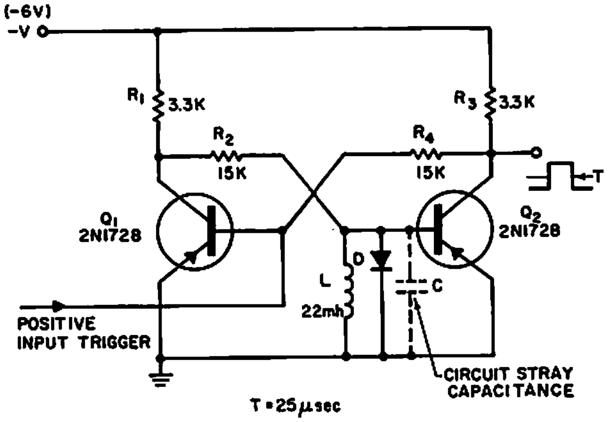

+12V
820
8.2K
0.02μf
8.2K
0.02μf
820
f = 100 KC
2N388
2N388
3.3K
3.3K
330
330
470


800pf
0.1
INPUT
2.5khz
SINE WAVE
5vpp
5.6k
Q_1
2N404
3k
2.4k
2.2k
560
1000pf
8.2k
3k
12v
ZENER
Q_2
2N404
C_1
.02
D_1
D_2
R_1
22k
R_2
22k
2.7k
2.7k
D_3
①
ALL DIODES IN456
+18v
300
4.7k
8.2k
R_3
33k
2.7k
2.7k
C_2
250
Q_3
2N718
Q_4
2N718
6.8k
S1
②
TRIGGER INPUT
OUTPUT OF MONOSTABLE 1 WHEN MONOSTABLE 2 IS NOT TRIGGERED
OUTPUT OF MONOSTABLE 2 WHEN TRIGGERED
OUTPUT OF MONOSTABLE 1 WHEN MONOSTABLE 2 IS TRIGGERED

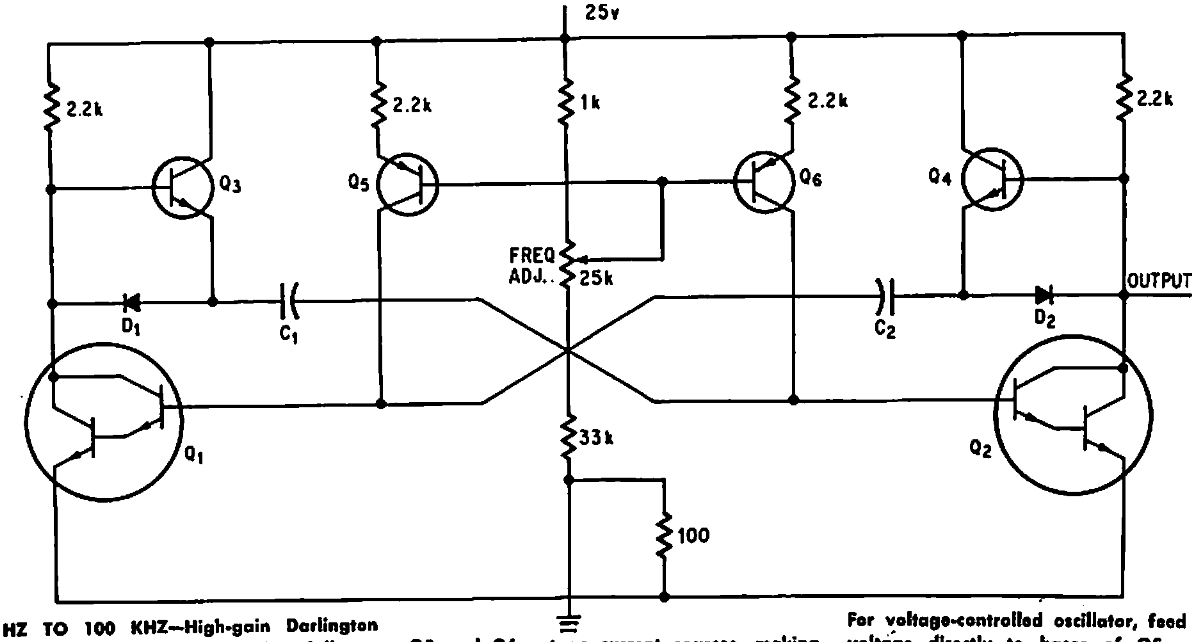
CASCADING ONE-SHOTS—Permits doubling pulse width for desired time interval. Initially, Q1 and Q3 are on, and Q2 and Q4 are off. Switch one is open, so 2.5-kHz sine-wave input triggers first mono. To increase pulse width, S1 is momentarily closed to trigger second mono. Duration of this mono, 0.7 x R3 x C2, determines how long wider pulses will be gated out. Output of mono 1 is at collector of Q2, and output of mono 2 is at collector of Q3.—K. Vijaya Raghavan, Two One-Shots Control Waveform's Pulse Width, *Electronics*, Jan. 6, 1969, p 93.

ZERO STANDBY POWER—One-shot draws no power from supply when in normal standby or OFF mode. When either d-c level or pulse turns on scr, values of R1 and C1 determine how long regenerative action is sustained before scr is turned off. With 10K and 10 μF, ON time is 270 ms, while with 1K and 1 μF, ON time is 5.5 ms. Article gives values for other times, along with design equations. —A. L. Lew, Zero (Quiescent) Power One-Shot, *EEE*, Dec. 1969, p 91.

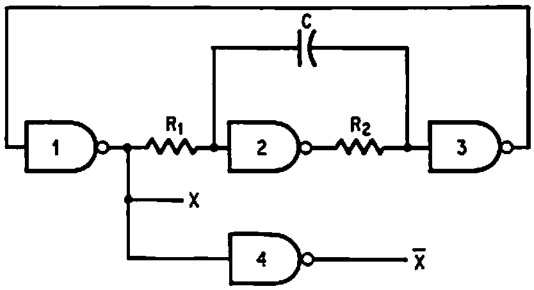

+Vcc
R3
Q1
Rc
iB
R
ic
POINT A
i1
R2
C1
POINT B
R5
SCR-CR1
R4
C2
+20V
R3
20k
Q1
2N2907A
Rc
100k
R1
R2
10k
POINT A
C1
D1
POINT B
RLOAD
10k
R5
10k
SCR-CR1
2N886
R4
10k
C2
1000
pF


(-6V)
-V
R1
3.3K
R3
3.3K
R2
15K
R4
15K
T
Q1
2N1728
Q2
2N1728
D
L
22mh
C
POSITIVE
INPUT TRIGGER
CIRCUIT STRAY
CAPACITANCE
T = 25μsec

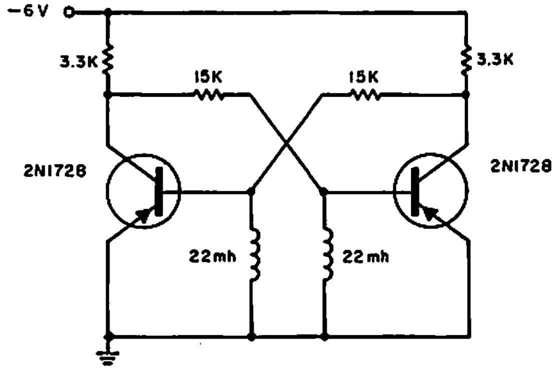
INDUCTOR-CONTROLLED—Use of inductor in place of conventional capacitor for controlling timing gives rise and fall times limited only by transistor switching speed. Capacitor charging curve is eliminated from output waveform. Circuit is stall-proof if small amount of resistance is used in series with inductor to bias transistors into their linear region; for circuit shown, d-c resistance of inductor was enough for this purpose.—R. J. Bouchard, Inductor Timing Improves Multivibrator Action, *Electronic Design*, July 20, 1964, p 78–80.


25v
2.2k
2.2k
1k
2.2k
2.2k
Q3
Q5
Q6
Q4
FREQ
ADJ.
25k
D1
C1
C2
D2
OUTPUT
Q1
Q2
33k
100

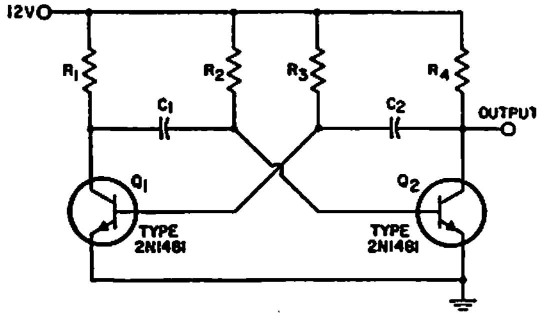
50 HZ TO 100 KHZ—High-gain Darlington transistors and quick-acting emitter-follower transistors broaden frequency range of free-running mvbr. Q3 and Q4 boost upper frequency limit by discharging C1 and C2 faster. Q5 and Q6 act as current sources, making linear tuning possible over range of 1,000 to 1 with 25K pot. When C1 and C2 are 250 pF, frequency range is 50 Hz to 100 kHz. For voltage-controlled oscillator, feed control voltage directly to bases of Q5 and Q6. Transistor types are not critical.—F. B. Golden, Darlington Transistors Widen Multivibrator's Range, *Electronics*, Nov. 25, 1968, p 82.


C
R1
R2
1
2
3
X
4
X̄

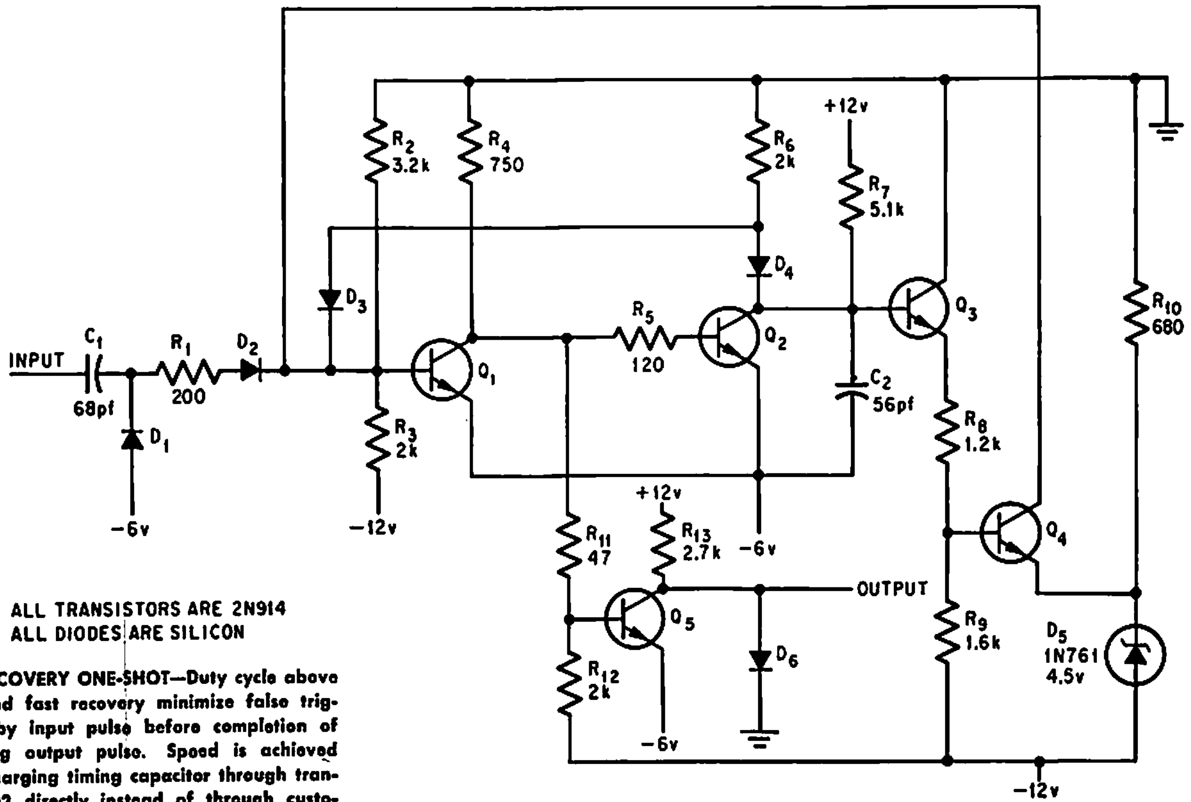
QUAD NAND GATE RUNS FREE—Low-cost mvbr is self-starting, with rise and fall times below 50 ns, complementary outputs, and wide frequency range. C and R2 control-frequency, while R1 changes symmetry of output. With R1 and R2 both 510 ohms, output varies from 200 Hz to several MHz when C is varied from 10 μF to 100 pF.—O. Q. Flint, Jr., Free-Running Multivibrator Is Made with a NAND Gate, *Electronics*, Jan. 6, 1969, p 95–96.


−6V
3.3K
3.3K
15K
15K
2N1728
2N1728
22mh
22mh

20-KHZ INDUCTOR-CONTROLLED—Use of inductors in place of capacitors gives rise and fall times limited only by transistor switching speeds. Circuit is stall-proof.—R. J. Bouchard, Inductor Timing Improves Multivibrator Action, *Electronic Design*, July 20, 1964, p 78–80.


12V
R1
R2
R3
R4
C1
C2
OUTPUT
Q1
Q2
TYPE 2N1481
TYPE 2N1481

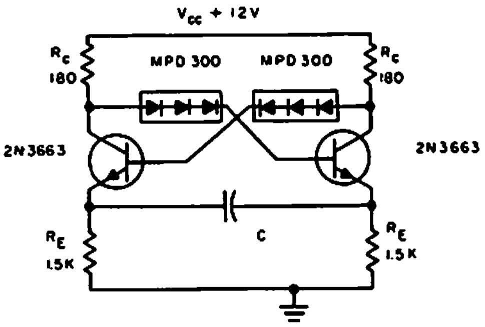
7-KHZ ASTABLE—Provides square-wave output with peak value equal to d-c supply voltage. Capacitors are 0.1 μF, R1 and R4 are 60 ohms, and R2 and R3 are 1K.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 533.

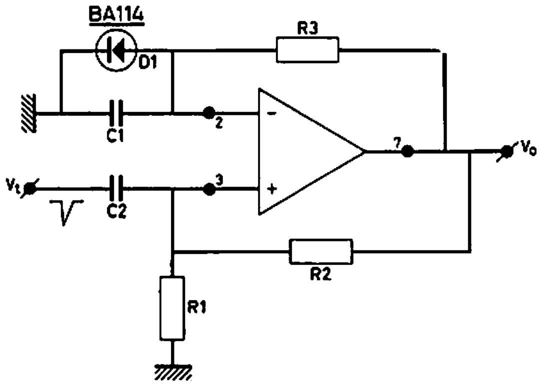

INPUT
C1
68pf
R1
200
D2
D1
−6v
D3
R2
3.2k
R4
750
R3
2k
−12v
Q1
R5
120
R6
2k
D4
Q2
+12v
R7
5.1k
C2
56pf
Q3
R8
1.2k
Q4
R9
1.6k
R10
680
D5
1N761
4.5v
−12v
R11
47
R12
2k
+12v
R13
2.7k
−6v
Q5
−6v
OUTPUT
D6

ALL TRANSISTORS ARE 2N914
ALL DIODES ARE SILICON

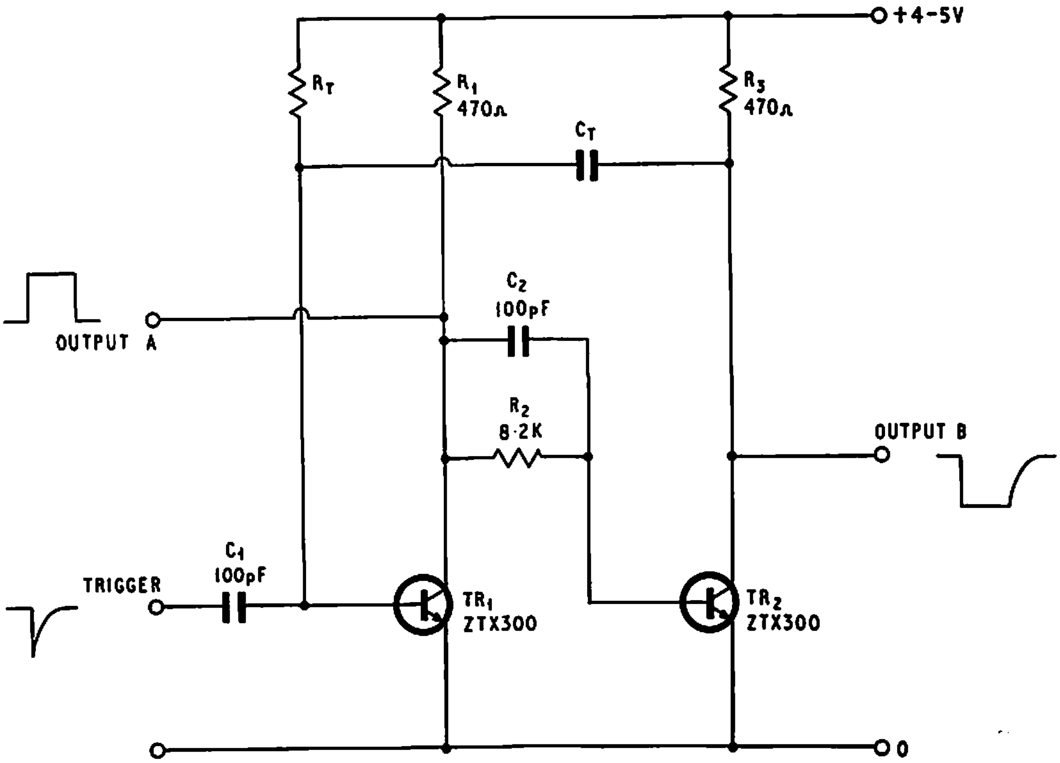
FAST-RECOVERY ONE-SHOT—Duty cycle above 95% and fast recovery minimize false triggering by input pulse before completion of preceding output pulse. Speed is achieved by discharging timing capacitor through transistor Q2 directly instead of through customary transistor. Output pulse width is 100 ns. Once timed interval has started, circuit is insensitive to input variations except for about 10 ns.—J. H. Williams, Full Duty Single Shot Recovers Fast, *Electronics*, March 31, 1969, p 89.

D-C COUPLING WITH DIODES—Multi-pellet diodes provide d-c level-shifting to give desired output voltage swing in astable mvbr. Operation is stable from several Hz to about 10 MHz. Only one capacitor is needed. Rise time is about 5 ns.—Silicon Multi-Pellet Diodes MPD200/MPD300/MPD400, General Electric, Syracuse, N.Y., No. 75.42, 1966.

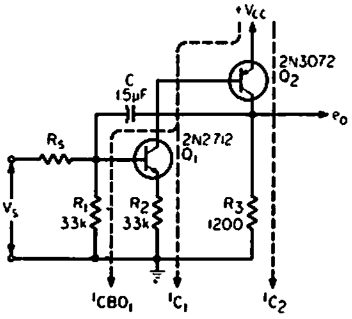

V_{cc} + 12V
R_c 180
MPD 300
MPD 300
R_c 180
2N3663
2N3663
C
R_E 1.5K
R_E 1.5K


BA114
D1
R3
C1
2
3
7
V_o
V_t
C2
R2
R1

IC MONO—Uses Philips TAA241 difference amplifier as monostable mvbr that is saturated in its quiescent state and then has output of +10 V. Negative-going trigger makes output switch to new value of about −5 V. R1 is 8.2K, R2 and R3 are 100K, C1 is 10 nF, and C2 is 4.7 nF. With these values, pulse time is 175 μs, rise time 0.35 μs, fall time 0.7 μs, and delay time 0.3 μs.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.

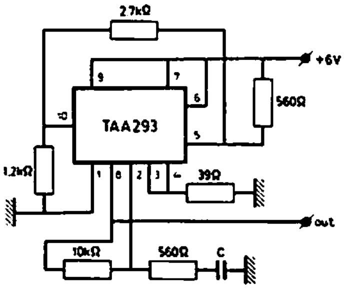

+4-5V
R_T
R_1 470Ω
C_T
R_3 470Ω
OUTPUT A
C_2 100pF
R_2 8·2K
OUTPUT B
TRIGGER
C_1 100pF
TR_1 ZTX300
TR_2 ZTX300
0

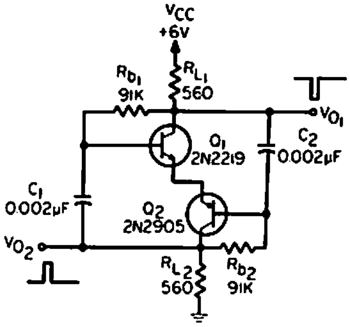
BASIC MONO—Minimum output pulse width is 1 μs. Report gives design procedure. One drawback is slow positive edge of output pulse from TR2, occurring because CT must recharge through R3. Report shows how to overcome this with diode from CT to output. —"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 14.


+Vcc
2N3072
Q2
C
15µF
eo
Rs
2N2712
Q1
Vs
R1
33k
R2
33k
R3
1200
ICBO1
IC1
IC2

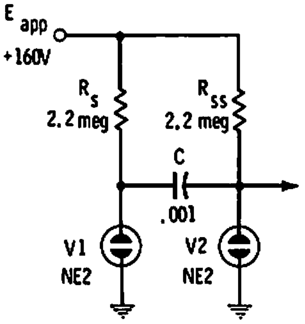
SIMPLIFIED ONE-SHOT—Complementary transistors give simplified design, with negligibly small quiescent currents (shown by dashed lines). Will also operate as free-running mvbr or as trigger by making minor changes in values of components.—A. C. Caggiano, Simplified One-Shot Multivibrator, *EEE*, Oct. 1967, p 140 and 142.

ASTABLE FROM IC AMPLIFIER—Uses Philips TAA293 general-purpose amplifier. Value of C determines period; 10 nF gives about 16 µs with high-to-low ratio of 0.6. Period for other values of C is in direct proportion to C down to 2 µs.—The TAA293 as a Schmitt Trigger and Multivibrator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 25, 1968.

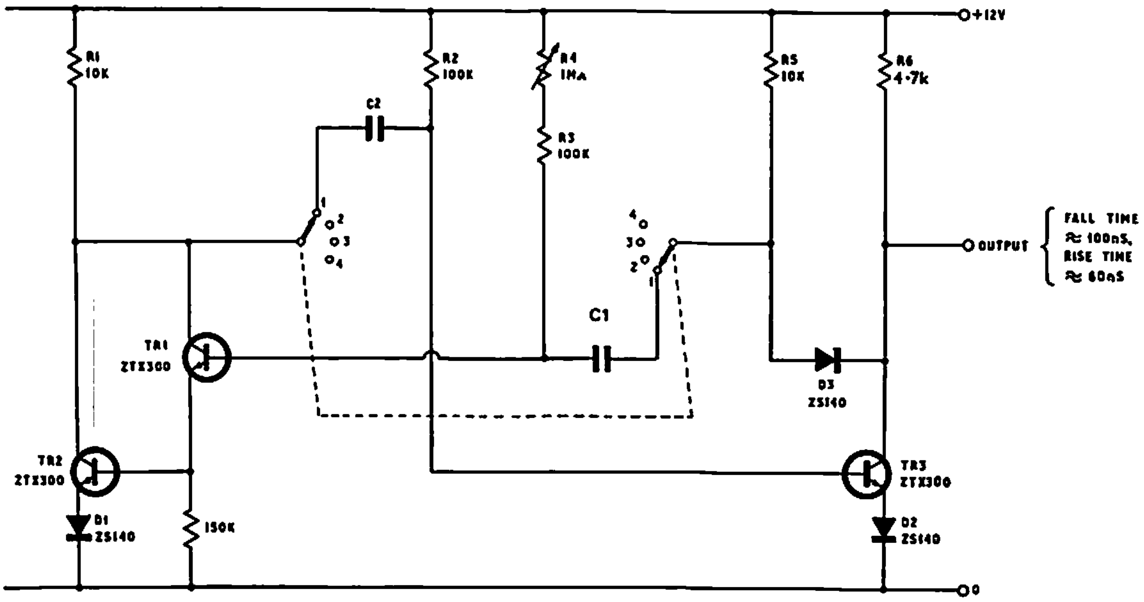

2.7kΩ
+6V
9
7
6
8
5
TAA293
560Ω
1.2kΩ
1
0
2
3
4
39Ω
out
10kΩ
560Ω
C


VCC
+6V
Rb1
91K
RL1
560
VO1
Q1
2N2219
C2
0.002µF
C1
0.002µF
Q2
2N2905
VO2
RL2
560
Rb2
91K

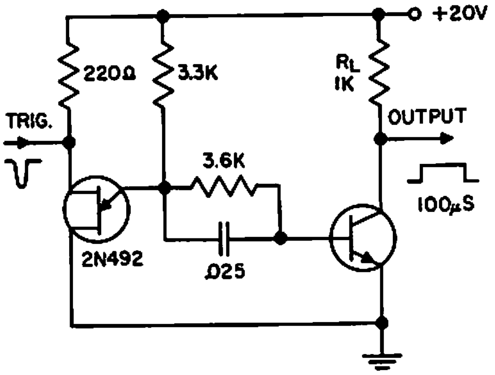
LOCK-UP IMMUNITY—With complementary transistors connected as shown, circuit is inherently self-starting, immune to lock-up, and useful over wide range of frequencies. Coincident positive and negative output pulses have equal amplitudes. With values shown, pulse width is about 2 µs and amplitude about half of supply voltage.—C. R. Bond, Complementary Series Multivibrator, *EEE*, Sept. 1967, p 135–136.


E app
+160V
Rs
2.2meg
Rss
2.2 meg
C
.001
V1
NE2
V2
NE2

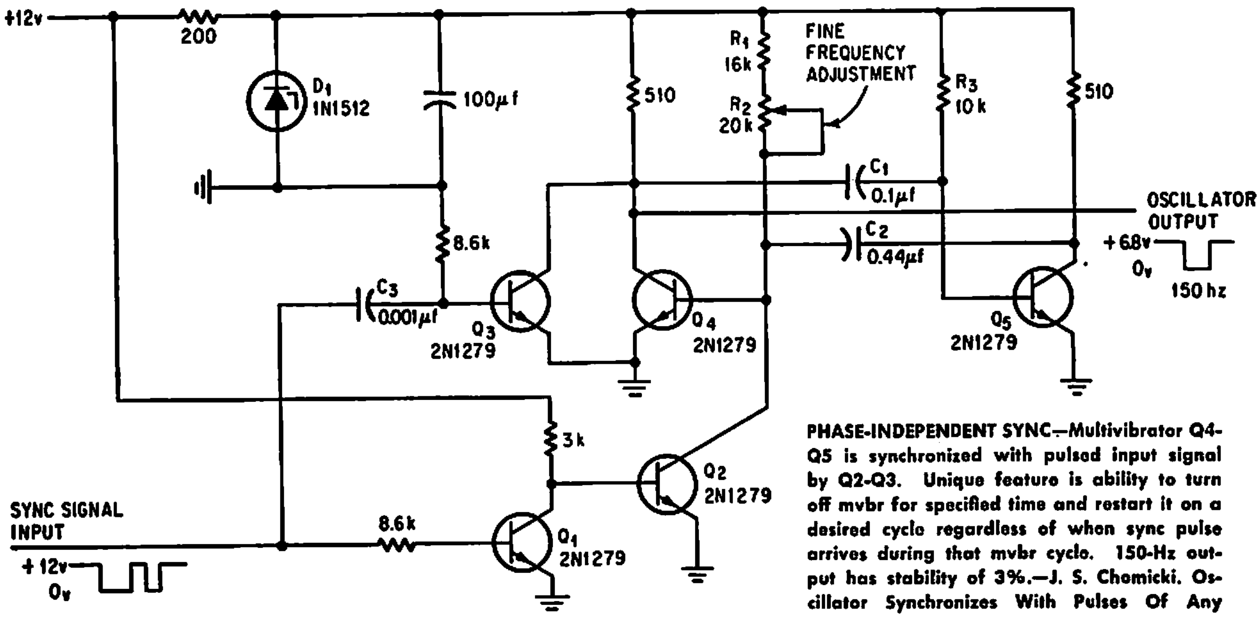
700-HZ ASTABLE NEON—Basic circuit may be modified by changing resistor values to obtain frequency up to 8 kHz.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 43.


+12V
R1
10K
R2
100K
R4
1MΩ
R5
10K
R6
4·7k
C2
R3
100K
1
2
3
4
OUTPUT
FALL TIME ≈ 100nS, RISE TIME ≈ 60nS
C1
TR1
ZTX300
D3
ZS140
TR2
ZTX300
TR3
ZTX300
D1
ZS140
150K
D2
ZS140
0

WIDE-RANGE MVBR—Gives pulse durations ranging from 26.5 µs to 66 s in nine ranges, by switching capacitors C1 and C2 which have identical values from 180 pF to 75 µF. TR1 and TR2 form Darlington pair giving required large value of base resistance for long pulse durations.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 8.


+20V
220Ω
3.3K
RL
1K
OUTPUT
TRIG.
3.6K
100μS
2N492
.025

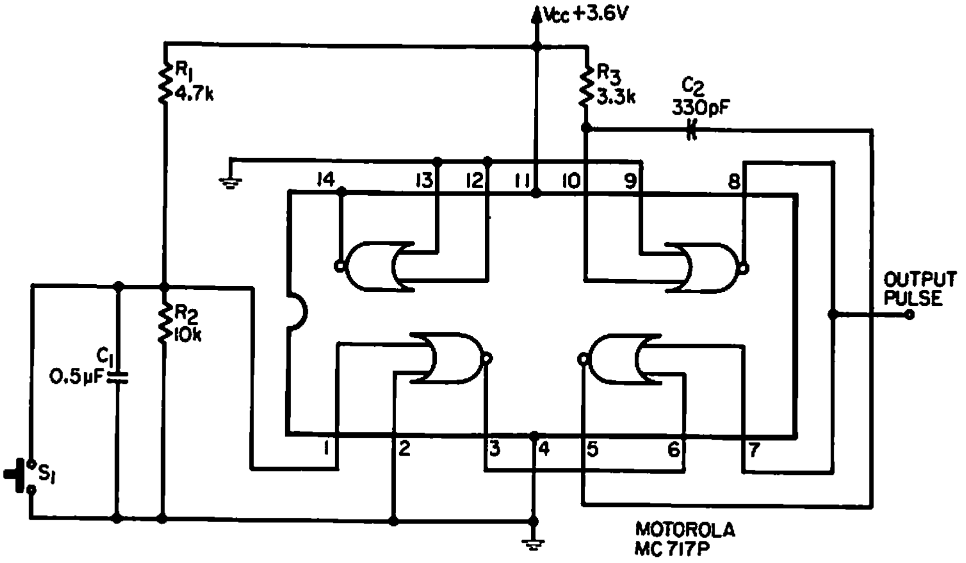
SINGLE-UJT ONE-SHOT—Addition of resistor between emitter and ground converts basic single-ujt mvbr to one-shot. Method of adding transistor output stage is also shown.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 76.


+12v
200
D1
1N1512
100μf
510
R1
16k
R2
20k
FINE
FREQUENCY
ADJUSTMENT
R3
10k
510
C1
0.1μf
C2
0.44μf
OSCILLATOR
OUTPUT
+6.8v
0v
150 hz
8.6k
C3
0.001μf
Q3
2N1279
Q4
2N1279
Q5
2N1279
3k
Q2
2N1279
SYNC SIGNAL
INPUT
+12v
0v
8.6k
Q1
2N1279

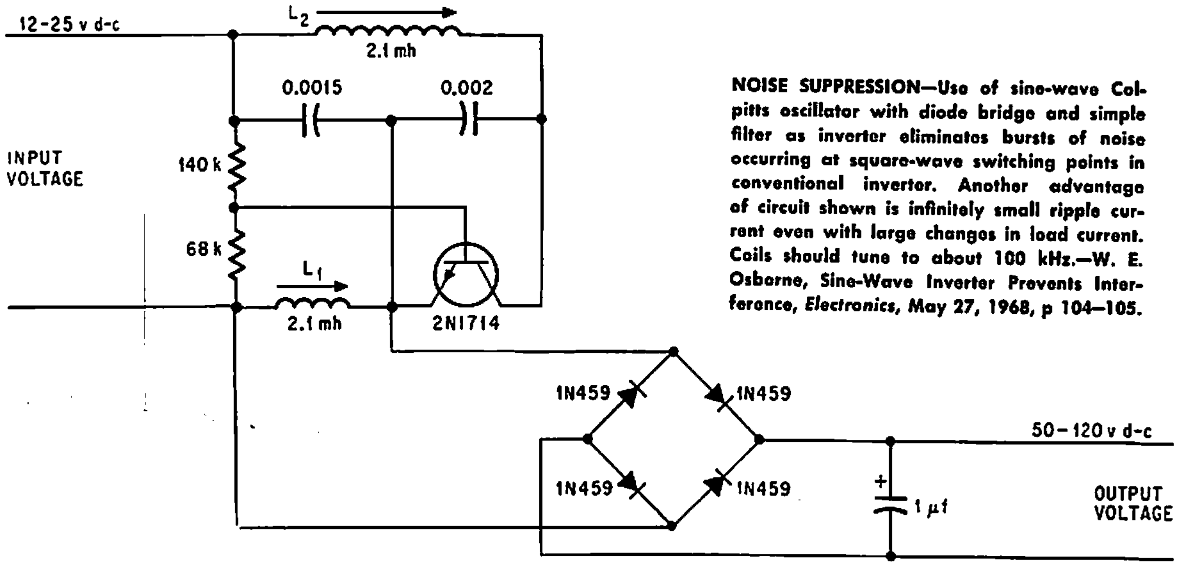
PHASE-INDEPENDENT SYNC—Multivibrator Q4-Q5 is synchronized with pulsed input signal by Q2-Q3. Unique feature is ability to turn off mvbr for specified time and restart it on a desired cycle regardless of when sync pulse arrives during that mvbr cycle. 150-Hz output has stability of 3%.—J. S. Chomicki. Oscillator Synchronizes With Pulses Of Any Phase, *Electronics*, April 3, 1967, p 96–97.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

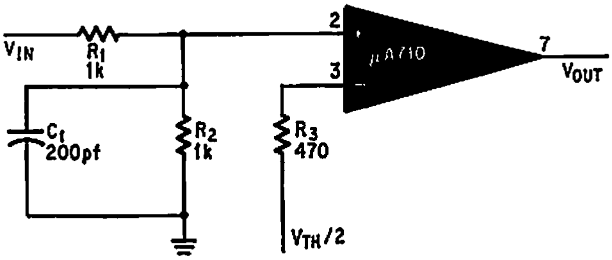
CHAPTER 55
Noise Circuits


Vcc +3.6V
R1 4.7k
R3 3.3k
C2 330pF
14
13
12
11
10
9
8
OUTPUT PULSE
R2 10k
C1 0.5μF
S1
1
2
3
4
5
6
7
MOTOROLA MC717P

SWITCH NOISE ELIMINATOR—Closing S1 gives output pulses from 1 μs to 80 ms, with width depending on value of C2. Built around RTL four-gate NOR IC, functioning as one-shot driven by inverter. Switch noise is below noise threshold of IC, so one-shot sees clean fast trigger signal. I. Isrealy, IC One Shot Generates Short-Duration Pulses and Eliminates Switch Noise, *EEE*, March 1968, p 129—130.

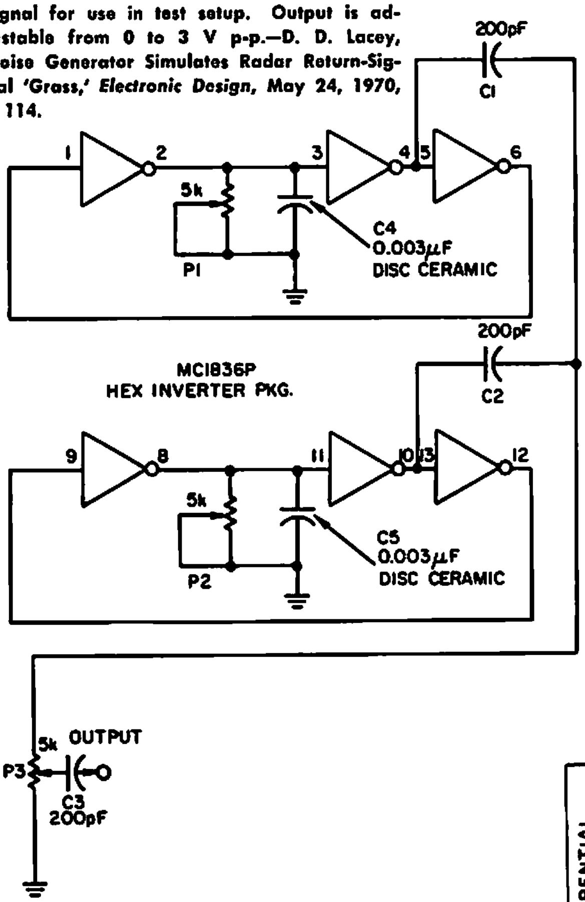

12-25 v d-c
L2
2.1 mh
0.0015
0.002
INPUT VOLTAGE
140 k
68 k
L1
2.1 mh
2N1714
1N459
1N459
1N459
1N459
50-120 v d-c
1 μf
OUTPUT VOLTAGE

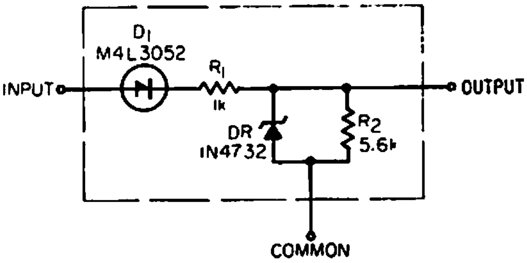
NOISE SUPPRESSION—Use of sine-wave Colpitts oscillator with diode bridge and simple filter as inverter eliminates bursts of noise occurring at square-wave switching points in conventional inverter. Another advantage of circuit shown is infinitely small ripple current even with large changes in load current. Coils should tune to about 100 kHz.—W. E. Osborne, Sine-Wave Inverter Prevents Interference, *Electronics*, May 27, 1968, p 104—105.


V_{IN}
R_1
1k
2
3
7
μA710
V_{OUT}
C_1
200pf
R_2
1k
R_3
470
$V_{TH}/2$

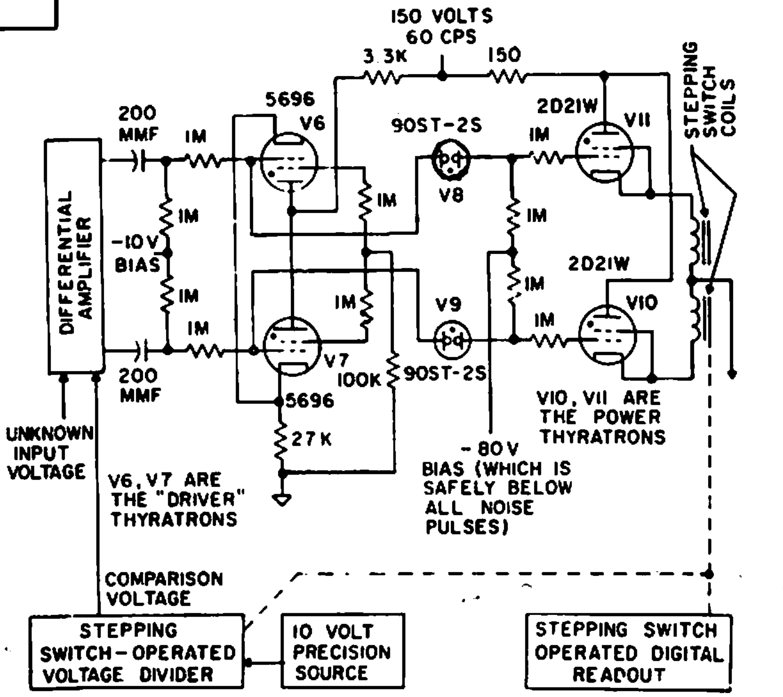
LONG-LINE NOISE SUPPRESSOR—IC opamp serves as preconditioner to improve signal-to-noise ratio in digital line. Divider R1-R2 permits handling large input signals (14 V). C1 shunts out fast noise spikes from high-gain Fairchild μA710 opamp. Output is generated when input exceeds half the threshold level established by reference voltage applied to terminal 3. Article contains thirteen other IC opamp application circuits.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.

GRASS SIMULATOR—Random-noise generator covering 100 kHz to 8 MHZ, with content and level both adjustable, simulates radar return signal for use in test setup. Output is adjustable from 0 to 3 V p-p.—D. D. Lacey, Noise Generator Simulates Radar Return-Signal 'Grass,' *Electronic Design*, May 24, 1970, p 114.


200pF
C1
1
2
3
4
5
6
5k
P1
C4
0.003μF
DISC CERAMIC
200pF
C2
MC1836P
HEX INVERTER PKG.
9
8
11
10
13
12
5k
P2
C5
0.003μF
DISC CERAMIC
5k
OUTPUT
P3
C3
200pF

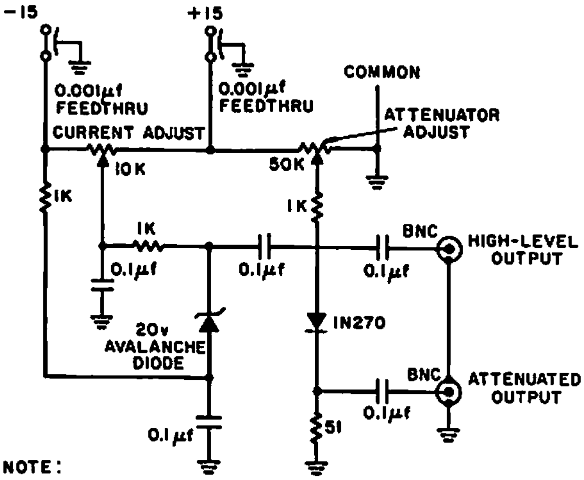

D_1
M4L3052
R_1
1k
INPUT
OUTPUT
DR
1N4732
R_2
5.6k
COMMON

ACTIVE NOISE FILTER—Developed for timing and logic circuits of industrial electronic controls having lines long enough to pick up severe 60-Hz radiation. Works like Schmitt trigger though requiring no external d-c supply. Article includes table showing d-c switching levels and ripple at various noise frequencies.—P. A. Lajoie, Simple Solid-State Noise Filter for Industrial Logic Systems, *EEE*, Oct. 1968, p 124 and 126.

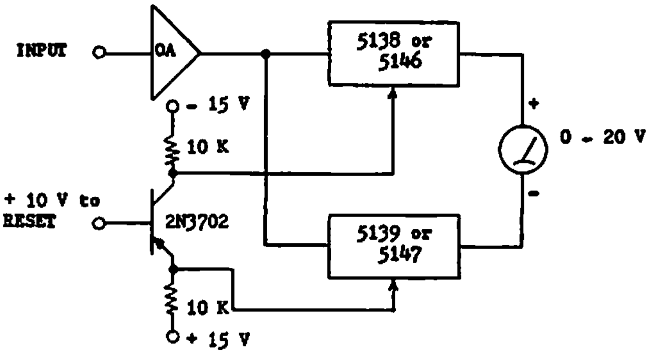

150 VOLTS
60 CPS
3.3K
150
5696
V6
90ST-2S
2D21W
VII
STEPPING SWITCH COILS
200 MMF
IM
IM
V8
IM
IM
IM
-10V BIAS
DIFFERENTIAL AMPLIFIER
IM
2D21W
IM
V9
IM
V10
IM
IM
V7
100K
90ST-2S
200 MMF
5696
27K
UNKNOWN INPUT VOLTAGE
V6, V7 ARE THE "DRIVER" THYRATRONS
-80V BIAS (WHICH IS SAFELY BELOW ALL NOISE PULSES)
V10, V11 ARE THE POWER THYRATRONS
COMPARISON VOLTAGE
STEPPING SWITCH-OPERATED VOLTAGE DIVIDER
10 VOLT PRECISION SOURCE
STEPPING SWITCH OPERATED DIGITAL READOUT

NEON ON-OFF SWITCH—In digital voltmeter stage, neons isolate driver thyratrons and amplifier from stepping switches, preventing thyratrons from firing due to noise pulses created by pulsing the stepping switches. When driver thyratrons are ignited on signal from amplifier, neons switch on and ignite power thyratrons.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 95.

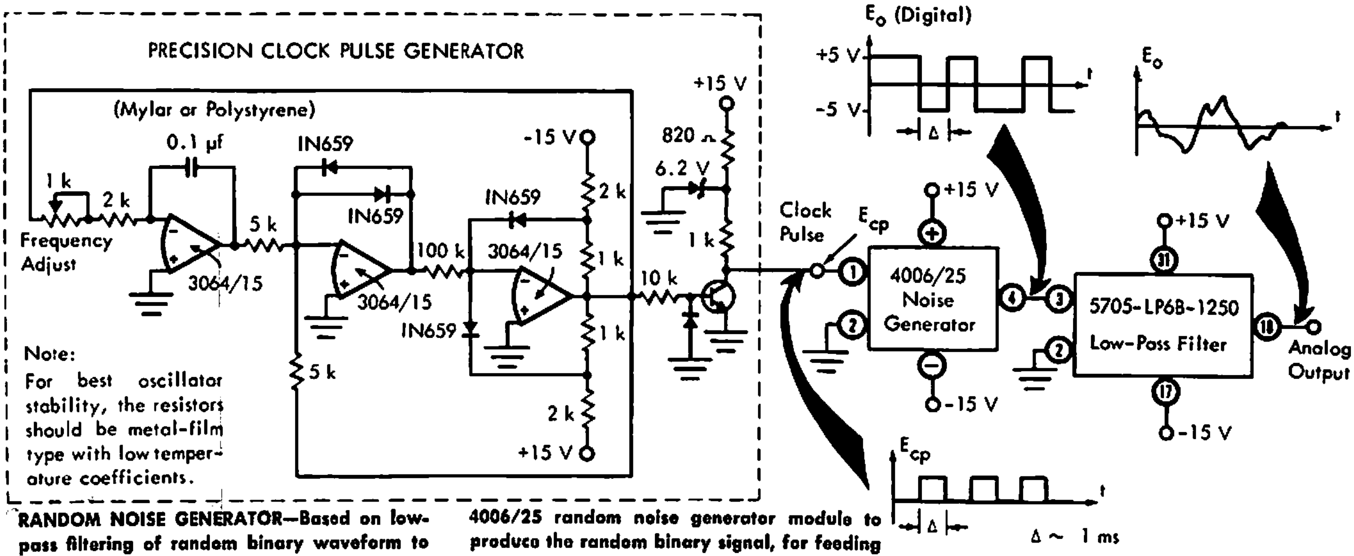
NOISE TO 500 KHZ—Avalanche diode noise source gives 1 to 2 mV into 50 ohms over frequency range of 2 kHz to over 500 MHz, for testing broadband video and r-f amplifier systems.—H. Penfield, Why Not The Avalanche Diode As An RF Noise Source? *Electronic Design*, April 12, 1965, p 32–35.


-15
+15
0.001µf FEEDTHRU
0.001µf FEEDTHRU
COMMON
CURRENT ADJUST
ATTENUATOR ADJUST
10 K
50K
1K
1K
1K
BNC
HIGH-LEVEL OUTPUT
0.1µf
0.1µf
0.1µf
20v AVALANCHE DIODE
IN270
BNC
ATTENUATED OUTPUT
0.1µf
51
0.1µf

NOTE:
Lower frequency range may be extended by increasing all 0.1µf capacitances.


INPUT
OA
5138 or 5146
- 15 V
10 K
+
0 - 20 V
-
+ 10 V to RESET
2N3702
5139 or 5147
10 K
+ 15 V

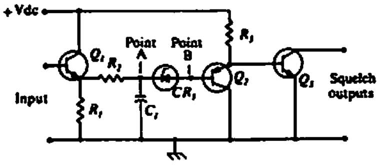
PEAK-READING NOISE METER—One module senses positive peaks of noise, while other senses negative peaks. Both outputs drive meter that reads p-p value of noise. Reset circuit provides both polarities, to reset both modules. Use OEI 5138 and 5139 modules for d-c to 10 kHz, and others for 10 MHz. When measuring very low-level signals, opamp preamp noise must be canceled by replacing meter circuit with opamp having offset voltage added to signal.—A Peak Reading Noise Meter, Optical Electronics, Tucson, Ariz., No. 10092.


PRECISION CLOCK PULSE GENERATOR
(Mylar or Polystyrene)
0.1 µf
1 k
2 k
Frequency Adjust
3064/15
5 k
IN659
IN659
3064/15
100 k
5 k
-15 V
IN659
3064/15
IN659
2 k
1 k
1 k
2 k
+15 V
+15 V
820 Ω
6.2 V
1 k
10 k
Clock Pulse
E_{cp}
+15 V
1
2
4006/25 Noise Generator
-15 V
4
3
2
5705-LP6B-1250 Low-Pass Filter
+15 V
31
17
-15 V
10
Analog Output
E_0 (Digital)
+5 V
-5 V
t
Δ
E_0
t
E_{cp}
t
Δ
Δ ~ 1 ms

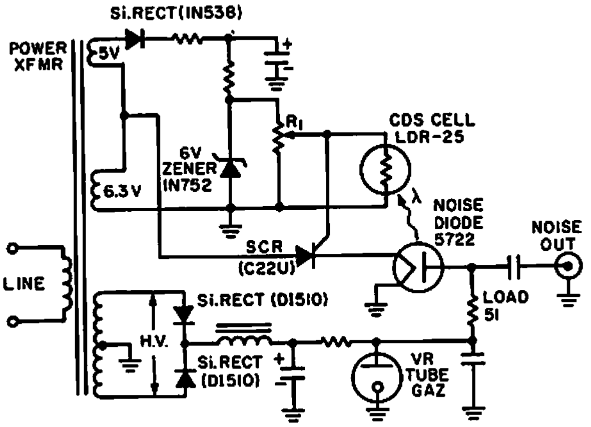
Note:
For best oscillator stability, the resistors should be metal-film type with low temperature coefficients.

RANDOM NOISE GENERATOR—Based on low-pass filtering of random binary waveform to obtain analog noise source having known power spectral density and rms value. Clock signal is applied to Burr-Brown 4006/25 random noise generator module to produce the random binary signal, for feeding to low-pass filter module. Resulting noise signal has flat power spectrum from d-c to 1 kHz. Article gives design equations.—Burr-Brown Computer Designed Active Filters, Burr-Brown Research, Tucson, Ariz., No. PDS-203A, 1968.

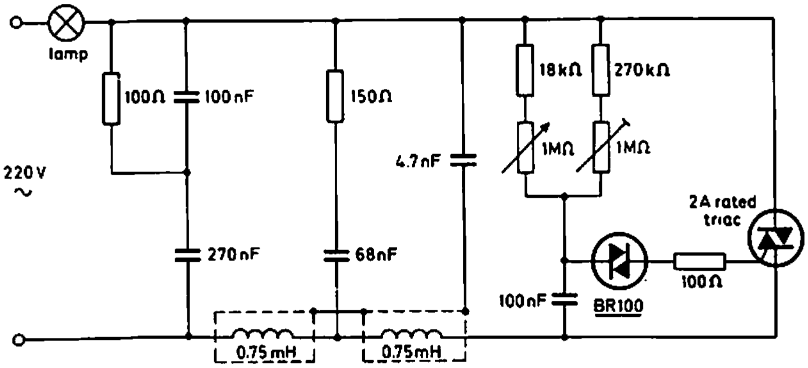
CONTAMINATED-SIGNAL REJECTOR—Simple circuit compares signal with noise in pulse system and delivers squelch output for rejecting noise-contaminated signals. Can be used in pulse command and control applications, as well as for code communication. When desired series of pwm pulses reaches input, integrated value at A is insufficient to break down CR1. When noise is present with signal, however, CR1 breaks down and resulting signal at B turns Q2 off, making Q3 turn on and provide ground point for squelch.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 71.


+Vdc
Input
Q_1
R_2
R_1
Point A
Point B
C_1
CR_1
R_3
Q_2
Q_3
Squelch outputs

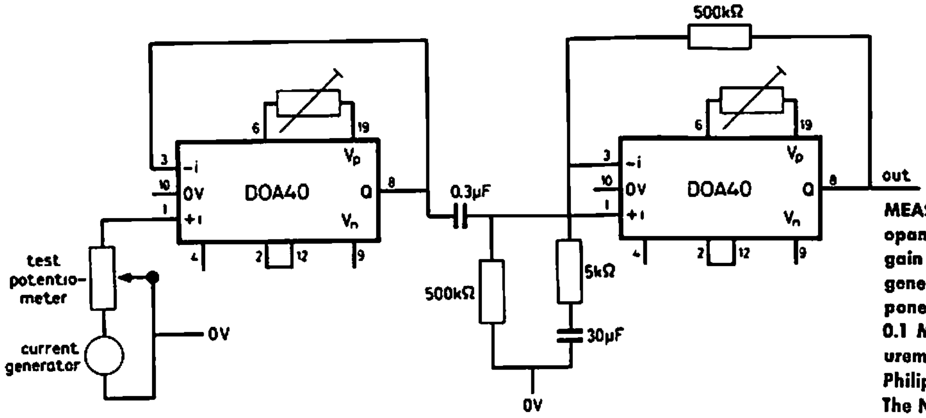
Supply	+ 28 V dc
Q_1	2N718A
Q_2	2N722
Q_3	2N718A
CR_1	1N756A
R_1	39K
R_2	100K
R_3	150K
C_1	1.0 μF


Si.RECT(IN538)
POWER XFMR
5V
R_1
CDS CELL LDR-25
6V ZENER 1N752
6.3V
λ
NOISE DIODE 5722
NOISE OUT
SCR (C22U)
LINE
Si.RECT (D1510)
LOAD 51
H.V.
Si.RECT (D1510)
+
VR TUBE GAZ

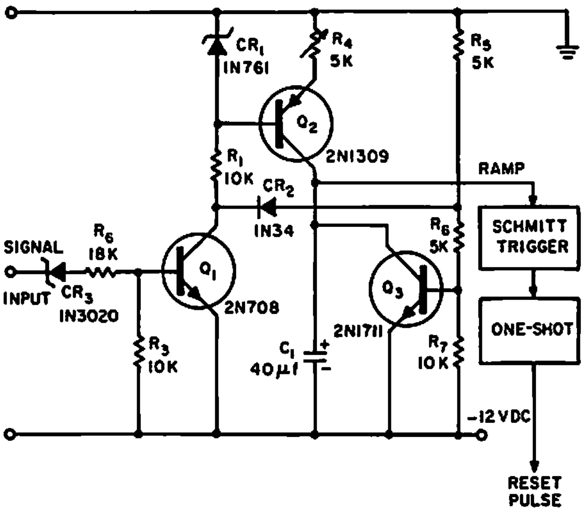
NOISE DIODE FILAMENT REGULATOR—Noise output current of temperature-limited noise diode is held constant at value determined by setting of R1, in range of 0.5 to 10 mA, by dual regulator and cadmium sulfide cell controlling conduction angle of scr. Cell monitors light output of noise diode, which increases with line voltage, to compensate for line voltage variations. Can be easily adapted for control of other noise sources.—H. D. Olson, Semiconductors Regulate Noise-Diode Plate Current, *Electronic Design*, March 16, 1964, p 108–109.


lamp
100Ω
100nF
150Ω
18kΩ
270kΩ
1MΩ
1MΩ
220V ~
4.7nF
2A rated triac
270nF
68nF
100Ω
100nF
BR100
0.75mH
0.75mH

TRIAC RFI SUPPRESSION—Used when it is possible to insert chokes in series with line. Series resistors must then be added as shown to prevent oscillation, because load no longer acts as damping element between filter and control circuit.—Triacs—Operation and Use, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1969.

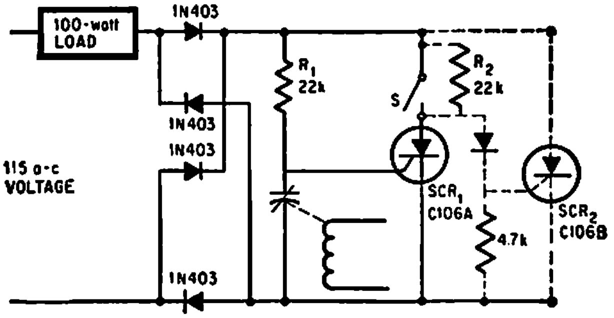

500kΩ
6
19
3
-i
10
0V
1
+i
DOA40
V_p
Q
V_n
8
4
2
12
9
0.3μF
500kΩ
5kΩ
30μF
out
test potentiometer
current generator
0V
0V

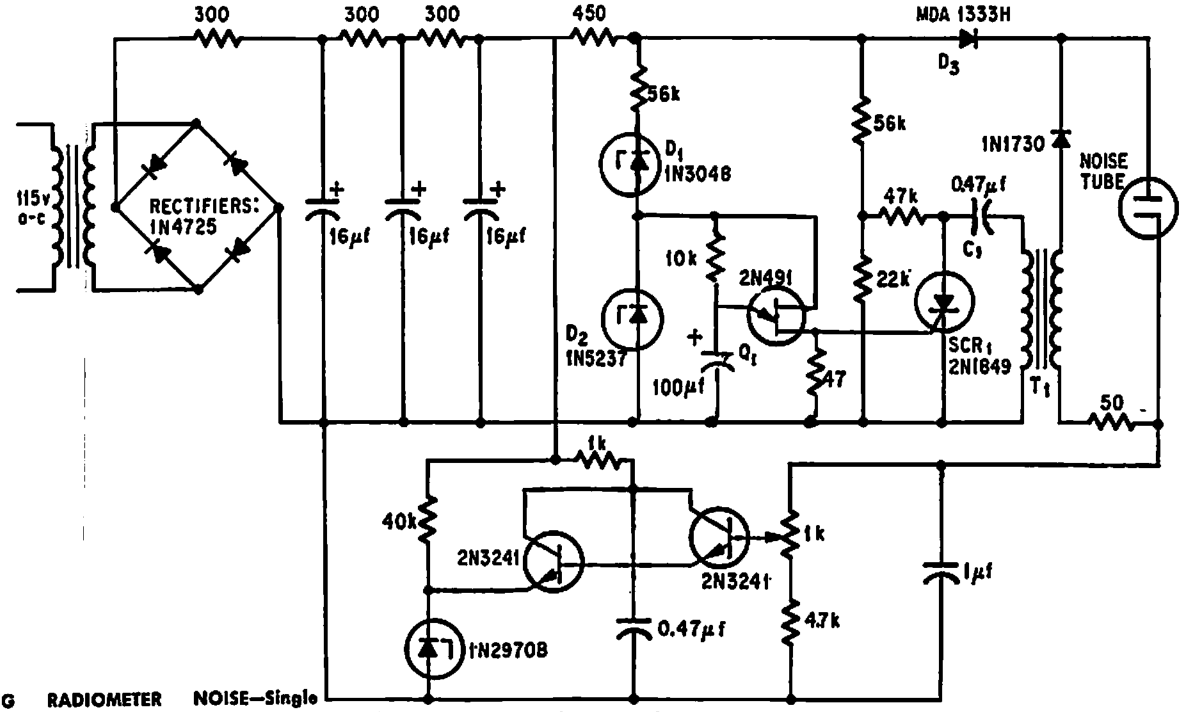
MEASURING NOISE—Two Philips DOA40 IC opamps connected as shown provide overall gain of 100 for measuring electrical noise generated by potentiometers and other components, at frequencies between 1 Hz and 0.1 MHz. Capacitor blocks d-c signal.—Measurement of Electrical Noise Using the DOA40, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 28.


CR1
1N761
R4
5K
R5
5K
Q2
2N1309
R1
10K
CR2
1N34
RAMP
SCHMITT TRIGGER
ONE-SHOT
R6
5K
SIGNAL
R6
18K
INPUT
CR3
1N3020
Q1
2N708
R3
10K
C1
40μf
2N1711
Q3
R7
10K
-12VDC
RESET PULSE

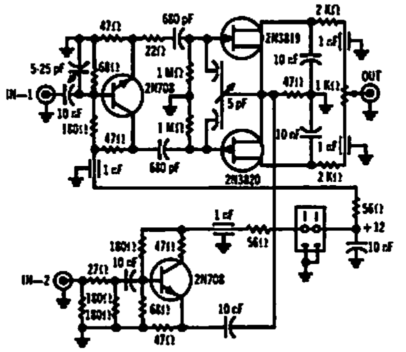
NOISE PULSE SUPPRESSOR—Pulse-width discriminator fires to provide output pulse for each input pulse exceeding level of zener CR3 and having width determined by setting of Schmitt trigger.—A. A. Dargis, Pulse Width Discriminator Rejects Narrow Noise Pulses, *Electronic Design*, Dec. 21, 1964, p 50.

KILLING TURN-ON AND TURN-OFF TRANSIENTS—Scr in solid-line portion of circuit (switch S closed) eliminates kilovolt spikes when inductive a-c load is turned off. Dotted portion of circuit eliminates turn-on transients (switch S is then left open). Both radiated and conducted r-f interference are eliminated. Can be used in paper-tape punches, tape transport motor drives, electric typewriters, and other a-c motor or solenoid devices.—J. L. Haynes, Reducing Transients in Switched Inductive Loads, *Electronics*, Oct. 17, 1966, p 88–89.

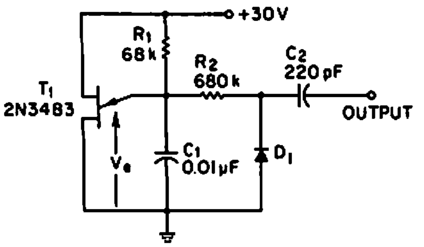

100-watt LOAD
1N403
1N403
1N403
1N403
R1
22k
S
R2
22k
115 a-c VOLTAGE
SCR1
C106A
4.7k
SCR2
C106B


300
300
300
450
MDA 1333H
D3
56k
D1
1N3048
56k
1N1730
NOISE TUBE
115v a-c
RECTIFIERS:
1N4725
16μf
16μf
16μf
47k
0.47μf
C1
10k
2N491
22k
SCR1
2N1849
D2
1N5237
Q1
100μf
47
T1
50
1k
40k
2N3241
2N3241
1k
1μf
0.47μf
4.7k
1N2970B

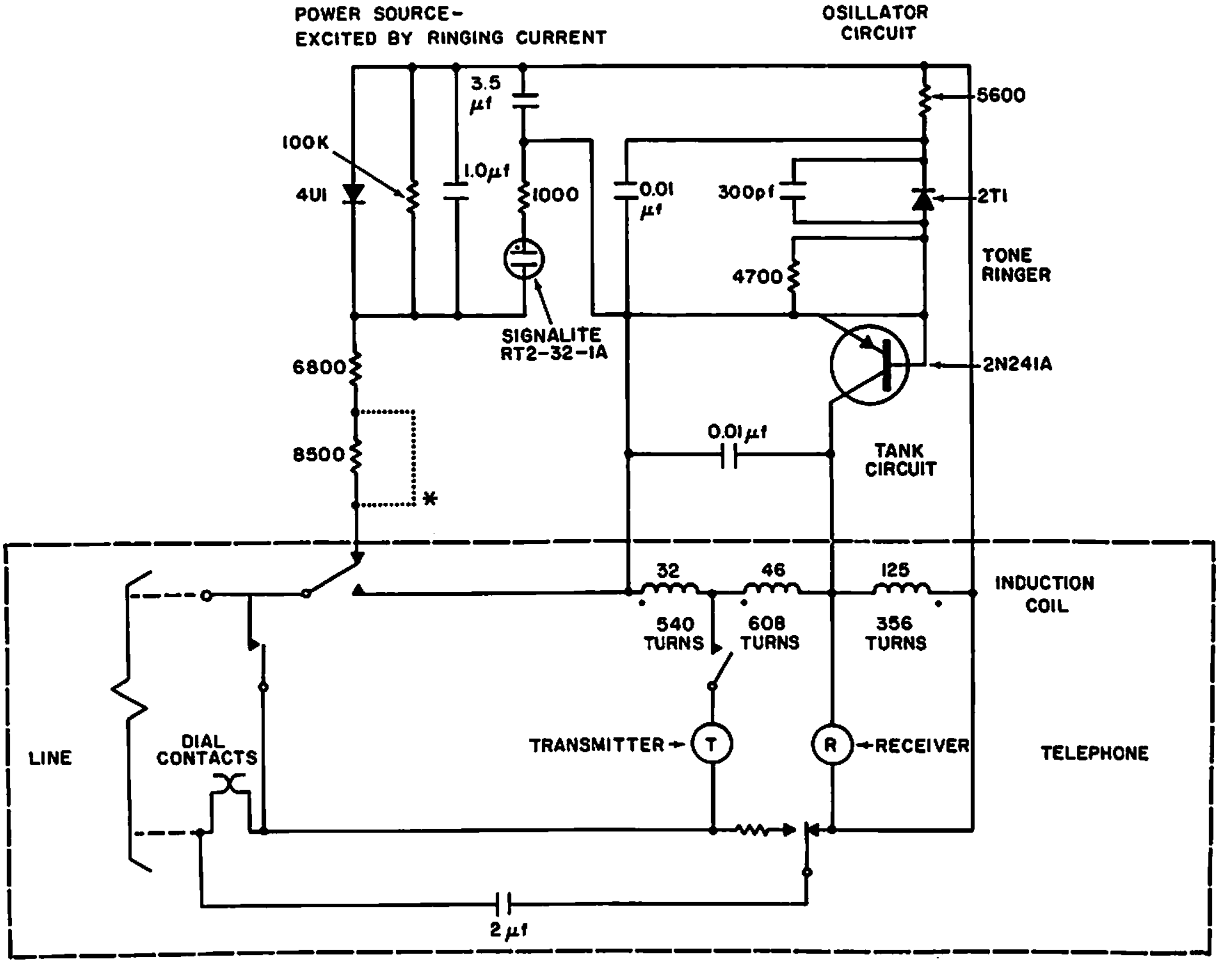
MEASURING RADIOMETER NOISE—Single power supply provides 7-kV pulse for ionizing gas-discharge noise tube and 300 V to keep it ionized. Ujt Q1 triggers SCR1 to generate pulse, then automatically switches to low-voltage operation. Shunt regulator, using two 2N3241 transistors with zener, keeps current constant to prevent variations in noise output. D3 can be seven 1N4725 diodes in series, costing much less than 1-kV prepotted stack shown.—J. M. Payne, Zeners and SCR Fire Gas Discharge Tube, *Electronics*, July 22, 1968, p 71.


47Ω
680 pF
22Ω
2N3819
2 KΩ
1 nF
10 nF
5-25 pF
68Ω
1 MΩ
IN—1
2N708
5 pF
47Ω
1 KΩ
OUT
10 nF
180Ω
1 MΩ
10 nF
47Ω
1 nF
1 nF
680 pF
2N3820
2 KΩ
56Ω
1 nF
+12
180Ω
47Ω
56Ω
10 nF
27Ω
10 nF
IN—2
2N708
180Ω
180Ω
68Ω
10 nF
47Ω

CORRELATOR—Provides 35 dB rejection of uncorrelated components for random signals in 10% band centered at 300 MHz, for radio astronomy applications. Complementary silicon fet's are used as direct multipliers while balancing out spurious responses.—Wideband Correlator Uses Complementary FETs for Signal Multiplication (Texas Instruments ad), *Electronics*, Oct. 31, 1966, p 107.

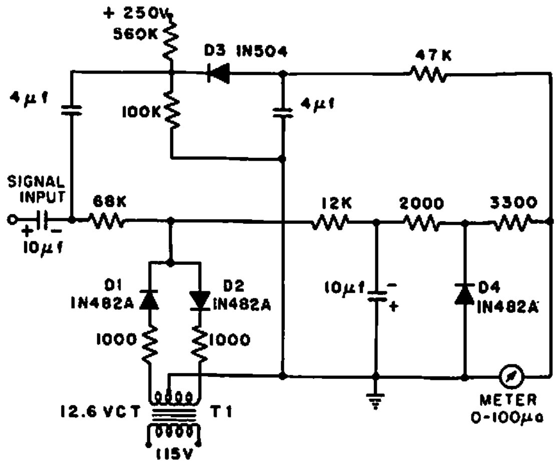

+30V
R1
68 k
R2
680 k
C2
220 pF
T1
2N3483
OUTPUT
Ve
C1
0.01μF
D1

0.5–500 MHZ A-M NOISE GENERATOR—Requires only diode, ujt, and four other components. Amplitude of output is sufficient for checking operation of a-m receiver on any h-f and vhf band without switching or tuning, by feeding noise output to input of receiver.—R. A. Reitmeyer, Jr. and R. A. Gilson, Simple Wideband A-M Noise Generator, *EEE*, Feb. 1970, p 116–117.

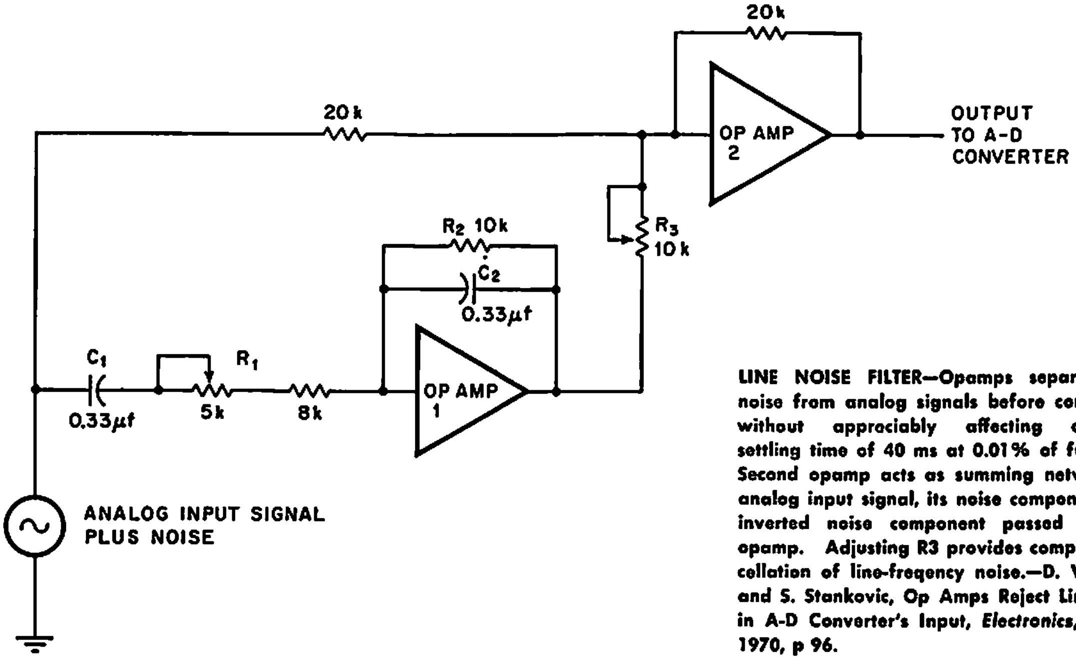

POWER SOURCE-
EXCITED BY RINGING CURRENT
OSILLATOR
CIRCUIT
3.5
μf
5600
100K
1.0μf
4UI
1000
0.01
μf
300pf
2TI
TONE
RINGER
4700
SIGNALITE
RT2-32-IA
6800
2N241A
0.01μf
8500
TANK
CIRCUIT
*
32
46
125
INDUCTION
COIL
540
TURNS
608
TURNS
356
TURNS
LINE
DIAL
CONTACTS
TRANSMITTER
T
R
RECEIVER
TELEPHONE
2μf

✱ INSERT JUMPER TO DECREASE LEVEL

DIALING SIGNAL SUPPRESSOR—Neon glow lamp in Ericofon handset suppresses undesirable dial-tapping sound that could sometimes activate another extension or telephone. Application requires that breakdown voltage of neon remain constant within 8% over life of telephone. Lamp has radioactive material that stabilizes its breakdown voltage. Circuit also shows tone oscillator that replaces conventional bell ringer and is activated by same 20-Hz ringing voltage.—E. Bauman, Glow Lamp Prevents Telephone Dial Tapping, *Electronic Design*, Dec. 21, 1964, p 46–48.


+ 250V
560K
D3 IN504
47K
4µf
100K
4µf
SIGNAL INPUT
68K
12K
2000
3300
+
-
10µf
D1 IN482A
D2 IN482A
10µf
-
+
D4 IN482A
1000
1000
12.6 VCT
T1
115V
METER 0-100µa

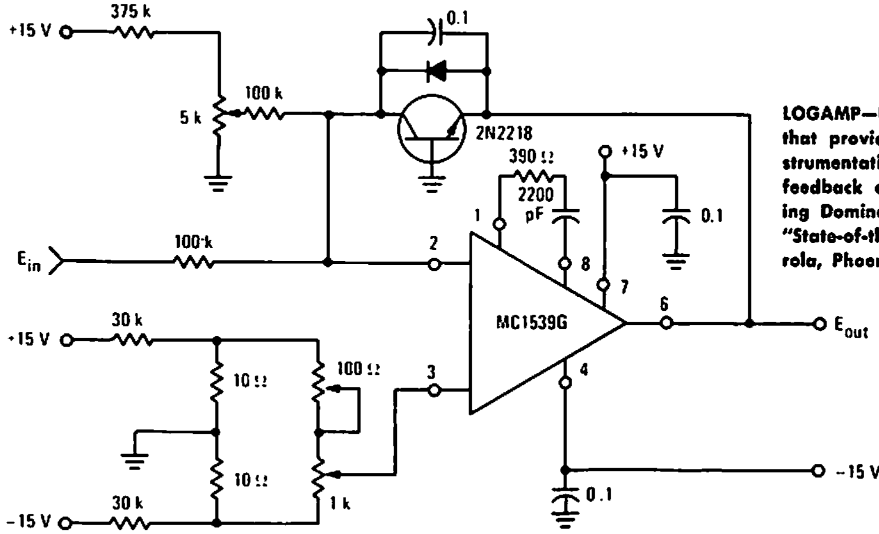
TUNING 60-HZ SIGNAL BURIED IN NOISE—Uses synchronous modulation to get peak output level of desired signal at power-line frequency even though buried in noise exceeding it by one or two orders of magnitude. Output actuates meter through RC filter having time constant of about 0.04 s.—H. L. Kahn, Peak Voltage Indicator Solves Tuning Problem, *Electronic Design*, Jan. 20, 1964, p 84–85.


20k
20k
OP AMP 2
OUTPUT TO A-D CONVERTER
R3 10k
R2 10k
C2
0.33µf
C1
R1
0.33µf
5k
8k
OP AMP 1
ANALOG INPUT SIGNAL PLUS NOISE

LINE NOISE FILTER—Opamps separate line noise from analog signals before conversion, without appreciably affecting converter settling time of 40 ms at 0.01% of full scale. Second opamp acts as summing network for analog input signal, its noise component, and inverted noise component passed by first opamp. Adjusting R3 provides complete cancellation of line-freqency noise.—D. Velasevic and S. Stankovic, Op Amps Reject Line Noise in A-D Converter's Input, *Electronics*, Jan. 5, 1970, p 96.

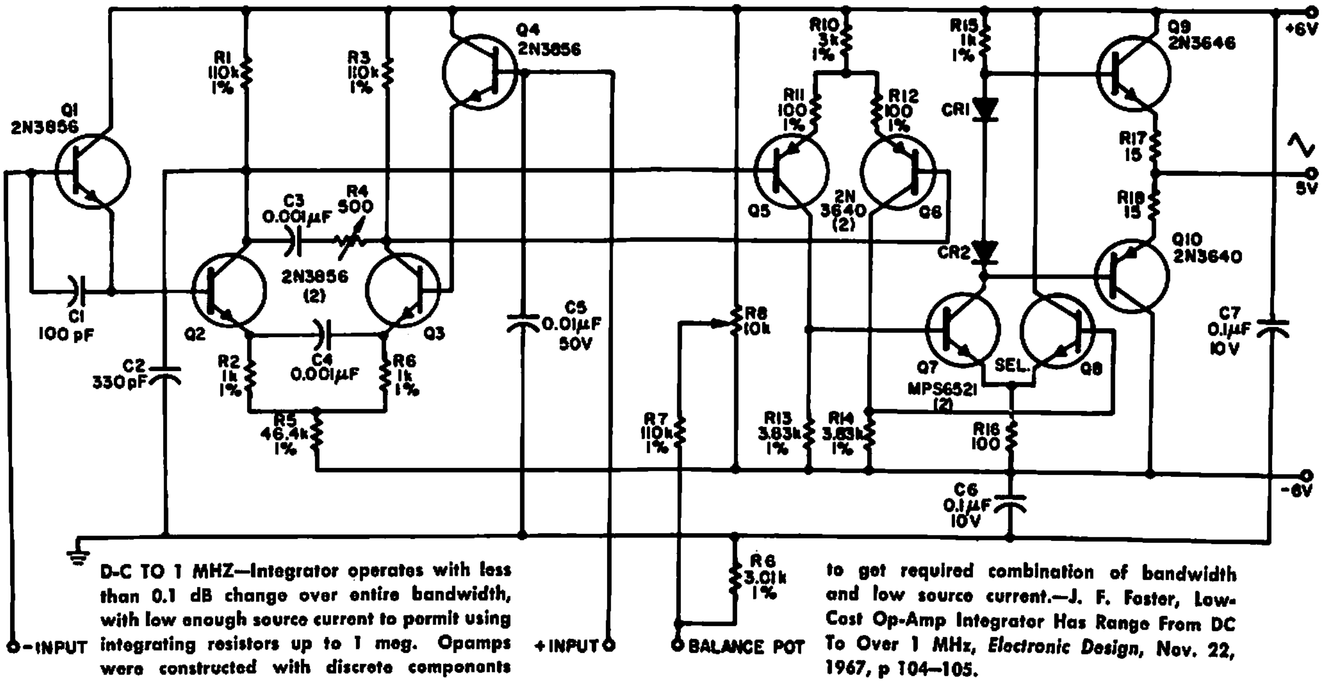
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 56
Operational Amplifier Circuits



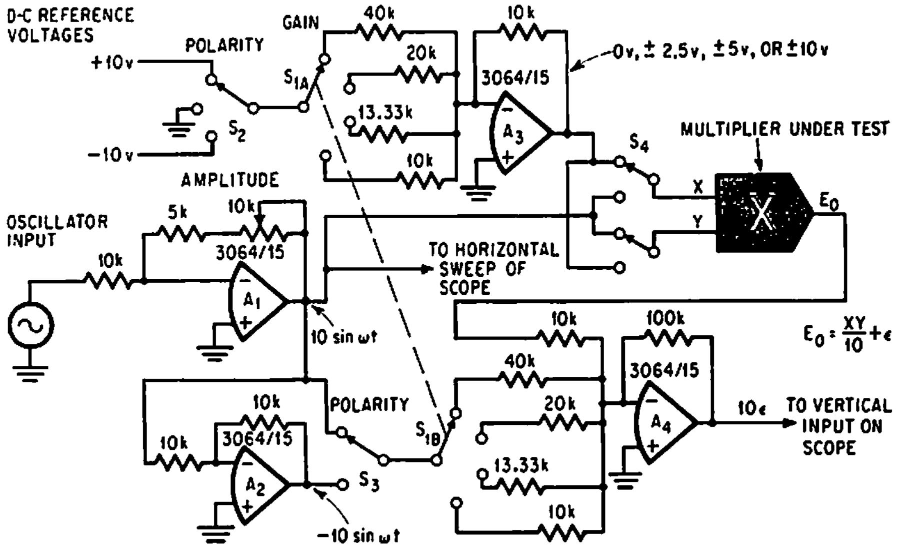
+15 V
375 k
5 k
100 k
0.1
2N2218
390 Ω
2200 pF
+15 V
0.1
1
2
8
7
6
E_{in}
100 k
MC1539G
E_{out}
+15 V
30 k
10 Ω
100 Ω
3
4
10 Ω
1 k
−15 V
30 k
−15 V
0.1

LOGAMP—Uses Motorola opamp in circuit that provides logarithmic compression of instrumentation data. Transistor serves as feedback element.—K. Huehne, The Continuing Dominance of the Operational Amplifier, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 5–13.

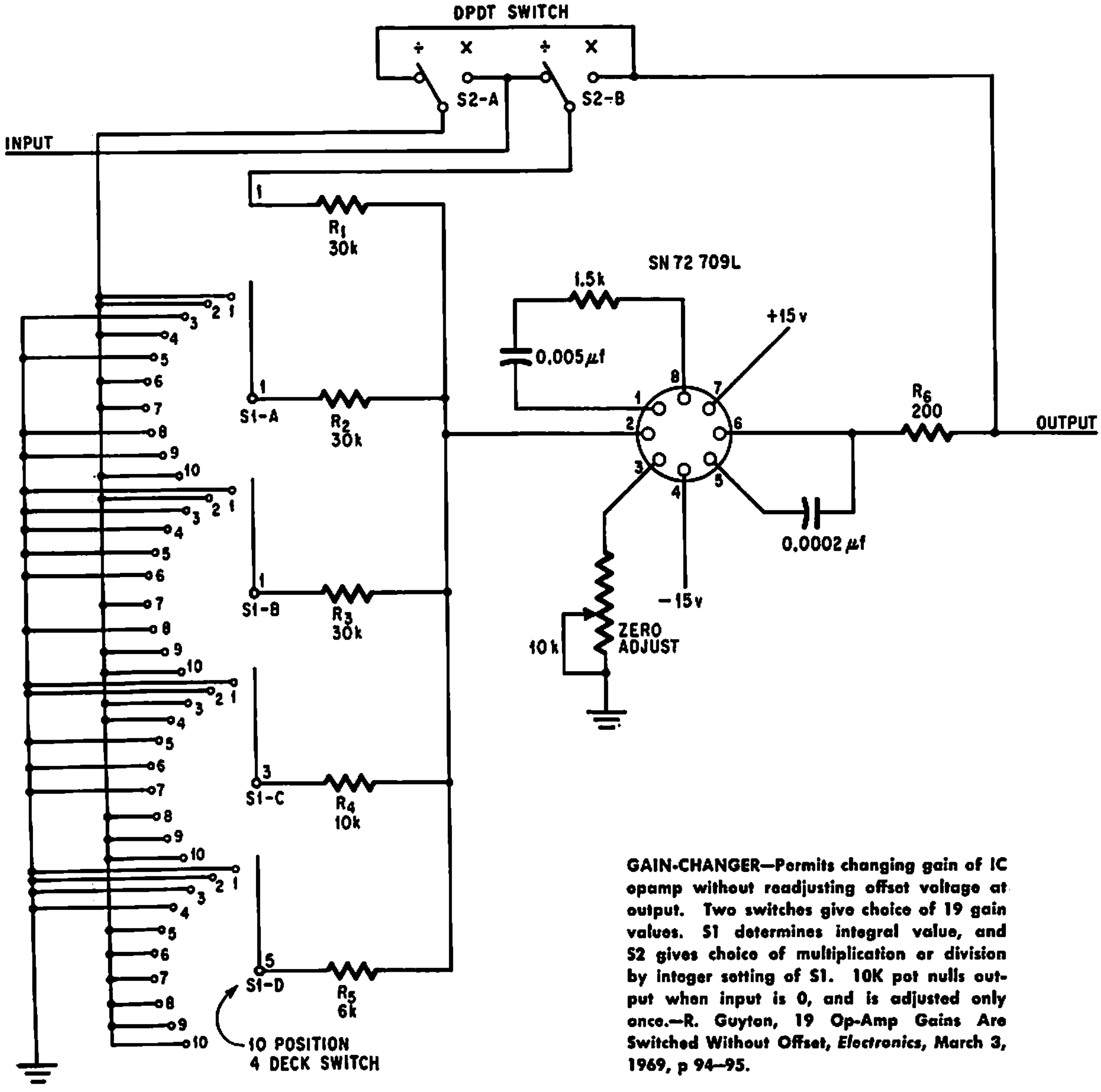


Q1
2N3856
R1
110k
1%
R3
110k
1%
Q4
2N3856
R10
3k
1%
R15
1k
1%
Q9
2N3646
+6V
R11
100
1%
R12
100
1%
CR1
R17
15
5V
C3
0.001μF
R4
500
2N
3640
(2)
Q5
Q6
R18
15
Q10
2N3640
CR2
2N3856
(2)
C1
100 pF
Q2
Q3
C5
0.01μF
50V
R8
10k
C7
0.1μF
10V
C4
0.001μF
R2
1k
1%
R6
1k
1%
Q7
SEL.
Q8
MPS6521
(2)
C2
330pF
R5
46.4k
1%
R7
110k
1%
R13
3.83k
1%
R14
3.83k
1%
R16
100
-6V
C6
0.1μF
10V
R6
3.01k
1%
-INPUT
+INPUT
BALANCE POT

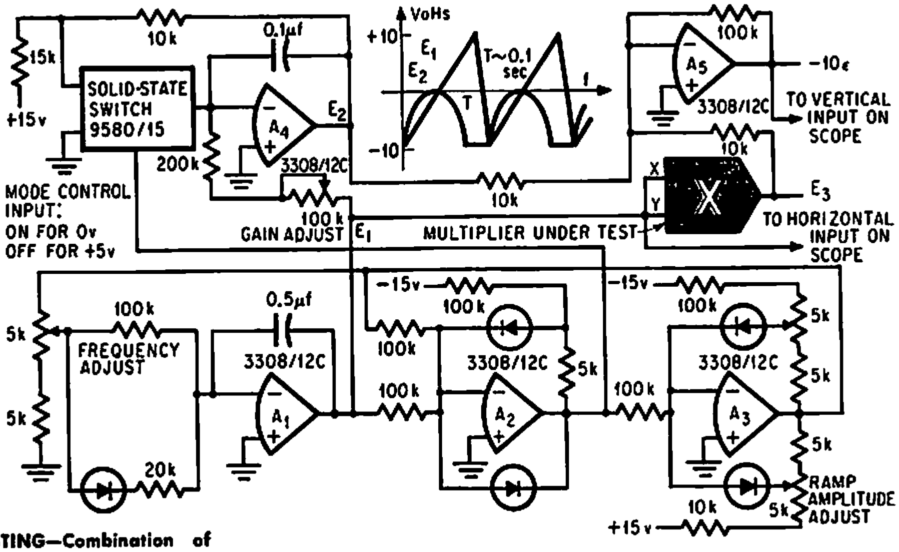
D-C TO 1 MHZ—Integrator operates with less than 0.1 dB change over entire bandwidth, with low enough source current to permit using integrating resistors up to 1 meg. Opamps were constructed with discrete components to get required combination of bandwidth and low source current.—J. F. Foster, Low-Cost Op-Amp Integrator Has Range From DC To Over 1 MHz, *Electronic Design*, Nov. 22, 1967, p 104–105.


D-C REFERENCE VOLTAGES
+10v
-10v
POLARITY
S_2
GAIN
S_{1A}
40k
20k
13.33k
10k
10k
3064/15
A_3
-0v, ± 2.5v, ±5v, OR ±10v
S_4
MULTIPLIER UNDER TEST
X
Y
E_0
AMPLITUDE
OSCILLATOR INPUT
5k
10k
10k
3064/15
A_1
10 sin ωt
TO HORIZONTAL SWEEP OF SCOPE
$E_0 = \frac{XY}{10} + \epsilon$
10k
100k
40k
20k
13.33k
10k
3064/15
A_4
10ϵ
TO VERTICAL INPUT ON SCOPE
10k
10k
3064/15
A_2
POLARITY
S_{1B}
S_3
-10 sin ωt

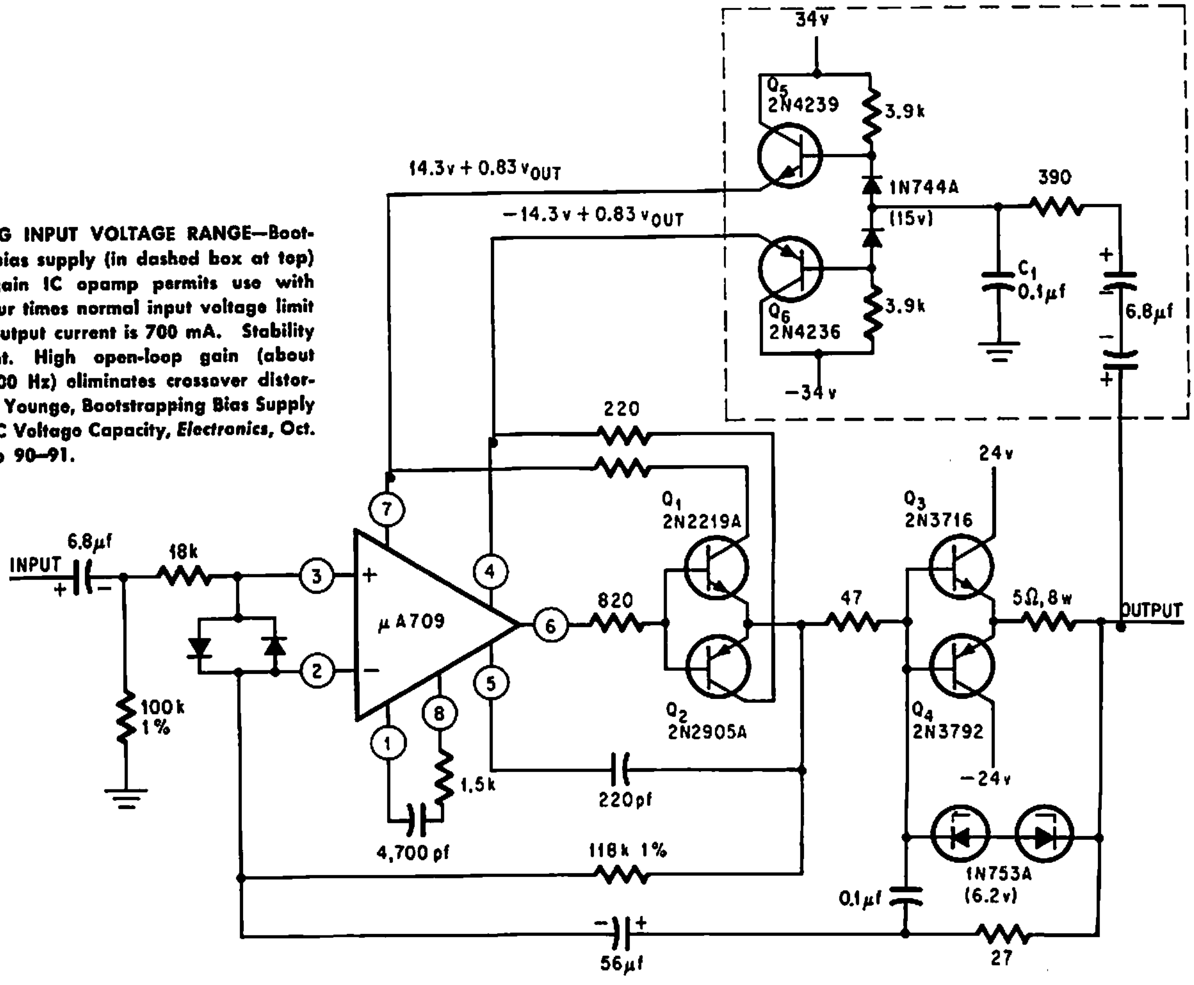
ANALOG MULTIPLIER TESTER—Combination of four opamps and scope serves for measuring gain and offset errors of analog multipliers quickly, efficiently, and accurately. S1 gives choice of four d-c input voltages—0, 2.5, 5, and 10 V—with either polarity, and also sets gain for multiplier. Amplitude of sine-wave input is not critical. Same test setup will measure frequency response of multiplier.—T. Cate, Top Performance from Analog Multipliers? Much Depends on Errors Gauged in Your Circuit, *Electronics*, April 13, 1970, p 114–117.


DPDT SWITCH
÷
X
÷
X
S2-A
S2-B
INPUT
1
R_1 30k
SN 72 709L
1.5k
0.005µf
+15v
8
7
1
2
6
3
4
5
R_6 200
OUTPUT
0.0002µf
-15v
10k
ZERO ADJUST
S1-A
R_2 30k
S1-B
R_3 30k
S1-C
R_4 10k
S1-D
R_5 6k
1
2
3
4
5
6
7
8
9
10
10 POSITION 4 DECK SWITCH

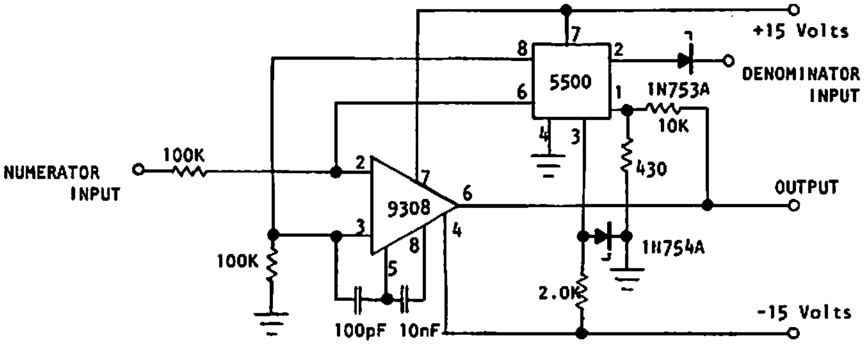
GAIN-CHANGER—Permits changing gain of IC opamp without readjusting offset voltage at output. Two switches give choice of 19 gain values. S1 determines integral value, and S2 gives choice of multiplication or division by integer setting of S1. 10K pot nulls output when input is 0, and is adjusted only once.—R. Guyton, 19 Op-Amp Gains Are Switched Without Offset, *Electronics*, March 3, 1969, p 94–95.


15k
+15v
10k
0.1μf
SOLID-STATE SWITCH 9580/15
200k
A4
3308/12C
E2
100k
GAIN ADJUST
E1
MODE CONTROL INPUT:
ON FOR 0v
OFF FOR +5v
VoHs
+10
-10
E1
E2
T~0.1 sec
T
t
A5
100k
3308/12C
-10ε
TO VERTICAL INPUT ON SCOPE
10k
10k
X
Y
E3
TO HORIZONTAL INPUT ON SCOPE
MULTIPLIER UNDER TEST
5k
100k
FREQUENCY ADJUST
5k
20k
0.5μf
3308/12C
A1
-15v
100k
100k
100k
3308/12C
A2
5k
-15v
100k
100k
3308/12C
A3
5k
5k
5k
RAMP AMPLITUDE ADJUST
10k
5k
+15v

SQUARING-MODE TESTING—Combination of five low-cost fet-input opamps, IC solid-state switch, and scope serves for testing squaring accuracy of quarter-square or variable-transconductance-type analog multipliers. Two equal inputs are integrated to give ramp functions, which in turn are integrated and resulting curves subtracted from ramps to determine multiplier error. Article gives relevant equations and graphs.—T. Cate, Top Performance from Analog Multipliers? Much Depends on Errors Gauged in Your Circuit, *Electronics*, April 13, 1970, p 114–117.

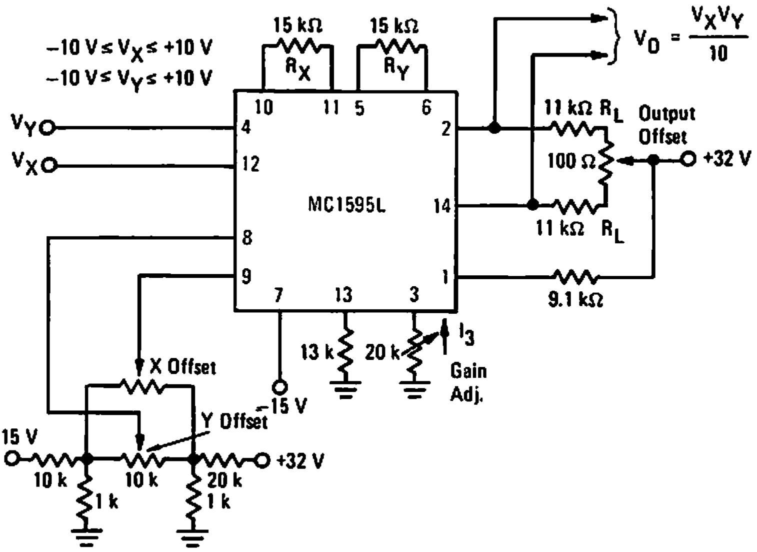

34v
Q5
2N4239
3.9k
1N744A
(15v)
390
C1
0.1μf
6.8μf
Q6
2N4236
3.9k
-34v
14.3v + 0.83 vOUT
-14.3v + 0.83 vOUT
220
INPUT
6.8μf
18k
100k 1%
7
3
2
4
μA709
6
5
1
8
1.5k
4,700 pf
820
Q1
2N2219A
Q2
2N2905A
220pf
118k 1%
56μf
47
24v
Q3
2N3716
Q4
2N3792
-24v
5Ω, 8w
OUTPUT
1N753A
(6.2v)
0.1μf
27

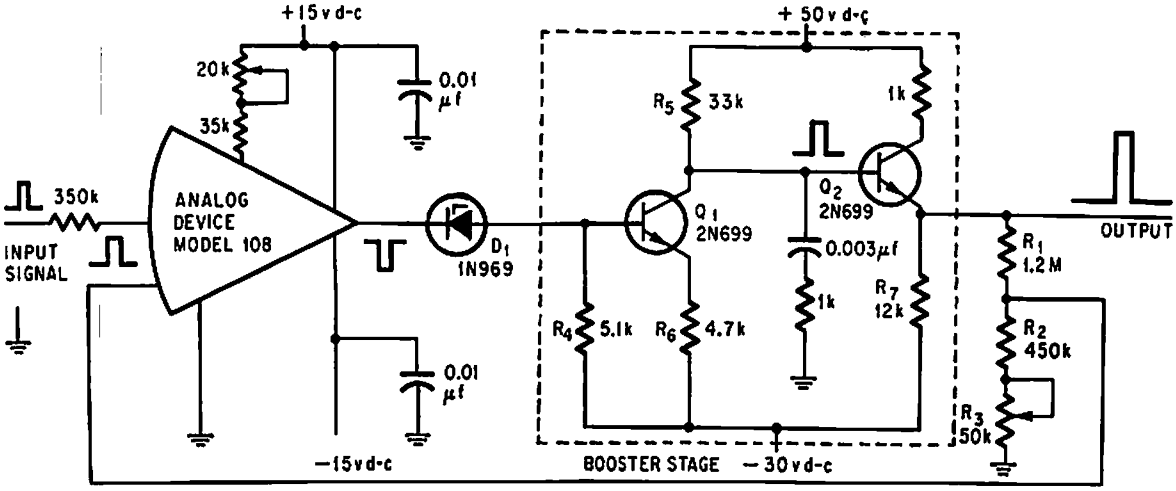
INCREASING INPUT VOLTAGE RANGE—Bootstrapping bias supply (in dashed box at top) for unity-gain IC opamp permits use with three to four times normal input voltage limit of 7 V. Output current is 700 mA. Stability is excellent. High open-loop gain (about 2,000 at 400 Hz) eliminates crossover distortion.—D. R. Younge, Bootstrapping Bias Supply Increases IC Voltage Capacity, *Electronics*, Oct. 28, 1968, p 90–91.


+15 Volts
DENOMINATOR INPUT
5500
1N753A
10K
430
OUTPUT
NUMERATOR INPUT
100K
9308
100K
1N754A
2.0K
100pF
10nF
-15 Volts
8
7
2
6
1
4
3
2
3
7
6
4
8
5

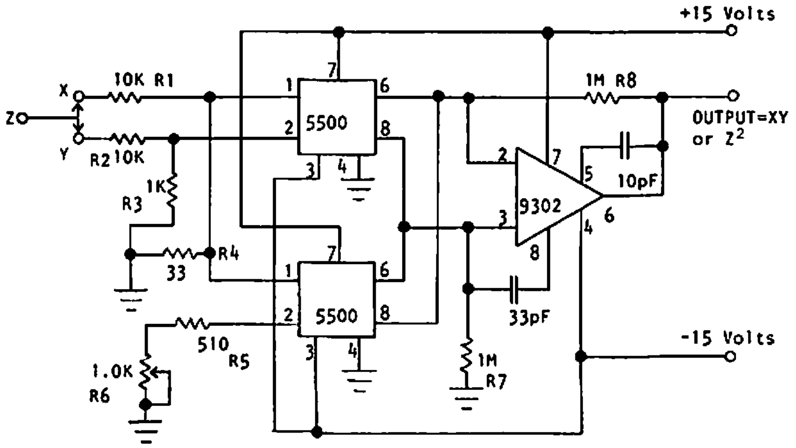
TWO-QUADRANT ANALOG DIVIDER—Input and output signal levels are 10 V full scale. Numerator and output are bipolar but denominator is positive only. Division is obtained by connecting analog multiplier 5500 in feedback loop of opamp.—Applying the Model 5500 Monolithic Analog Multiplier, Optical Electronics, Tucson, Ariz., No. 10138.

IC MULTIPLIER—Accommodates input voltages over range of −10 V to +10 V. Output dynamic swing will ride 22-V common-mode level. Frequency response is down 3 dB at 4.5 MHz.—E. Renschler, The Monolithic Multiplier Breakthrough, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 27–36.


$-10\text{ V} \le V_X \le +10\text{ V}$
$-10\text{ V} \le V_Y \le +10\text{ V}$
15 kΩ
R_X
15 kΩ
R_Y
$V_0 = \frac{V_X V_Y}{10}$
V_Y
V_X
MC1595L
10
11
5
6
4
12
2
14
8
9
1
7
13
3
11 kΩ R_L
Output Offset
100 Ω
+32 V
11 kΩ R_L
9.1 kΩ
13 k
20 k
I_3
Gain Adj.
X Offset
Y Offset
−15 V
−15 V
10 k
10 k
20 k
+32 V
1 k
1 k

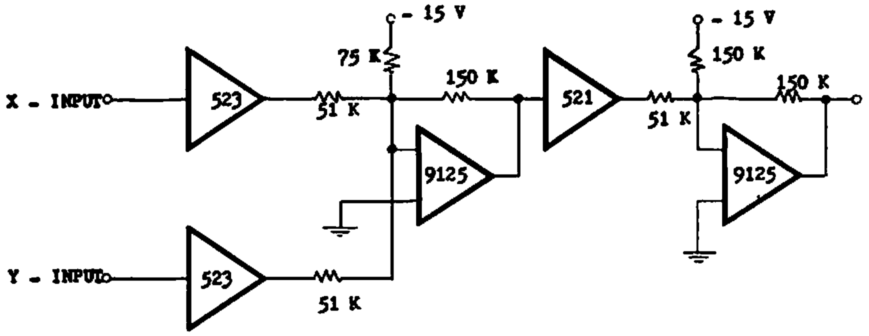

+15 v d-c
20k
35k
0.01 μf
350k
INPUT SIGNAL
ANALOG DEVICE MODEL 108
D_1
1N969
0.01 μf
−15 v d-c
+ 50 v d-c
R_5 33k
1k
Q_1 2N699
Q_2 2N699
0.003 μf
1k
R_7 12k
R_4 5.1k
R_6 4.7k
BOOSTER STAGE
−30 v d-c
OUTPUT
R_1 1.2 M
R_2 450k
R_3 50k

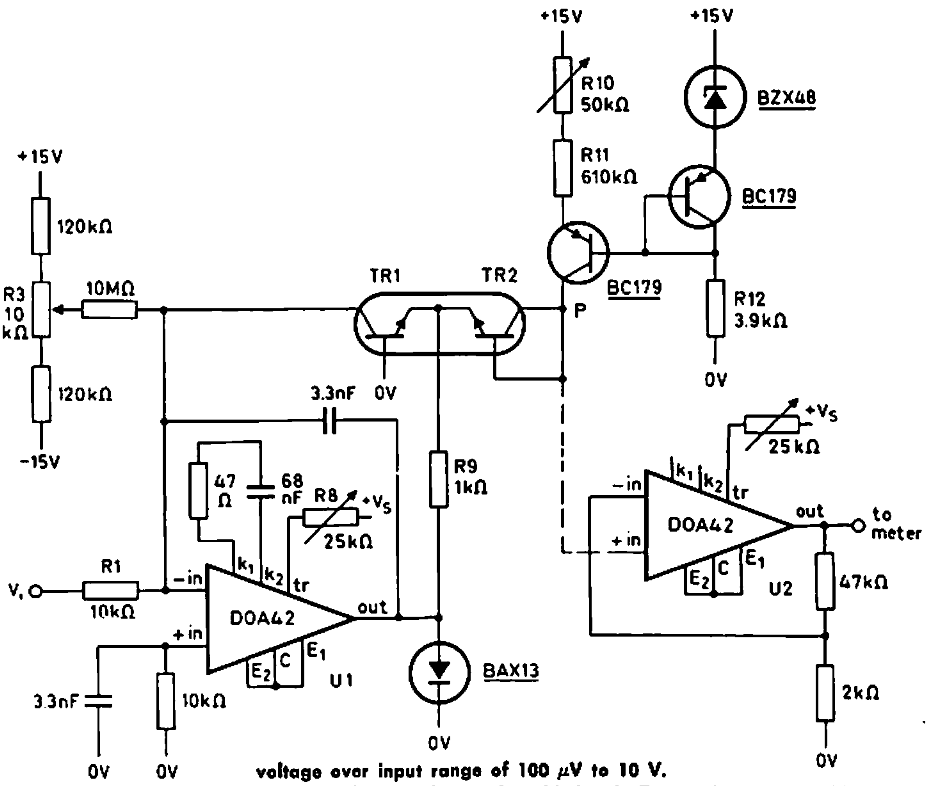
VOLTAGE BOOSTER—Two transistors and zener diode give high output voltage from low-voltage opamp having good gain and stability. Can be used to measure phase angle changes as small as 0.01%.—A. Freilich, Boosting Op-Amp Output With Two Transistors, *Electronics*, June 10, 1968, p 110–111.


+15 Volts
X
Z
Y
10K R1
R2 10K
1K
R3
33
R4
510
R5
1.0K
R6
5500
5500
1
2
3
4
6
7
8
1M R8
OUTPUT=XY
or Z^2
9302
10pF
33pF
1M
R7
-15 Volts

BIPOLAR SQUARING—Consists of four-quadrant multiplier having 10 V input and output signal levels of both polarities. Bandwidth is d-c to 10 kHz, but may be increased by changing R7 and R8 to 100K. When inputs are connected together as shown, circuit becomes squaring amplifier. R6 adjusts offset at Y input or adjusts symmetry of output parabola when squaring.—Applying the Model 5500 Monolithic Analog Multiplier, Optical Electronics, Tucson, Ariz., No. 10138.

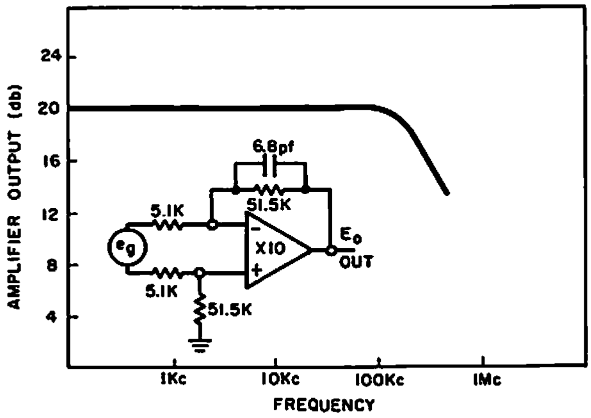
SQUARE ROOT OF SUM OF SQUARES—Uses five OEI IC's to square X and Y inputs. First 9125 opamp sums the squares, 521 performs square root, and 9125 at output cancels offset so output is absolute value of input function. Inputs and outputs are all positive.—Generating Square Root of Sum of Squares Function, Optical Electronics, Tucson, Ariz., No. 10085.

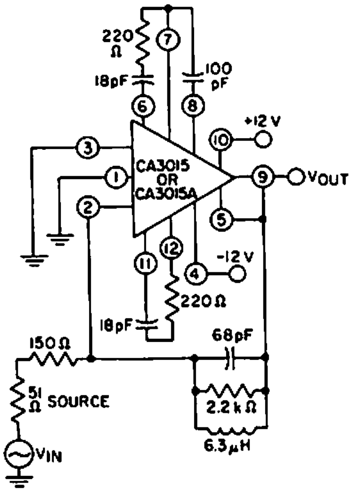

X - INPUT
Y - INPUT
523
523
51 K
51 K
75 K
- 15 V
150 K
9125
521
51 K
- 15 V
150 K
150 K
9125


+15V
120kΩ
R3
10
kΩ
120kΩ
-15V
10MΩ
TR1
TR2
0V
3.3nF
47
Ω
68
nF
R8
+Vs
25kΩ
V_i
R1
10kΩ
-in
+in
k_1
k_2
tr
DOA42
out
E_2
C
E_1
U1
3.3nF
10kΩ
0V
0V
R9
1kΩ
BAX13
0V
+15V
R10
50kΩ
R11
610kΩ
BC179
P
+15V
BZX48
BC179
R12
3.9kΩ
0V
+Vs
25kΩ
-in
+in
DOA42
out
to
meter
U2
47kΩ
2kΩ
0V

LOGAMP—Uses logarithmic voltage-current relationship in semiconductor junction to provide, by means of feedback in Philips DOA42 IC opamp, output which is logarithm of input voltage over input range of 100 μV to 10 V. Opamp at lower right may be added as buffer and amplifier for logarithmic signal. Transistors TR1 and TR2 can be selected examples of BCY87 having high hFE at low IC values. Circuit is suitable for positive input voltages only.—A. Schechtman, A Logarithmic Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 86.

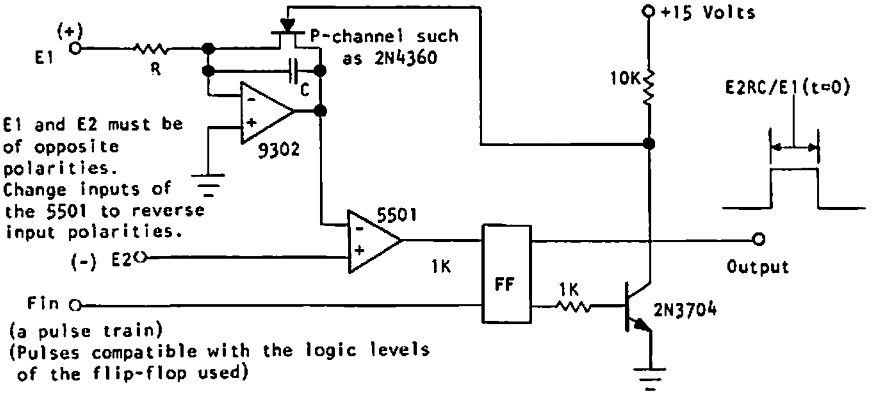
IC DIFFERENCE AMPLIFIER—Provides gain of 20, with frequency response shown by curve. IC can be SN521, or SN522 having added emitter-follower for greater drive capability. —L. Housey and G. McFarland, Using Integrateds as Feedback Amplifiers, *Electronic Design*, March 2, 1964, p 49–52.





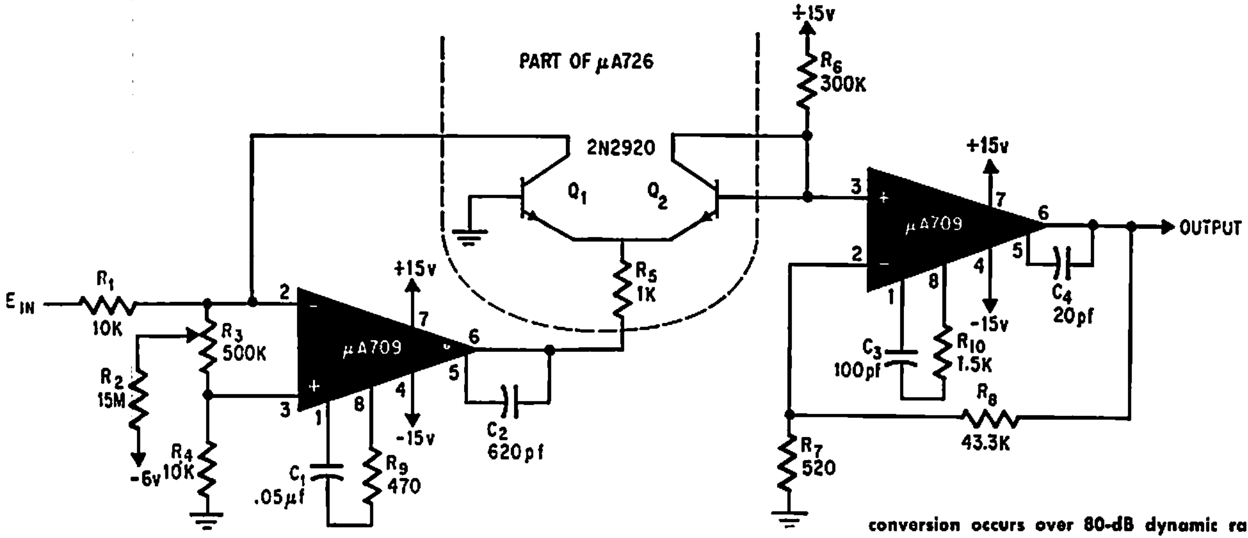
220Ω
18pF
7
100 pF
6
8
+12 V
3
10
1
CA3015 OR CA3015A
9
VOUT
2
5
-12V
11
12
4
220Ω
18pF
68pF
150Ω
51Ω SOURCE
2.2kΩ
6.3μH
VIN

10-MHZ R-L-C BANDPASS—Gain is about 20 dB at resonance, and 3-dB bandwidth is about 1 MHz. Inputs are effectively grounded.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 262.



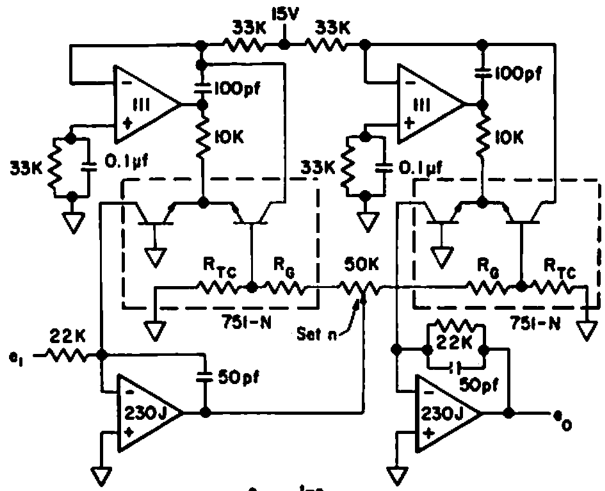
(+)
E1
R
P-channel such as 2N4360
C
+15 Volts
10K
E2RC/E1(t=0)
E1 and E2 must be of opposite polarities. Change inputs of the 5501 to reverse input polarities.
9302
5501
(-) E2
1K
FF
Output
1K
2N3704
Fin
(a pulse train)
(Pulses compatible with the logic levels of the flip-flop used)

ANALOG DIVIDER—Analog input E1 drives integrator, while analog input E2 is reference level of analog comparator. When integrator output is greater than reference, comparator sets flip-flop FF, which changes state at next clock pulse, making fet reset integrator and start process over again. End of clock pulse resets flip-flop. Output is rectangular pulse train. Flip-flop may be any RS type having sufficient speed for clock rate used.—An Average Value Analog Divider, Optical Electronics, Tucson, Ariz., No. 10145.



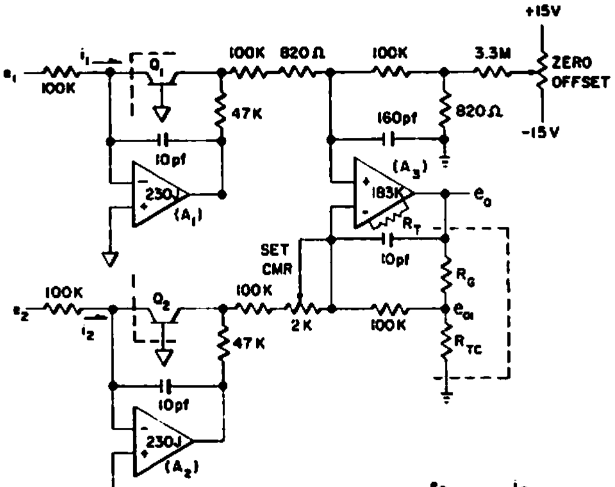
PART OF μA726
+15v
R6 300K
2N2920
Q1
Q2
+15v
3
7
6
μA709
OUTPUT
2
5
4
8
1
+15v
C4 20pf
R5 1K
-15v
EIN
R1 10K
2
7
C3 100pf
R10 1.5K
R3 500K
μA709
6
5
R8 43.3K
R2 15M
3
1
8
4
-15v
C2 620pf
R7 520
-6v
R4 10K
C1 .05μf
R9 470

LOG AMPLIFIER—Two Fairchild μA709 IC opamps and transistor pair from temperature-compensated IC differential amplifier together serve to multiply and divide signals in true logarithmic fashion. The transistors, connected as feedback stage between IC's, add the two signal levels after they have been converted to logarithmic form. Logarithmic conversion occurs over 80-dB dynamic range and wide temperature range.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


15V
33K
33K
100pf
100pf
111
111
10K
10K
33K
0.1µf
33K
0.1µf
R_TC
R_G
50K
R_G
R_TC
751-N
Set n
751-N
22K
e_i
22K
50pf
50pf
230J
230J
e_o

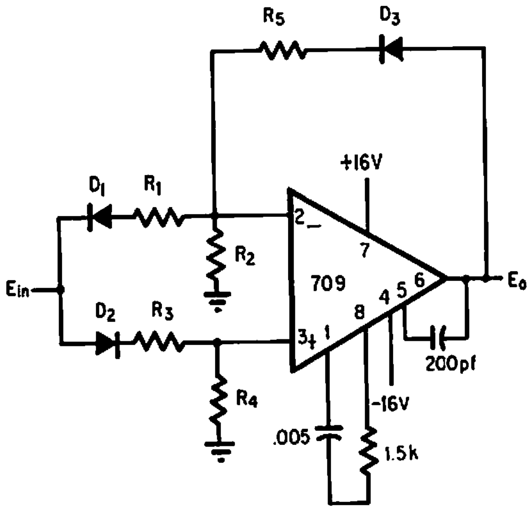
$e_o = (e_i)^n \times 10^{1-n}$

EXPONENTIAL FUNCTION OF VOLTAGE—Exponent generated is adjustable between 0.25 and 4 by means of single potentiometer. Dashed rectangles are Analog Devices 751N log modules; 111 is reference opamp and 230J is chopper-stabilized opamp.—W. Borlase and E. David, Design of Temperature Compensated Log Circuits Employing Transistors and Operational Amplifiers, Analog Devices, Cambridge, Mass., E020-10-3/69, p 12.


+15V
e_1
100K
i_1
Q_1
100K
820Ω
100K
3.3M
ZERO OFFSET
-15V
47K
160pf
820Ω
10pf
230J
(A_1)
(A_3)
183K
e_o
R_T
SET CMR
10pf
R_G
100K
e_2
i_2
Q_2
100K
2K
100K
e_oi
47K
R_TC
10pf
230J
(A_2)

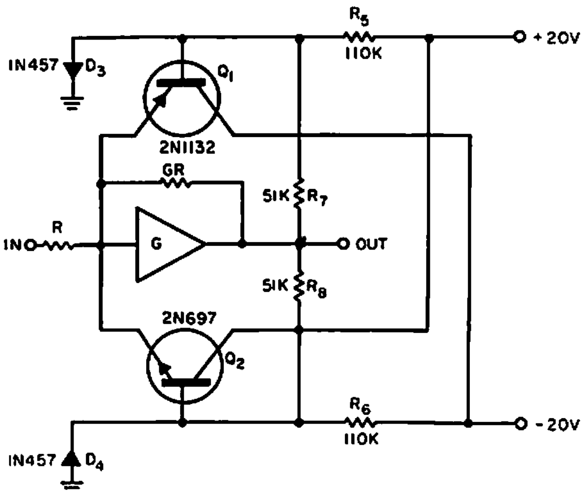
$e_o = 1.0 \log \frac{e_2}{e_1} = 1.0 \log \frac{i_2}{i_1}$ V

PRECISION LOG OF VOLTAGE OR CURRENT RATIO—Provides accurate logarithmic conversion on both inputs. Uses Analog Devices 230J chopper-stabilized amplifiers with 751N log element for positive inputs (dashed rectangle) or 751P for negative inputs. Differential amplifier 183K is high-impedance type. Circuit includes common mode response zeroing control and zero offset control.—W. Borlase and E. David, Design of Temperature Compensated Log Circuits Employing Transistors and Operational Amplifiers, Analog Devices, Cambridge, Mass., E020-10-3/69, p 12.

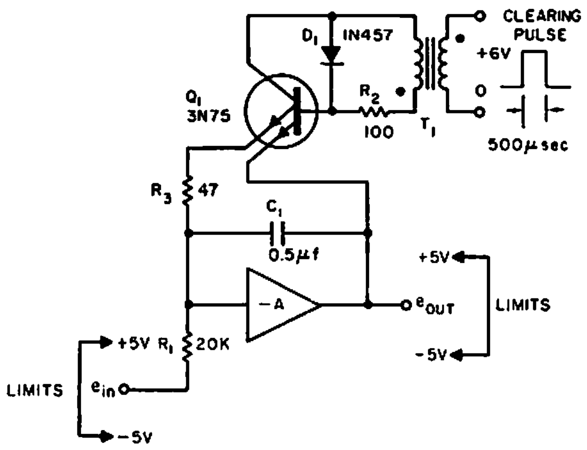

R5
D3
+16V
D1
R1
2
R2
7
Ein
709
6
E_o
5
4
8
D2
R3
3
1
200pf
R4
-16V
.005
1.5k

$R_1 - R_5 = 50k$

ABSOLUTE VALUES—Requires only single IC opamp for converting d-c input voltages of either polarity to their absolute value. Accuracy is 0.1% from 0 to 50 C for bipolar inputs of 0.5 to 15 V. Article tells how input polarity changes transfer function. R1 through R5 have equal values, and forward resistances of all three diodes are identical. —W. Spani, Absolute Value Circuit Needs Only One Op Amp, *Electronics*, Jan. 20, 1969, p 89.

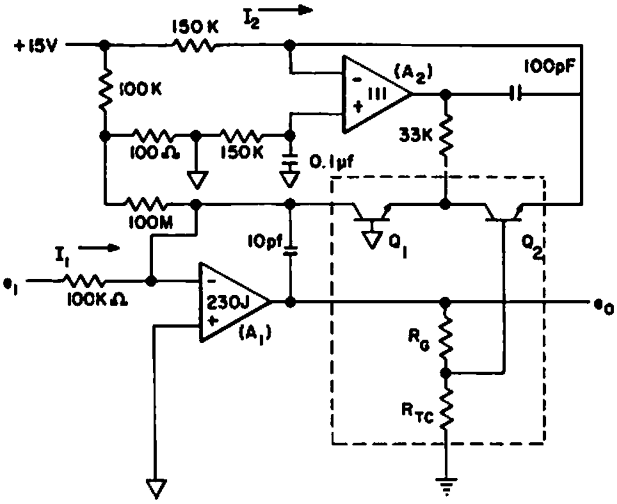

R_5
+20V
110K
1N457
D_3
Q_1
2N1132
GR
51K
R_7
R
IN
G
OUT
51K
R_8
2N697
Q_2
R_6
-20V
110K
1N457
D_4

OPAMP LIMITER—Modification of differential amplifier circuit Q1-Q2 serves to limit output of opamp G to plus or minus 10 V. Coupling and biasing resistors are not in feedback loop, so arrangement gives good hard limiting.—P. A. Ralatos, Reset Circuit Independent of Amplitude and Polarity, *Electronic Design*, Oct. 25, 1965, p 70 and 72.


D1 1N457
CLEARING PULSE
+6V
0
500µsec
Q1 3N75
R2 100
T1
R3 47
C1 0.5µf
-A
eOUT
+5V
-5V
LIMITS
+5V R1 20K
ein
-5V
LIMITS

T1 = 400 OHMS, 1:1 RATIO MINIATURE AUDIO TRANSFORMER

CLEARING—Combination of dual-emitter transistor Q1, transformer, and diode D1 clears integrator by discharging its capacitor when clearing pulse is applied, without producing d-c leakage path between either end of C1 and control signal. Circuit will reset integrator to within 10 mV of zero.—J. A. Wisnia, Dual-Emitter Transistor Clears Integrator Circuit, *Electronic Design*, June 7, 1965, p 41–42.


+15V
150K
I_2
100K
(A_2)
111
100pF
100Ω
150K
0.1µf
33K
100M
Q1
Q2
I_1
10pf
e_1
100KΩ
230J
(A_1)
R_G
R_{TC}
e_o

INPUT RANGE:

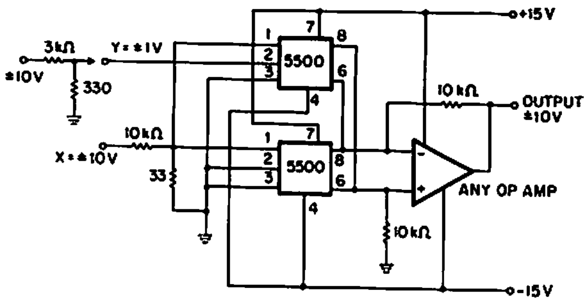
$1\text{mV} < e_1 < 10\text{V}$ or $10\text{nA} < I_1 < 100\mu\text{A}$

$$-e_o = 1.0 \log \frac{e_1}{e_R}\frac{R_R}{R_1} = \log \frac{e_1 \times 150K}{15 \times 100K} = \log \frac{e_1}{10}\,(V)$$

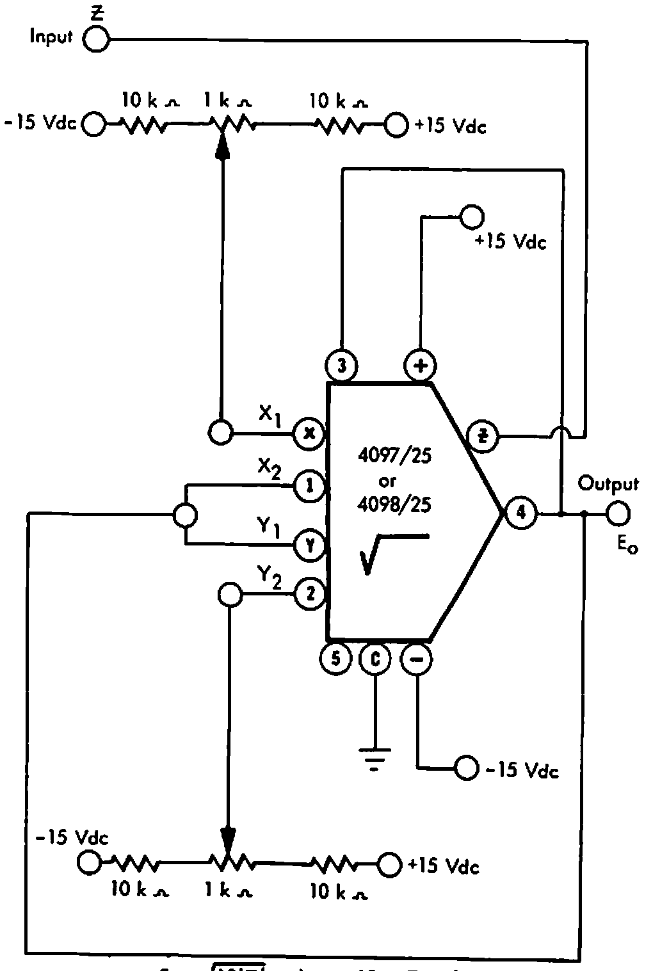
$$\tau = \left(\frac{1}{40I}R_E\right)C_f,\; I_{min} = \frac{15mV}{100M\Omega} = 150\,pA$$

$$\tau_{min} = \left(\frac{1}{40 \times 1.5 \times 10^{-10}} + 33K\right)10^{-11} \approx 1.6\,ms$$

LOG OF VOLTAGE OR CURRENT—Provides logarithmic compression of inputs to 230J chopper-stabilized amplifier over wide dynamic range (10 pA to 100 µA). Dashed rectangle is Analog Devices 751N log element for positive inputs (use 751P for negative inputs).—W. Borlaso and E. David, Design of Temperature Compensated Log Circuits Employing Transistors and Operational Amplifiers, Analog Devices, Cambridge, Mass., E020-10-3/69, p 11.

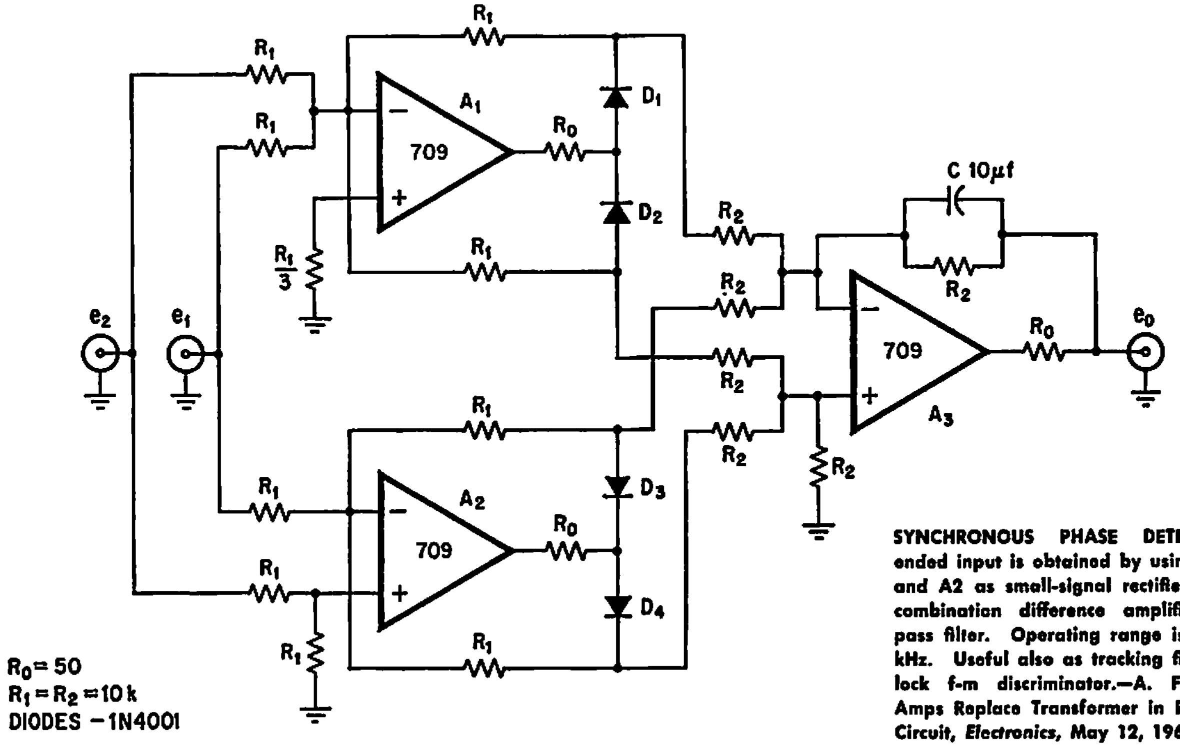

+15V
3kΩ
Y=±1V
±10V
330
5500
10kΩ
OUTPUT ±10V
10kΩ
X=±10V
33
5500
ANY OP AMP
10kΩ
-15V

FOUR-QUADRANT MULTIPLIER—Two OEI 5500 analog multipliers feed opamp to provide product of two inputs over four quadrants. Opamp is not critical. Output is 10 V full-scale with either polarity when R is 100K. Frequency response depends on opamp up to 10 MHz.—Two and Four Quadrant Multipliers using the OEI Model 5500, Optical Electronics, Tucson, Ariz., No. 10140.

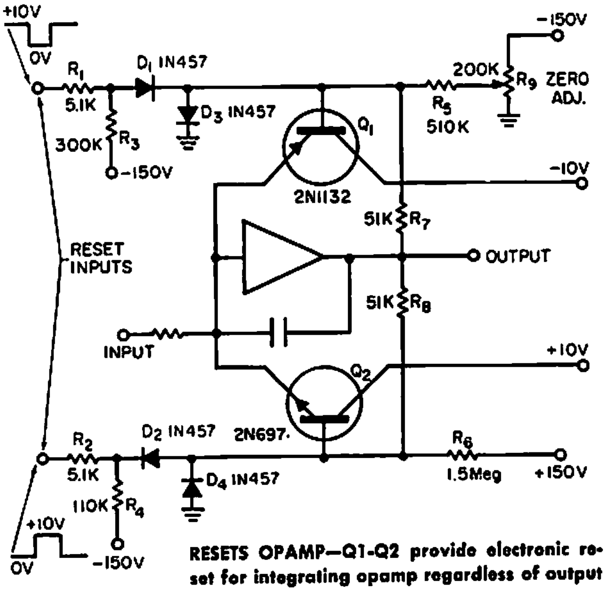

Z
Input
10 kΩ
1 kΩ
10 kΩ
-15 Vdc
+15 Vdc
+15 Vdc
X1
X2
Y1
Y2
4097/25 or 4098/25
Output
E_o
-15 Vdc
-15 Vdc
+15 Vdc
10 kΩ
1 kΩ
10 kΩ

$E_o = \sqrt{10|Z|}$, where $-10 \le Z \le 0$.

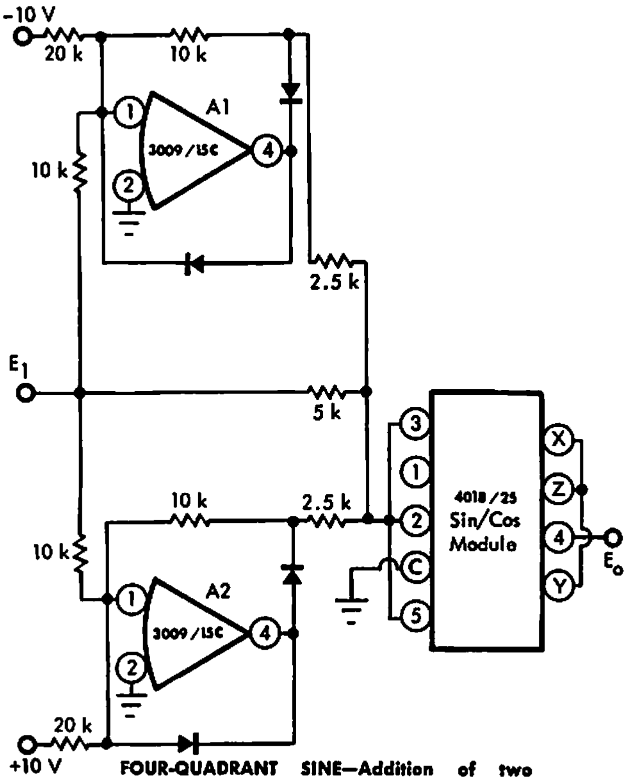
SQUARE-ROOTING—Connection shown for Burr-Brown differential-input multiplier-divider package provides noninverting square-root mode of operation with offset nulling. Multiplier is used to square output signal. Report discusses causes of square-rooting errors.—Differential Input Multiplier/Dividers, Burr-Brown Research, Tucson, Ariz., PDS-201A-2, 1969.


R1
R1
R1
A1
709
R0
D1
D2
R1/3
R1
C 10μf
R2
R2
R2
R2
R2
R2
709
R0
A3
e2
e1
e0
R1
R1
A2
709
R0
D3
D4
R1
R1
R1
R0 = 50
R1 = R2 = 10 k
DIODES – 1N4001

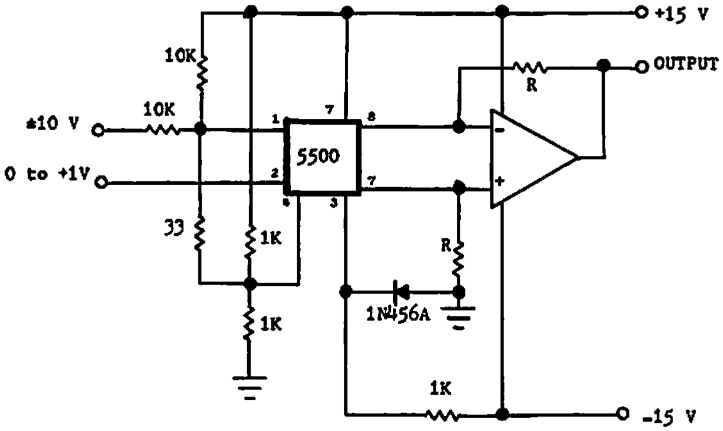
SYNCHRONOUS PHASE DETECTOR—Single-ended input is obtained by using opamps A1 and A2 as small-signal rectifiers and A3 as combination difference amplifier and low-pass filter. Operating range is 10 Hz to 10 kHz. Useful also as tracking filter or phase-lock f-m discriminator.—A. F. Gangi, Op Amps Replace Transformer in Phase Detector Circuit, *Electronics*, May 12, 1969, p 109.


+10V
0V
R1
5.1K
D1 IN457
D3 IN457
300K R3
-150V
Q1
2N1132
200K
R9 ZERO ADJ.
R5
510K
-150V
-10V
51K R7
OUTPUT
51K R8
RESET INPUTS
INPUT
+10V
Q2
2N697
R2
5.1K
D2 IN457
D4 IN457
110K R4
R6
1.5Meg
+150V
+10V
0V
-150V

RESETS OPAMP—Q1-Q2 provide electronic reset for integrating opamp regardless of output amplitude or polarity. Differential IC current amplifier is gated ON for reset period and provides full-signal negative feedback, to convert integrator to zero-gain amplifier. Article describes function of integrating capacitor across opamp, whose value is chosen to give desired discharge rate.—P. A. Ralatos, Reset Circuit Independent of Amplitude and Polarity, *Electronic Design*, Oct. 25, 1965, p 70 and 72.

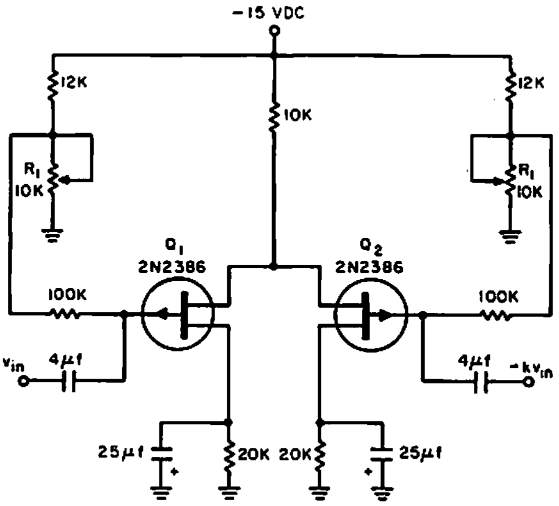

-10 V
20 k
10 k
A1
10 k
1
2
3009/15C
4
2.5 k
E1
5 k
10 k
2.5 k
A2
10 k
1
2
3009/15C
4
20 k
+10 V
3
1
2
C
5
4018/25
Sin/Cos
Module
X
Z
4
Y
Eo

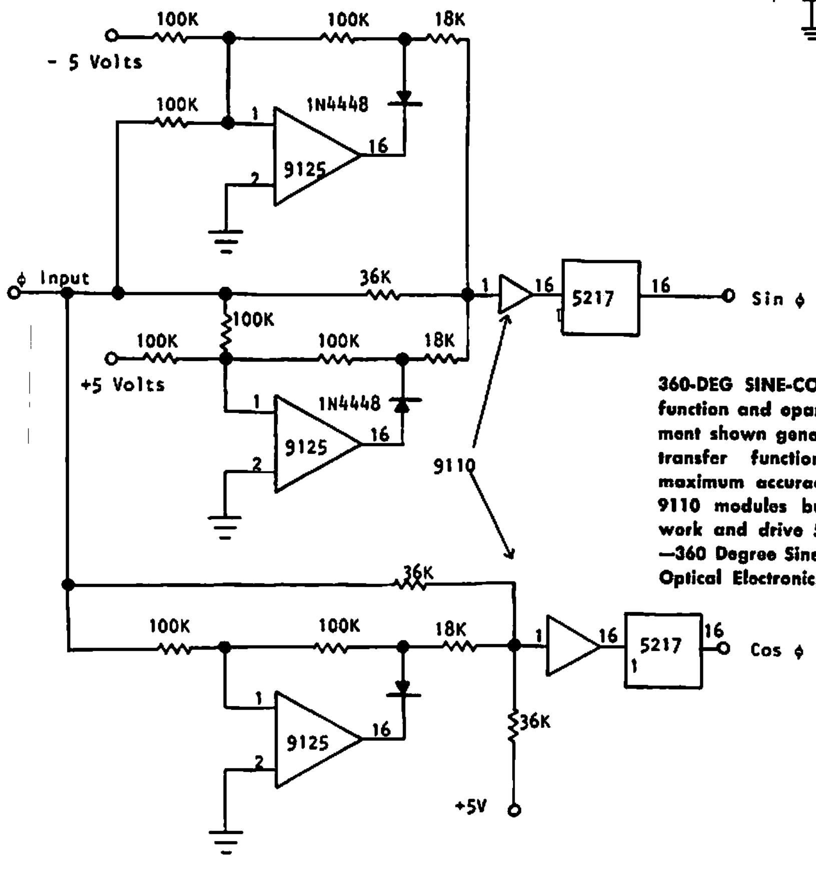
FOUR-QUADRANT SINE—Addition of two opamps to Burr-Brown 4018/25 two-quadrant sine-cosine generator module gives four-quadrant response. Equations are given. For 0.1% overall accuracy, all resistors should be trimmed to 0.01% of indicated values.—Sine/Cosine Function Generator, Burr-Brown Research, Tucson, Ariz., PDS-210, 1968, p 5.


+15 V
OUTPUT
R
10K
10K
±10 V
0 to +1V
5500
1
2
7
8
7
4
3
33
1K
1K
R
1N456A
1K
-15 V

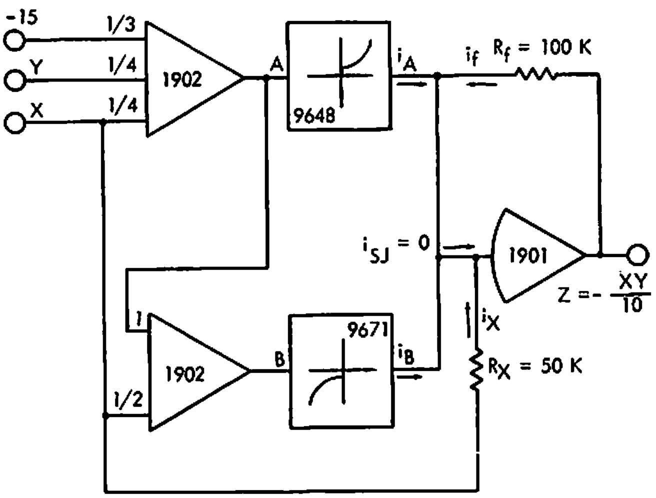
TWO-QUADRANT MULTIPLIER—Uses OEI Model 5500 single-chip analog multiplier providing differential output equal to product of two inputs. Opamp at output is not critical, and may be OEI 9302, 9125, etc. Value of R determines output amplitude; 100K gives 10 V full-scale bipolar output.—Two and Four Quadrant Multipliers using the OEI Model 5500, Optical Electronics, Tucson, Ariz., No. 10140.

CUBIC FUNCTION GENERATOR—Uses two low-cost unmatched fet squaring circuits with forced-matching scaling factor to approximate matched fet pairs. Used with quarter-square multiplier and summing and inverting amplifiers to generate cubic function. Circuit shown squares over 60-dB output signal range for inputs from 100 to 10,000 Hz when driven by sine wave. Article covers theory, design equations, and other applications for squarer. —T. F. Bogart, Jr., Matched Transistors Pass for FET Squarers, *Electronic Design*, Nov. 8, 1965, p 36–41.

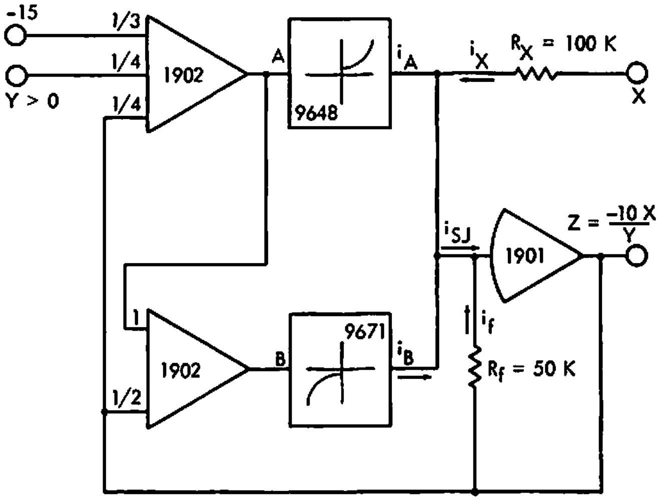

-15 VDC
12K
10K
12K
R1
10K
R1
10K
Q1
2N2386
Q2
2N2386
100K
100K
Vin
4μf
4μf
-kVin
25μf
20K
20K
25μf


- 5 Volts
100K
100K
18K
100K
1N4448
1
16
9125
2
φ Input
36K
1
16
5217
16
Sin φ
100K
100K
100K
18K
+5 Volts
1N4448
1
16
9125
2
9110
36K
100K
100K
18K
1
16
5217
1
16
Cos φ
1
9125
16
2
36K
+5V

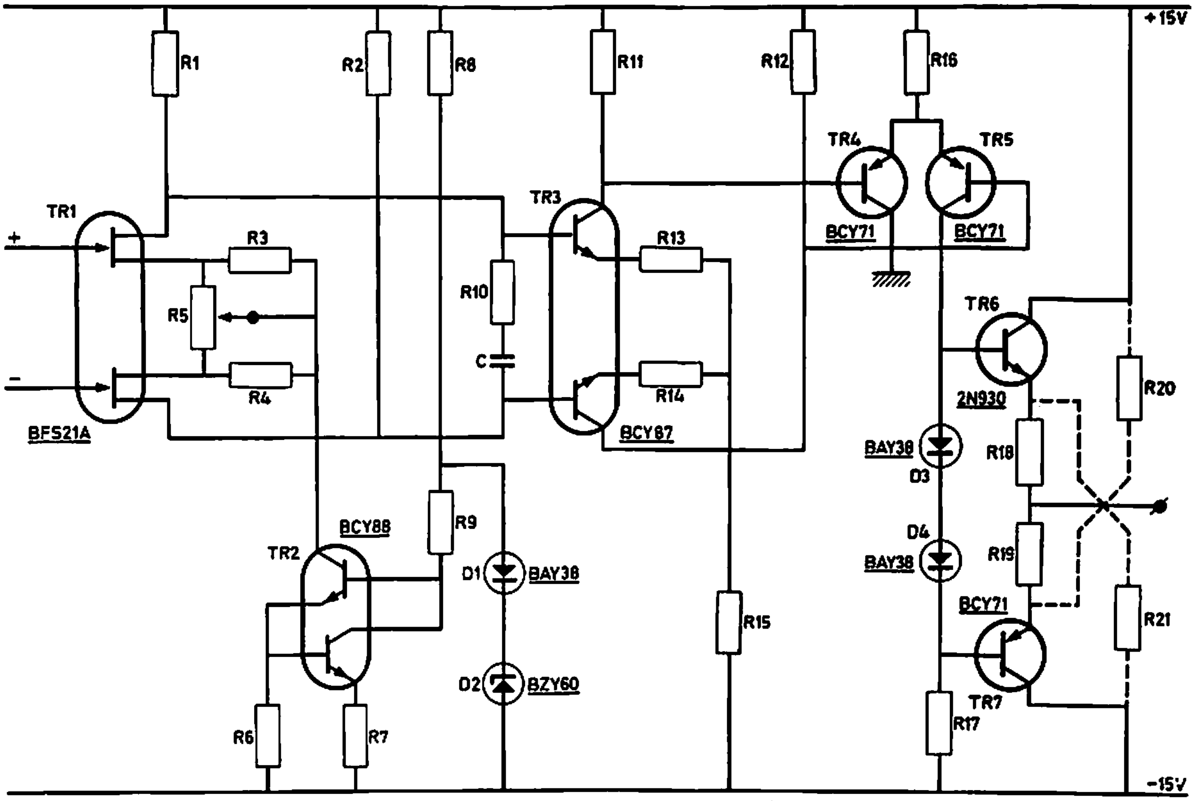
360-DEG SINE-COSINE—With basic OEI sine-function and opamp modules, circuit arrangement shown generates full 360-deg nonlinear transfer function. Useful bandwidth for maximum accuracy is d-c to 1 kHz. Model 9110 modules buffer summing resistor network and drive 5217 sine function modules. —360 Degree Sine/Cosine Function Generator, Optical Electronics, Tucson, Ariz., No. 10154.


-15
Y
X
1/3
1/4
1/4
1902
A
9648
i_A
i_f
R_f = 100 K
i_SJ = 0
1901
Z = - XY/10
i_X
R_X = 50 K
1
1/2
1902
B
9671
i_B

FOUR-QUADRANT MULTIPLIER—Combines Burr-Brown 9648 and 9671 squaring modules with three high-gain d-c opamps to give four-quadrant multiplication of input signals at X and Y. Output opamp is connected as summing amplifier.—Negative Input General Purpose Squaring Module, Burr-Brown Research, Tucson, Ariz., PDS-180A, 1968.


-15
Y > 0
1/3
1/4
1/4
1902
A
9648
i_A
i_X
R_X = 100 K
X
i_SJ
1901
Z = -10 X/Y
i_f
R_f = 50 K
1
1/2
1902
B
9671
i_B

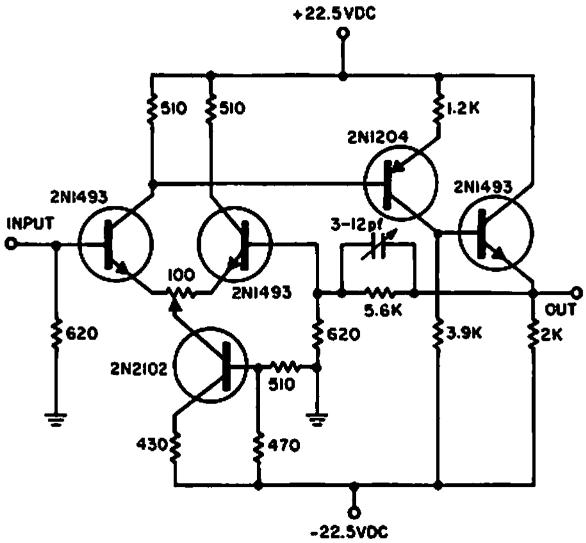
TWO-QUADRANT DIVIDER—Combines Burr-Brown 9648 and 9671 squaring modules with three high-gain d-c opamps to give two-quadrant division of signal at X by signal at Y.—Negative Input General Purpose Squaring Module, Burr-Brown Research, Tucson, Ariz., PDS-180A, 1968.


+15V
-15V
R1
R2
R8
R11
R12
R16
TR1
+
-
R3
R5
R4
BFS21A
TR3
R10
C
R13
R14
BCY87
TR4
TR5
BCY71
BCY71
TR6
2N930
R20
BAY38
D3
R18
D4
BAY38
R19
BCY71
R21
TR7
R17
R15
BCY88
TR2
R9
D1
BAY38
D2
BZY60
R6
R7

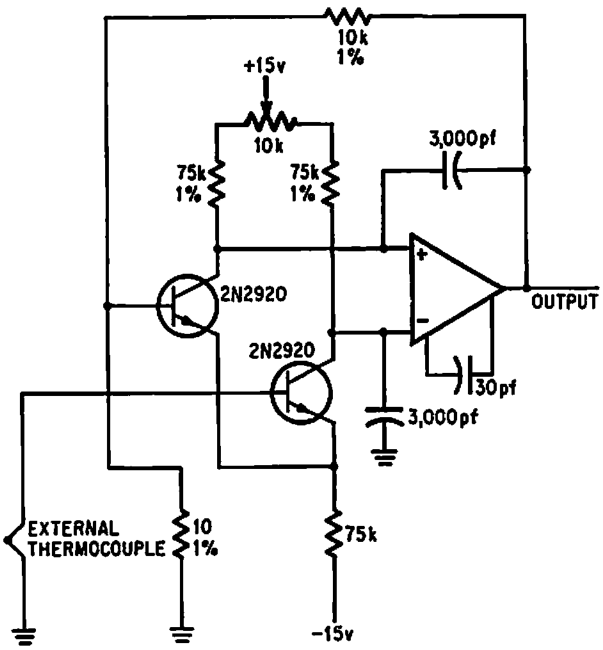
R_1, R_2	24 kΩ *	R_6	10 kΩ	R_{10}	110 Ω	R_{15}	24 kΩ	R_{18}, R_{19}	100 Ω
R_3, R_4	75 Ω	R_7, R_8	8.2 kΩ	R_{11}, R_{12}	6.2 kΩ **	R_{16}	2 kΩ	R_{20}, R_{21}	15 kΩ
R_5	2 kΩ	R_9	22 kΩ	R_{13}, R_{14}	100 Ω	R_{17}	17 kΩ	C	33 nF

* ± 0.1%, metal film resistors ** ± 1% resistors

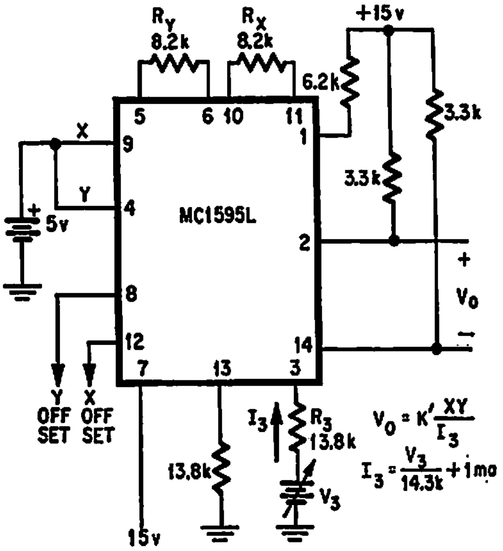
DIFFERENTIAL FET INPUT—Fet pair in first stage reduces bias and offset currents by factor of 1,000 as compared to bipolar transistors. Unity-gain bandwidth is 10 MHz, open-loop voltage gain 99 dB, and slewing rate with compensation network is 10 V per μs. Report gives design equations.—B. J. M. Overgoor, An Operational Amplifier with Differential FET Input, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 332, 1969.


+22.5VDC
510
510
1.2K
2N1204
2N1493
2N1493
INPUT
3-12pf
100
2N1493
5.6K
OUT
620
2N2102
620
3.9K
2K
510
430
470
-22.5VDC

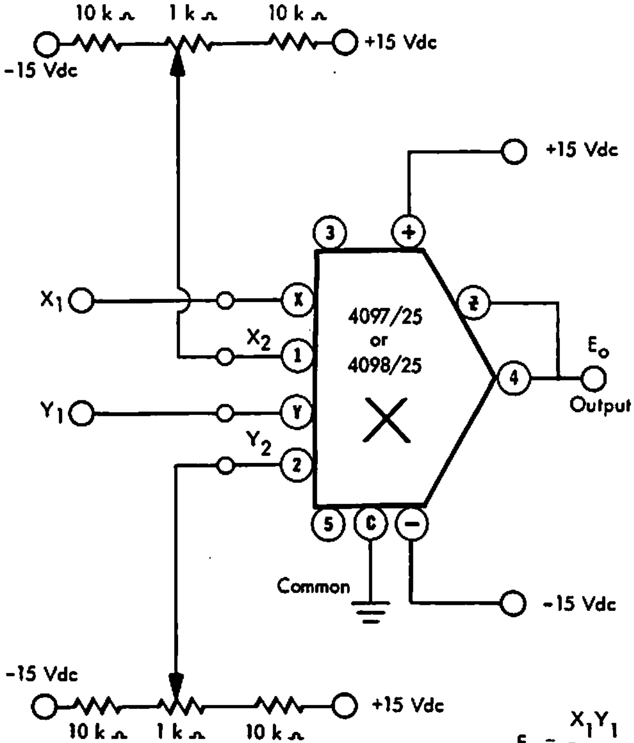
2 W FROM D-C TO 12 MHZ—Instability is avoided by limiting gain of each stage and using feedback for handling large voltage swings. Output stage can handle 20-V swing into 200 ohms, or 2 W for square wave. Bandwidth is flat within 3 dB and rise time is 25 ns.—R. H. McMorrow, Modified Operational Amplifier Has Flat Bandwidth to 12 Mc, *Electronic Design*, Aug. 30, 1965, p 47–48.


10k
1%
+15v
10k
3,000pf
75k
1%
75k
1%
2N2920
OUTPUT
2N2920
30pf
3,000pf
EXTERNAL THERMOCOUPLE
10
1%
75k
-15v

OFFSET VOLTAGE DRIFT SUPPRESSION—Bias current drift compensation techniques for IC amplifier, described in article, are here applied to complete amplifier having monolithic transistor pair as preamp. Null potentiometer unbalances collector load resistors so zero output is obtained for zero input. Change of 1 V in either supply makes offset voltage change only about 10 μV. Temperature drift is low, comparing favorably with that of expensive chopper-stabilized amplifiers.—R. J. Widlar, Linear IC's: Compensating For Drift, *Electronics*, Feb. 5, 1968, p 90–93.

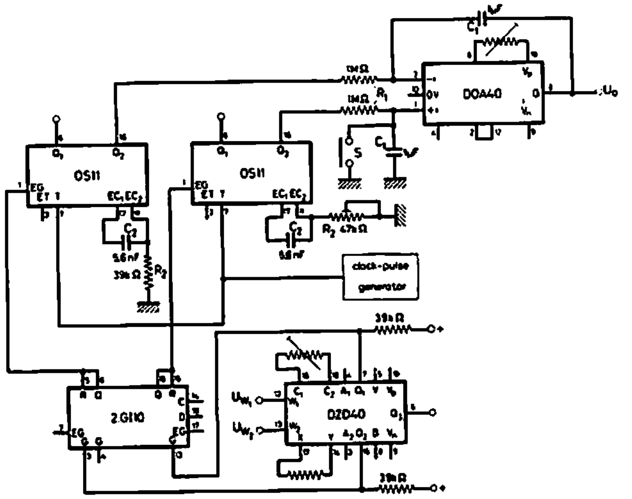

R_Y
8.2k
R_X
8.2k
+15v
6.2k
3.3k
5
6
10
11
X
9
1
3.3k
Y
4
MC1595L
5v
2
+
V_O
8
-
12
14
7
13
3
Y OFF SET
X OFF SET
I_3
R_3
13.8k
$V_O = K'\frac{XY}{I_3}$
13.8k
$I_3 = \frac{V_3}{14.3k} + 1ma$
V_3
15v

IC MULTIPLIER-DIVIDER—Motorola monolithic multiplier provides simultaneous multiplication and division when used with component values shown.—E. Renschler and D. Weiss, Try the Monolithic Multiplier as a Versatile A-C Design Tool, *Electronics*, June 8, 1970, p 100–105.

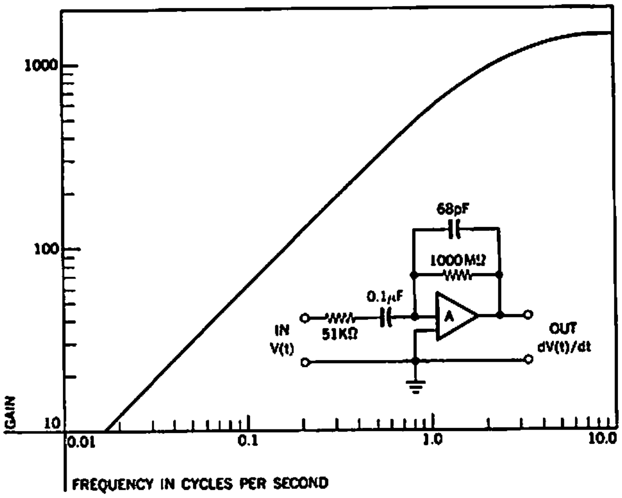

10 kΩ
1 kΩ
10 kΩ
-15 Vdc
+15 Vdc
+15 Vdc
3
+
X_1
X
2
X_2
1
4097/25
or
4098/25
E_o
4
Output
Y_1
Y
Y_2
2
5
C
-
Common
-15 Vdc
-15 Vdc
+15 Vdc
10 kΩ
1 kΩ
10 kΩ

$$E_o = \frac{X_1Y_1}{10}$$

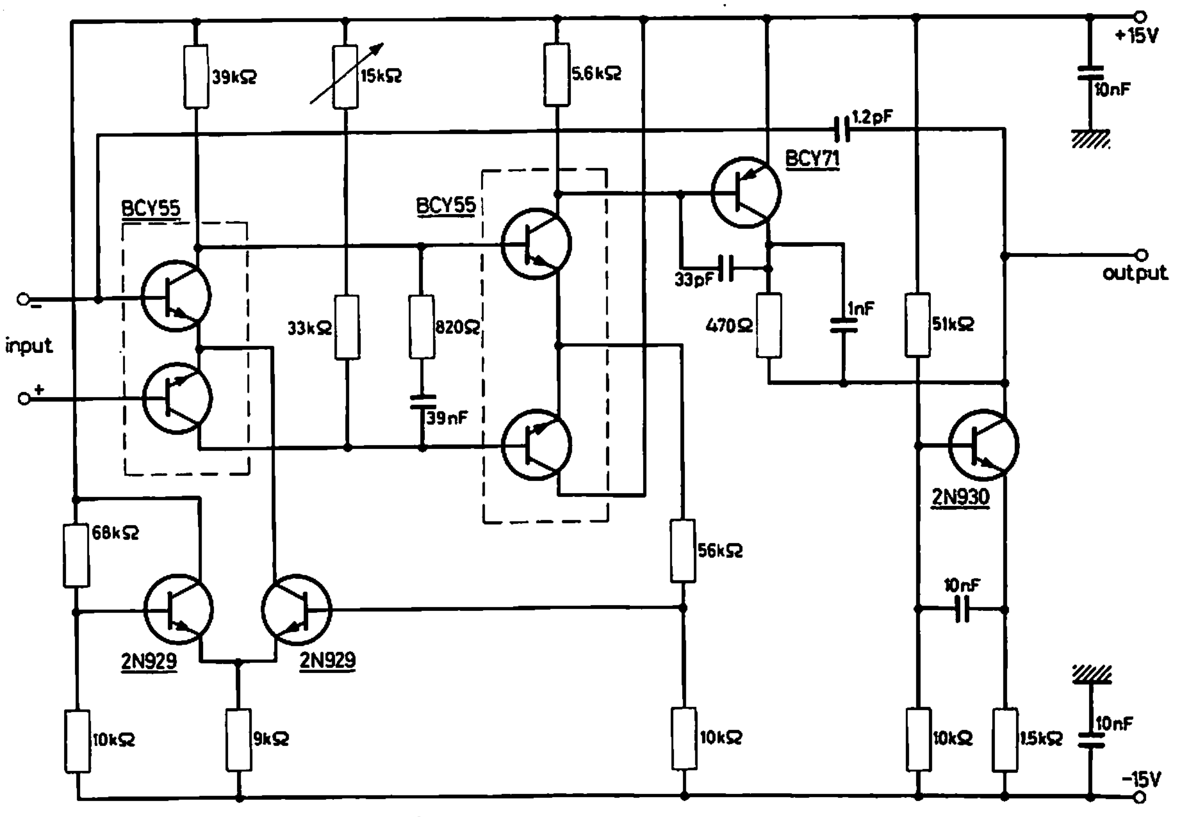
DIFFERENTIAL-INPUT MULTIPLIER—Connection shown for Burr-Brown multiplier-divider package multiplies inputs at X1 and Y1 with improved accuracy by using offset nulling principle. Accuracy is 2% of full-scale for 4097 and 1% for 4098. Report discusses offset errors.—Differential Input Multiplier/Dividers, Burr-Brown Research, Tucson, Ariz., PDS-201A-2, 1969.


C1
DOA40
1MΩ
R1
0V
Uo
OS11
Q1
Q2
EG
ET
EC1 EC2
C2
5.6nF
39kΩ
R2
R2 47kΩ
S
clock-pulse generator
39kΩ
2GI10
DZD40
UW1
UW2

ANALOG CONTROL OF VOLTAGE—Output voltage Uo of Philips DOA40 ·IC opamp is proportional to difference between input signal voltages applied to OS11 IC monostable mvbr's. Multivibrators are connected to DZD40 zero detector and to common clock pulse generator. Output voltage is returned to zero by operating reset switch S to short out C1.—Electronic Potentiometer With 40- and 10-Series Circuit Blocks, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands.

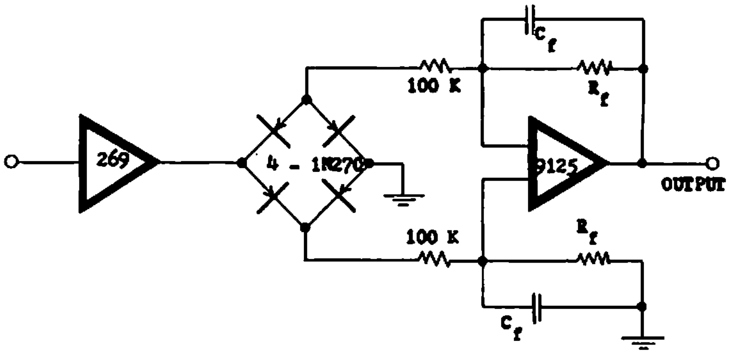


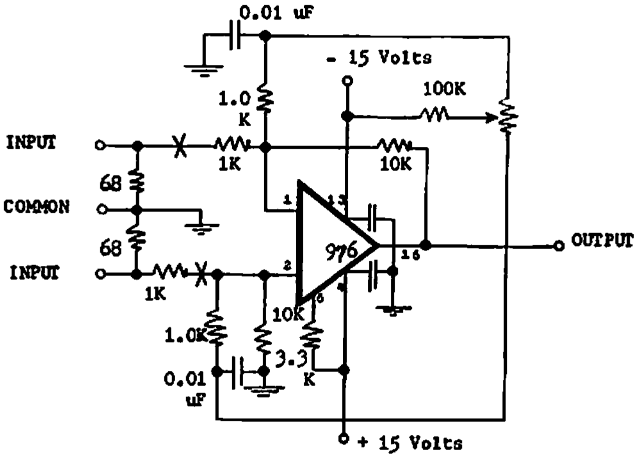
DIFFERENTIATOR—Uses high-gain Philbrick USA-3 opamp with capacitive input and resistive feedback. Developed for observing transverse dHS effect in bismuth at liquid helium temperatures. Output drives X-Y recorder.—R. D. Brown III, New Methods for De Haas-Shubnikov Measurements, *IBM Journal*, Nov. 1966, p 462–471.


+15V
10nF
39kΩ
15kΩ
5.6kΩ
1.2pF
BCY71
BCY55
BCY55
input
output
33kΩ
820Ω
39nF
33pF
470Ω
1nF
51kΩ
2N930
68kΩ
56kΩ
10nF
2N929
2N929
10kΩ
9kΩ
10kΩ
10kΩ
1.5kΩ
10nF
-15V

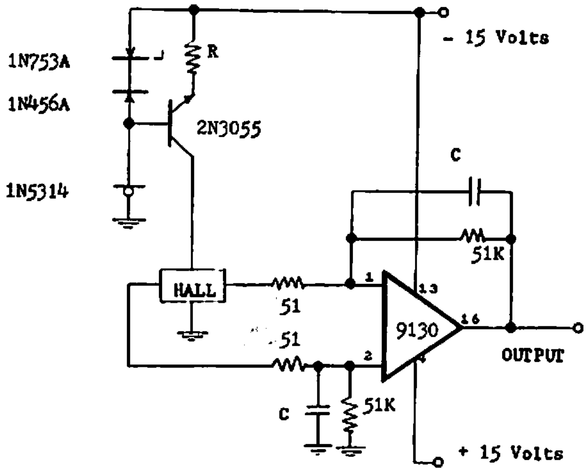
HIGH-GAIN D-C DIFFERENTIAL AMPLIFIER—Provides open-loop d-c gain of 200,000, differential input impedance of 100,000 ohms, common-mode input impedance of 20 meg, output impedance of 10K, unity-gain bandwidth of 9 MHz, and common-mode rejection ratio of 94 dB. Suitable for operational use in amplifying signal by known and accurately determined factor. Article includes mathematical discussion of amplification errors.—J. Oosterling and S. Sijtstra, Operational Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 26, No. 4, p 116–188.

A-C/D-C LOGARITHMIC CONVERTER—Uses OEI Model 269 four-decade bipolar logamp having frequency response covering entire audio spectrum down to d-c. Output is instantaneous log of input. With sine-wave input, output is rounded-top steep-sided waveform, with amplitude still equal to log of input peak amplitude. Compression of amplifier means that entire four decades of input produce output from 250-mV full-scale peak down to about 25 mV for minimum input. With d-c input, output is d-c voltage equal to log of input.—A Logarithmic AC to DC Converter, Optical Electronics, Tucson, Ariz., No. 10082.

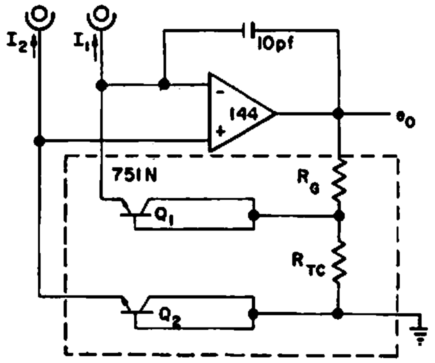

269
4 - 1N270
100 K
100 K
C_f
R_f
R_f
C_f
9125
OUTPUT


0.01 uF
- 15 Volts
100K
1.0 K
INPUT
1K
10K
COMMON
68
68
INPUT
1K
976
1
2
13
16
OUTPUT
10K
1.0K
0.01 uF
3.3 K
+ 15 Volts

BALANCED TERMINATION—Required for transducers and other signal sources having long lines. If common-mode voltage exists between both inputs and signal ground, opamp can reject voltage as common-mode signal. Arrangement shown provides for nulling of d-c unbalance with pot. Capacitors may be inserted in d-c lines at points marked X. Use 16 μF. High-frequency response for −3 dB is about 3 MHz.—An AC Coupled Balanced Input Pre-Amplifier, Optical Electronics, Tucson, Ariz., No. 10115.


1N753A
1N456A
1N5314
R
2N3055
- 15 Volts
C
51K
HALL
51
51
9130
1
2
13
16
OUTPUT
C
51K
+ 15 Volts

HALL-EFFECT PREAMP—OEI Model 9130 opamp provides differential input required for amplifying differential output voltage that may be as small as a few mV per gauss of magnetic field passing through Hall-effect device. Circuit has gain of 1,000, which means that placement of Hall device with respect to earth's magnetic field may affect output. Frequency response extends from d-c to about 1,000 Hz. Linearity is good if bias current is set properly.—A Hall Effect Device Pre-Amplifier, Optical Electronics, Tucson, Ariz., No. 10118.

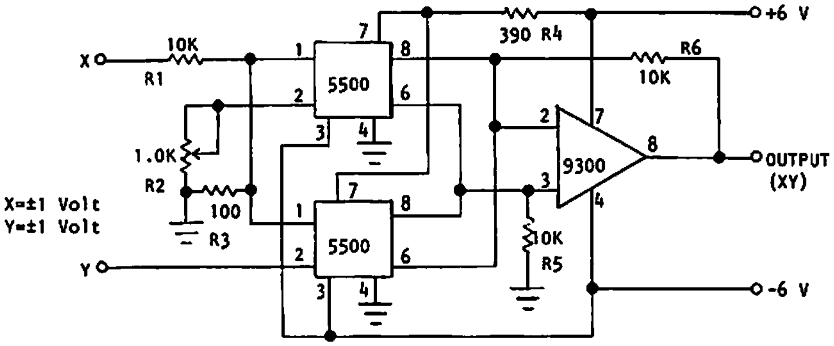

I_2
I_1
10pf
144
-
+
e_o
751N
R_G
Q_1
R_{TC}
Q_2

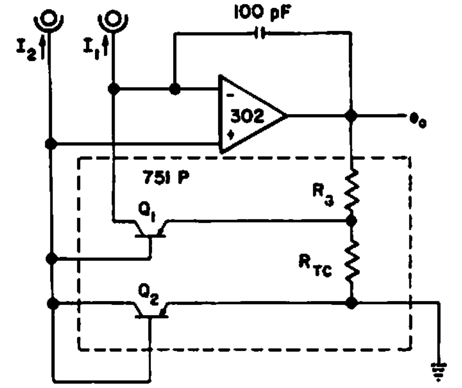
$$e_o = 1.0 \log \frac{I_2}{I_r} (V), \quad 10^{-9}A < I_1 < 10^{-7}A, \quad 10^{-9}A < I_2 < 10^{-4}A$$

$$\tau = \frac{1}{40I_1}\left(\frac{R_G + R_{TC}}{R_{TC}}\right) \times 10^{-11} = \frac{4 \times 10^{-12}}{I_1} \text{ sec}, \quad \frac{1}{40I_1} >> R_G$$

LOG OF CURRENT RATIO—Combines Analog Devices 751N matched transistor pair and calibrated voltage divider module with Model 144 fet amplifier to provide logarithm of ratio of two input currents greater than a nanoampere each. Diode-connected transistors are reversible. Used in colorimetry, where overall accuracy of 0.1 dB can be maintained.—W. Borlase and E. David, Design of Temperature Compensated Log Circuits Employing Transistors and Operational Amplifiers, Analog Devices, Cambridge, Mass., E020-10-3/69, p 10.

FOUR-QUADRANT FOR D-C TO 10 MHZ—Uses OEI 5500 analog multipliers. Bandwidth is limited only by slow rate or frequency response of 9300 opamp. Output is 1 V full scale.—Applying the Model 5500 Monolithic Analog Multiplier, Optical Electronics, Tucson, Ariz., No. 10138.

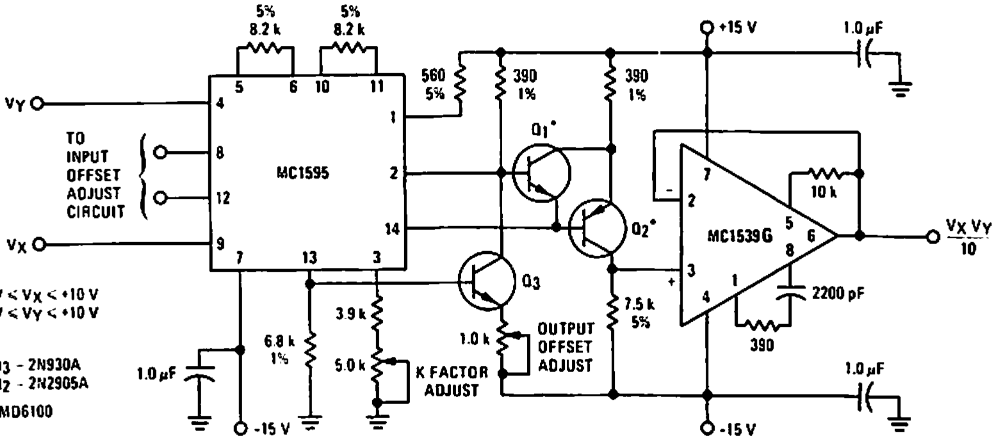

X
10K
R1
1.0K
R2
100
R3
X=±1 Volt
Y=±1 Volt
Y
5500
5500
1
2
3
4
6
7
8
390 R4
+6 V
R6
10K
9300
OUTPUT (XY)
10K
R5
-6 V


I_2
I_1
100 pF
302
e_o
751 P
Q_1
Q_2
R_3
R_{TC}

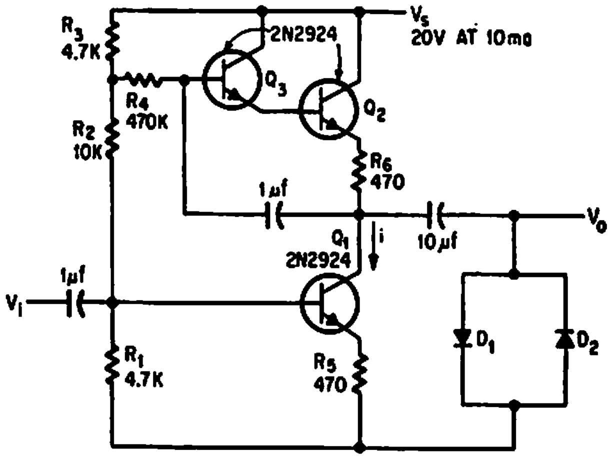
$$e_o = 1.0 \log_{10}\frac{I_2}{I_1}, \quad 10^{-11}A < I_1 < 10^{-7}A, \quad 10^{-8}A < I_2 < 10^{-4}A$$

$$\tau = \frac{1}{40I_1}\left(\frac{R_G + R_{TC}}{R_{TC}}\right) \times 10^{-10} \approx \frac{4 \times 10^{-11}}{I_1} \text{ sec}, \quad \frac{1}{40I_1} \gg R_G$$

LOG OF CURRENT RATIO WITHOUT REVERSIBILITY—Analog Devices 751P log element is transdiode-connected, for handling currents from few picoamperes to hundreds of nanoamperes with good accuracy. Model 302 amplifier error currents are much smaller than lowest signal currents which can be converted. Transdiode connection means loss of reversibility, so use 751P for negative input currents or 751N for positive input currents.—W. Borlase and E. David, Design of Temperature Compensated Log Circuits Employing Transistors and Operational Amplifiers, Analog Devices, Cambridge, Mass., E020-10-3/69, p 11.

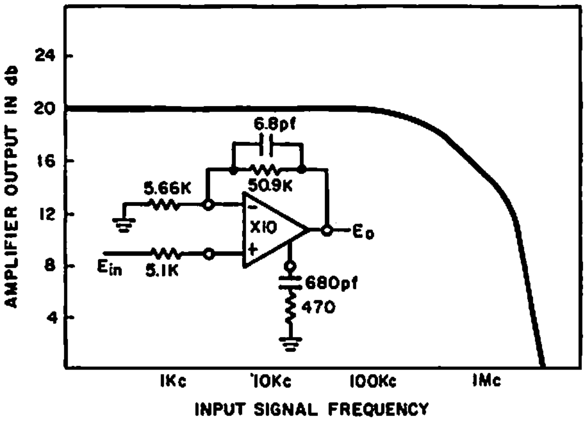

5%
8.2 k
5%
8.2 k
VY
TO INPUT OFFSET ADJUST CIRCUIT
VX
MC1595
560
5%
390
1%
390
1%
+15 V
1.0 µF
Q1*
Q2*
Q3
MC1539G
10 k
2200 pF
390
7.5 k
5%
$\frac{V_X V_Y}{10}$
-10 V ≤ VX ≤ +10 V
-10 V ≤ VY ≤ +10 V
Q1, Q3 - 2N930A
Q2 - 2N2905A
*OR MD6100
1.0 µF
-15 V
6.8 k
1%
3.9 k
5.0 k
K FACTOR ADJUST
1.0 k
OUTPUT OFFSET ADJUST
1.0 µF
-15 V

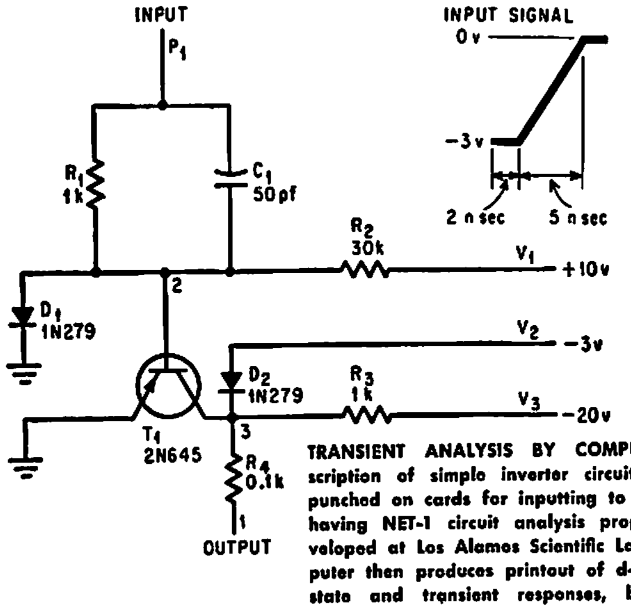
MULTIPLY WITH DISCRETE LEVEL SHIFT—Circuit takes differential output current and translates directly to ground reference, using inexpensive discrete components. Upper frequency limit depends only on 7.5K resistor and straight capacitance at output. High output impedance, with resulting limitation on drive capability, is overcome by using opamp voltage follower at output. Input IC is Motorola MC1595 linear four-quadrant multiplier.—E. Renschler, The Monolithic Multiplier Breakthrough, "State-of-the Art—Linears In Action," Motorola, Phoenix, Ariz., 1969, p 27–36.


R3 4.7K
2N2924
Q3
V_S 20V AT 10ma
R4 470K
Q2
R2 10K
R6 470
1μf
Q1 2N2924
i
10μf
V_0
1μf
V_1
D1
D2
R1 4.7K
R5 470

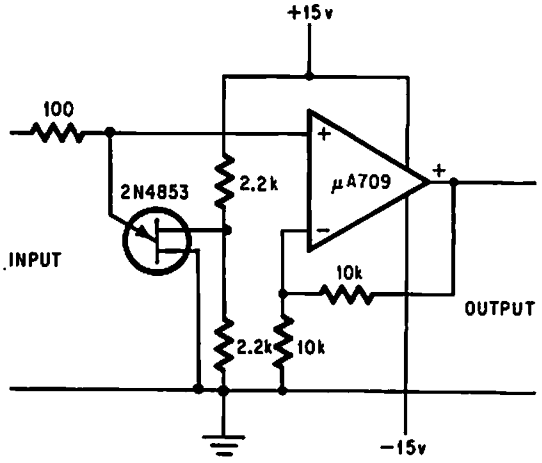
ANALOG MULTIPLICATION—Two diodes driven by three-transistor Darlington current generator form low-cost logarithmic amplifier providing multiplication at 1 kHz over 3-decade signal range. Diodes are 1N914 silicon planar units.—J. F. Delpech, Logarithmic Amplifier Has 66-dB Range, *Electronics*, Oct. 17, 1966, p 89–90.

IC NONINVERTING OPAMP—Provides gain of 20 dB, 100-kHz bandwidth for 5,000-ohm source impedance, and frequency response shown by curve. IC can be SN521, or SN522 having added emitter-follower for greater drive capability.—L. Housey and G. McFarland, Using Integrateds as Feedback Amplifiers, *Electronic Design*, March 2, 1964, p 49–52.

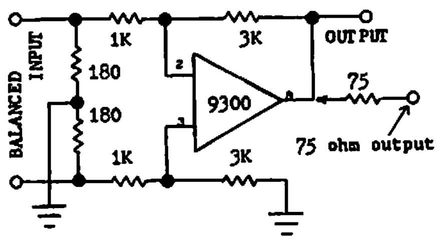



INPUT
P1
INPUT SIGNAL
0 v
−3 v
2 n sec
5 n sec
R1 1k
C1 50pf
R2 30k
V1
+10v
2
D1 1N279
V2
−3v
D2 1N279
R3 1k
V3
−20v
T1 2N645
3
R4 0.1k
1
OUTPUT

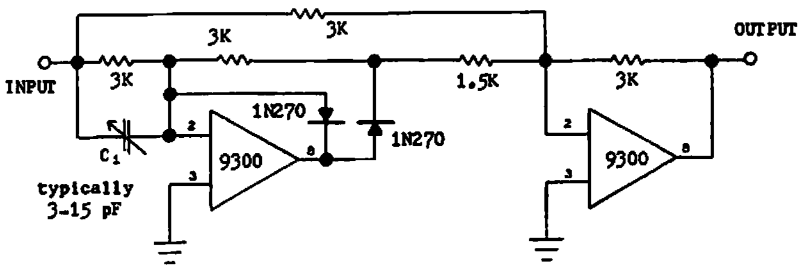
TRANSIENT ANALYSIS BY COMPUTER—Description of simple inverter circuit can be punched on cards for inputting to computer having NET-1 circuit analysis program developed at Los Alamos Scientific Lab. Computer then produces printout of d-c steady-state and transient responses, based on characteristics of diodes and transistor used. —A. F. Malmberg, Net-1 Gets an "A" For Accuracy, *Electronics*, Feb. 6, 1967, p 76–82.


+15v
100
2N4853
2.2k
μA709
+
−
+
INPUT
10k
OUTPUT
2.2k
10k
−15v

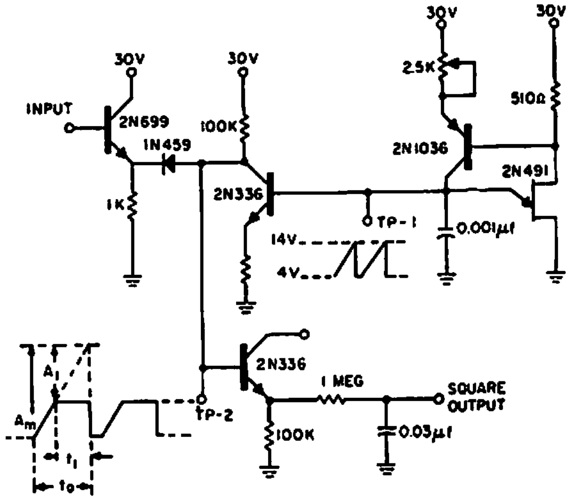
TRANSIENT PROTECTION—Large positive-going voltage transients at input of IC opamp are suppressed by using ujt at input to serve as variable threshold limiter and maintain resistance of about 3 gigohms. To limit negative transients, use complementary ujt instead of or with this circuit.—R. Chapman, UJT Protects Op Amp From Voltage Transients, *Electronics*, Nov. 25, 1968, p 83.


BALANCED INPUT
1K
3K
OUTPUT
180
180
2
9300
3
75
1K
3K
75 ohm output

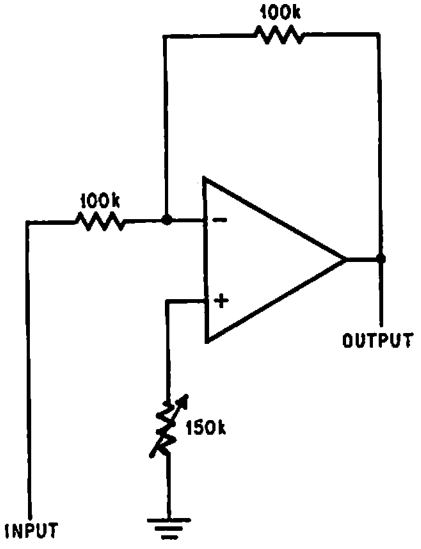
DIFFERENTIAL WITH GAIN OF 3—When driven from balanced line, bandwidth is well above 10 MHz. Input impedance is 300 ohms. Uses OEI 9300 opamp.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


3K
3K
OUTPUT
INPUT
3K
1.5K
3K
1N270
1N270
2
9300
8
3
C_1
typically
3-15 pF
2
9300
8
3

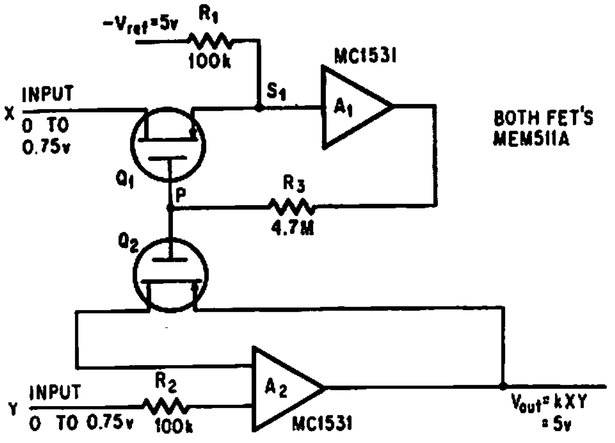
WIDE-BAND ABSOLUTE-VALUE—Provides accurate full-wave rectification of input, from d-c to 5 MHz for 1 V peak output, using two OEI 9300 opamps.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


30V
30V
30V
30V
INPUT
2N699
1N459
100K
1K
2N336
2.5K
2N1036
510Ω
2N491
TP-1
14V
4V
0.001μf
A_1
A_m
t_1
t_0
TP-2
2N336
1 MEG
SQUARE OUTPUT
100K
0.03μf

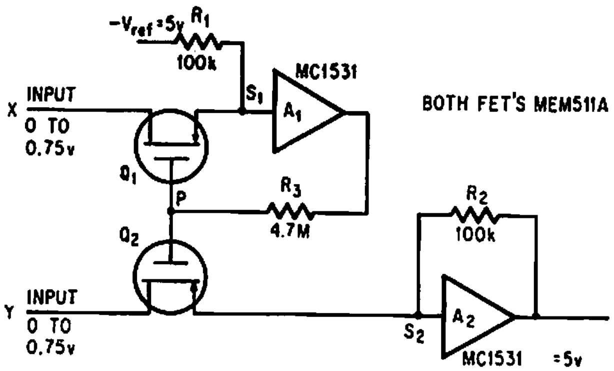
SQUARER—Output voltage of circuit is directly proportional to square of d-c input voltage.—R. L. Colcord, Circuit Squares DC Input Voltage, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 83.


100k
100k
−
+
OUTPUT
150k
INPUT

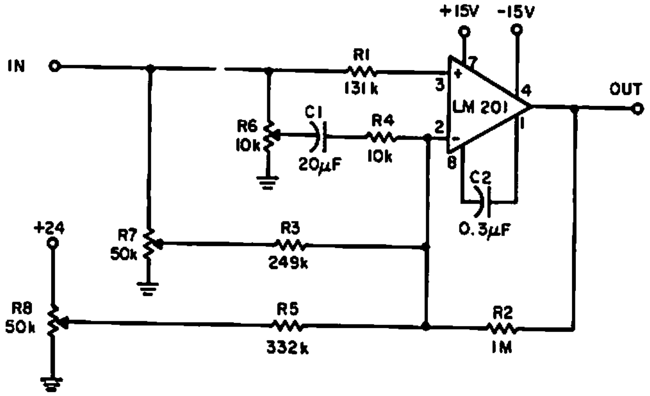
SUMMING AMPLIFIER—Variable resistor provides bias current compensation for linear IC used with fixed source impedance. Temperature characteristics are excellent, but arrangement works only for fixed values of feedback resistors.—R. J. Widlar, Linear IC's: Compensating For Drift, *Electronics*, Feb. 5, 1968, p 90–93.


$-V_{ref}=5v$
R_1
100k
MC1531
INPUT
X
0 TO
0.75v
S_1
A_1
BOTH FET'S
MEM511A
Q_1
P
R_3
4.7M
Q_2
INPUT
Y
0 TO 0.75v
R_2
100k
A_2
MC1531
$V_{out}=kXY$
$=5v$

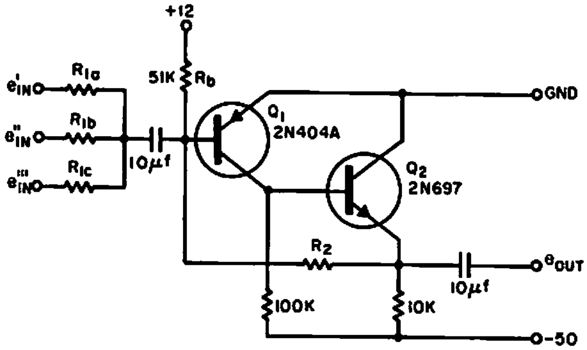
IC MULTIPLIER—Input signals X and Y are combined by fet's operated as voltage-variable resistors by keeping signal voltages below 0.75-V pinchoff of these fet's. Opamps A1 and A2 then make output proportional to product of X and Y. Useful in desktop computers.—B. Shore, Pocket-Size Analog Computer Divides and Multiplies, *Electronics*, Dec. 25, 1967, p 66–67.


$-V_{ref}=5v$
R_1
100k
INPUT
X
0 TO 0.75v
S_1
MC1531
A_1
BOTH FET'S MEM511A
Q_1
P
R_3
4.7M
Q_2
R_2
100k
INPUT
Y
0 TO 0.75v
S_2
A_2
MC1531
=5v

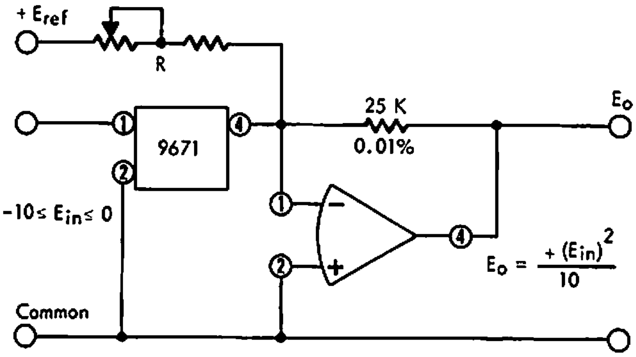
IC DIVIDER—Input signals X and Y are combined by fet's operated as voltage-variable resistors by keeping signal voltages below 0.75-V pinchoff. Opamps then make output proportional to quotient Y/X. Used in desk-top analog computers.—B. Shore, Pocket-Size Analog Computer Divides and Multiplies, *Electronics*, Dec. 25, 1967, p 66–67.


+15V
-15V
IN
R1
131k
3
7
4
OUT
R6
10k
C1
20µF
R4
10k
2
LM 201
1
8
C2
0.3µF
+24
R7
50k
R3
249k
R8
50k
R5
332k
R2
1M

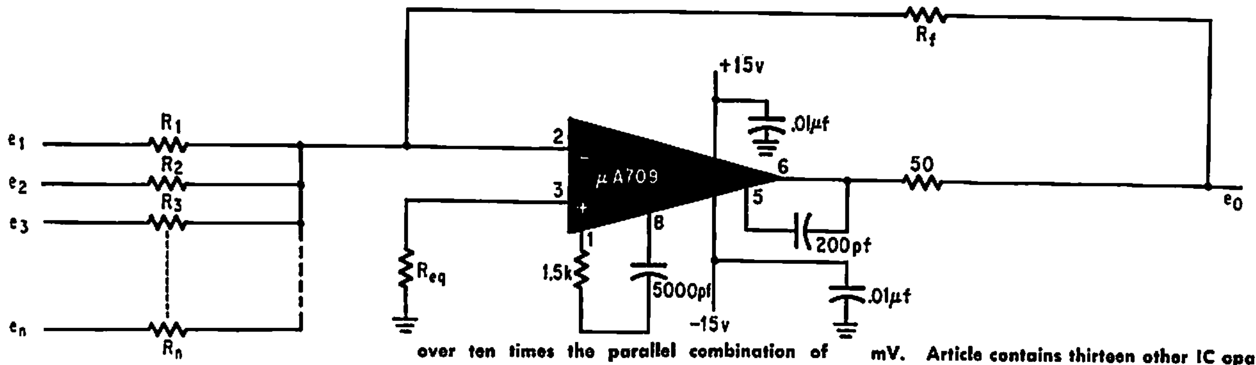
TRACKING WITHOUT CAPACITIVE INPUT—Has independent adjustments for gain, offset, and differentiating time constant. Output drifts only 10 mV per day and 0.25 mV per deg C.—J. Harris, A Tracking Differentiator Has Noncapacitive Input, *Electronic Design*, Aug. 15, 1968, p 238.


+12
e'_{IN}
R_{1a}
e''_{IN}
R_{1b}
e'''_{IN}
R_{1c}
51K
R_b
10µf
Q_1
2N404A
Q_2
2N697
GND
R_2
e_{OUT}
10µf
100K
10K
-50

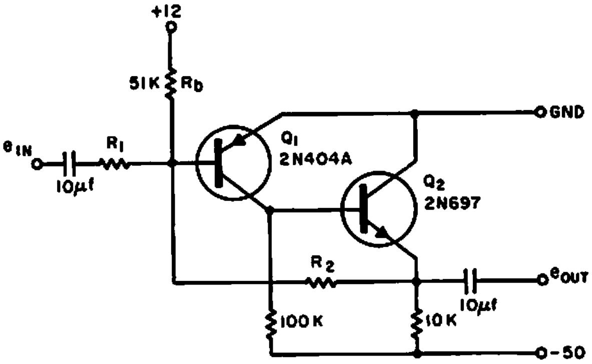
ALGEBRAIC SUMMING—Minor modifications in input of two-stage operational inverter convert it into excellent summing amplifier having gains up to 10, depending on values used for input resistors and R2.—W. Rosenbluth, Two-Stage Transistor Replaces Precision Operational Inverter, *Electronic Design*, April 12, 1965, p 54–56.


$+E_{ref}$
R
①
9671
④
②
25 K
0.01%
E_o
$-10 \le E_{in} \le 0$
①
②
④
$E_o = \frac{+(E_{in})^2}{10}$
Common

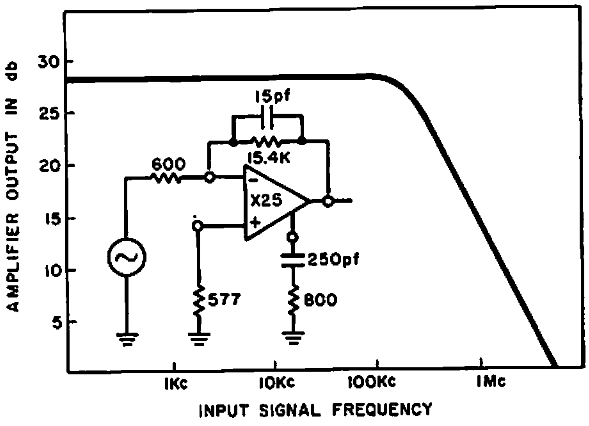
SQUARING CIRCUIT—Burr-Brown general-purpose negative-input 9671 squaring module may be used with variety of standard opamps to provide current into opamp summing junction that is proportional to square of applied negative input voltage. Module requires +15 V and −15 V from external regulated power supply.—Negative Input General Purpose Squaring Module, Burr-Brown Research, Tucson, Ariz., PDS-180A, 1968.


R_f
+15v
.01µf
e_1
R_1
e_2
R_2
e_3
R_3
2
3
µA709
6
5
50
e_0
1
8
200pf
R_{eq}
1.5k
5000pf
.01µf
-15v
e_n
R_n

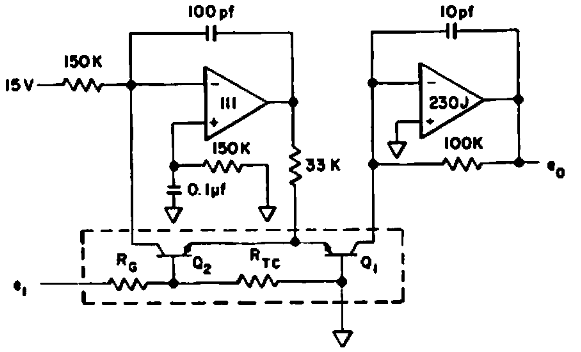
SUMMING—Circuit using Fairchild µA709 IC opamp can sum many input signals with high accuracy, provided input resistance of IC is over ten times the parallel combination of feedback resistor Rf and the source resistors. With three inputs and with input resistors and Rf all 20,000 ohms, maximum error is only 30 mV. Article contains thirteen other IC opamp application circuits.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


+12
51K
Rb
eIN
R1
10μf
Q1
2N404A
Q2
2N697
GND
R2
eOUT
10μf
100K
10K
-50

OPTIMUM TWO-STAGE INVERTER—Provides constant input impedance and unity gain of opamp, along with broadband, 180-deg phase shift at much lower cost and less complexity. Output impedance is low, and gain is independent of transistor parameters. Can be used in analog computer to invert 400-Hz sine and square-wave signals. Gain depends on R2; if R1 is 50K, gain will be unity if R2 is 50.85K.—W. Rosenbluth, Two-Stage Transistor Replaces Precision Operational Inverter, *Electronic Design*, April 12, 1965, p 54–56.

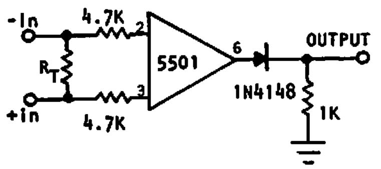


IC INVERTING OPAMP—Provides gain of 28 dB, bandwidth of 100 kHz, and choice of inverting or noninverting input. Frequency response is shown by curve. IC can be SN521, or SN522 having added emitter-follower for greater drive capability.—L. Housey and G. McFarland, Using Integrateds as Feedback Amplifiers, *Electronic Design*, March 2, 1964, p 49–52.

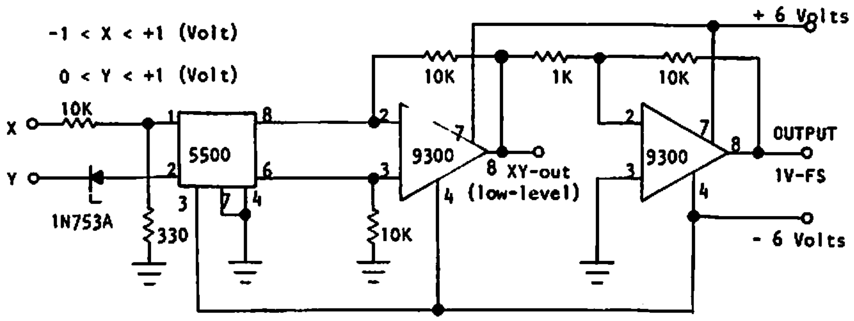

100pf
10pf
150K
15V
111
230J
150K
0.1μf
33K
100K
e0
RG
Q2
RTC
Q1
e1

$e_0 = 100K \exp_{10}(-e_1 + \log\frac{15}{150K}) = 10^{1-e_1} (V)$

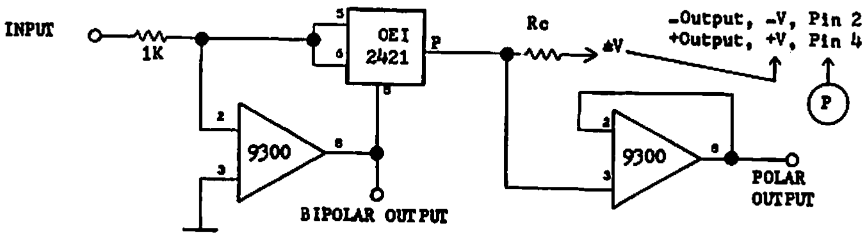
ANTILOG OF VOLTAGE—Uses Analog Devices 751N log module (dashed rectangle) for positive inputs or 751N for negative inputs, with model 111 reference opamp and 230J chopper-stabilized opamp. With input varying from 0 to 5 V, output will vary from 10 V to 100 μV, representing one decade of output voltage change per volt of input voltage change.—W. Borlase and E. David, Design of Temperature Compensated Log Circuits Employing Transistors and Operational Amplifiers, Analog Devices, Cambridge, Mass., E020-10-3/69, p 12.


-In
4.7K
RT
+In
4.7K
2
3
5501
6
OUTPUT
1N4148
1K

DIGITAL LINE RECEIVER—Uses analog comparator IC to detect differential digital signal that may be riding on some common-mode signal. Positive supply voltage is set for logic-compatible output voltage level. Line termination shown eliminates reflection problems of long line lengths, if RT is chosen for best match.—Applying the Model 5501 Monolithic Analog Comparator, Optical Electronics, Tucson, Ariz., No. 10147.

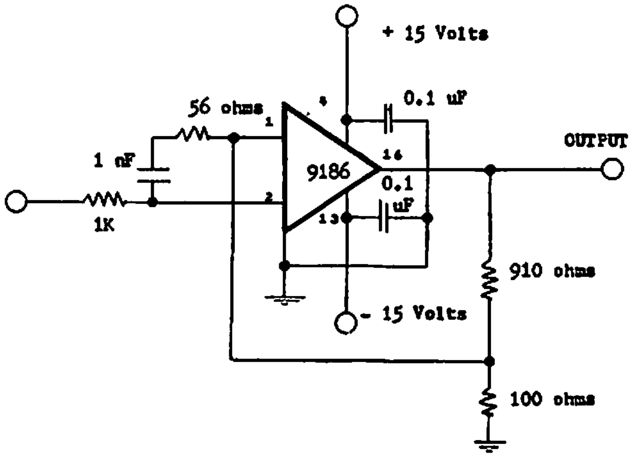

-1 < X < +1 (Volt)
0 < Y < +1 (Volt)
X
10K
Y
1N753A
330
5500
1
2
3
7
4
8
6
10K
2
3
9300
7
8 XY-out
4 (low-level)
10K
1K
10K
2
3
9300
7
8
4
+ 6 Volts
OUTPUT
1V-FS
- 6 Volts

TWO-QUADRANT FOR D-C TO 10 MHZ—OEI Model 5500 analog multiplier and two opamps give wideband multiplier function at 1 V output.—Applying the Model 5500 Monolithic Analog Multiplier, Optical Electronics, Tucson, Ariz., No. 10138.

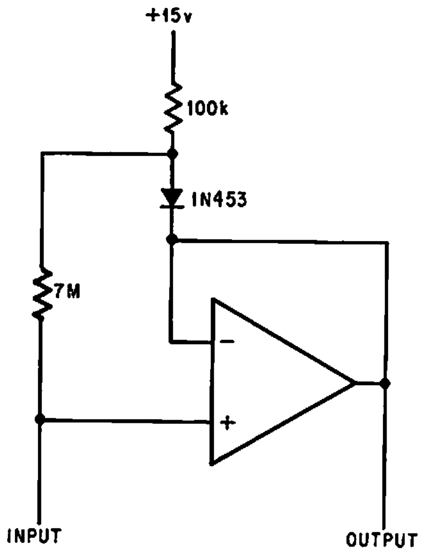

INPUT
1K
OEI 2421
5
6
8
P
2
3
9300
BIPOLAR OUTPUT
Rc
±V
-Output, -V, Pin 2
+Output, +V, Pin 4
P
9300
POLAR OUTPUT

Rc sets the output zero level and the zero TC input level.

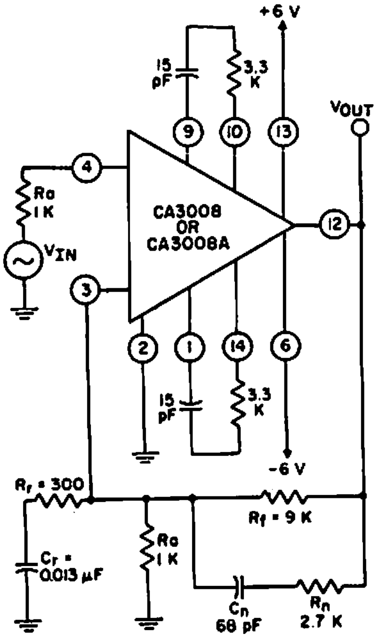
POLAR LOGAMP—Two opamps and Model 2421 diode cluster having log characteristics give 250-mV peak output, inverted in polarity from input, as temperature-compensated polar logamp or as wideband bipolar logamp. —Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.

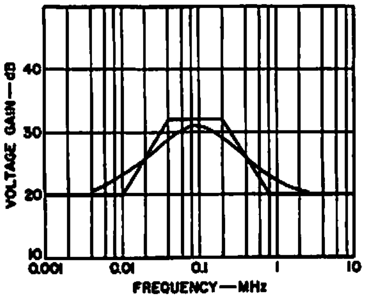

+ 15 Volts
56 ohms
0.1 uF
1 nF
9186
OUTPUT
1K
0.1 uF
14
13
910 ohms
- 15 Volts
100 ohms

VOLTAGE FOLLOWER—Uses OEI Model 9186 uhf opamp with compensation for stabilizing as voltage follower with gain of 10, bandwidth of 30 MHz, and normal slewing rate of 600 V per μs.—A Wide Band Voltage Follower, Optical Electronics, Tucson, Ariz., No. 10108.

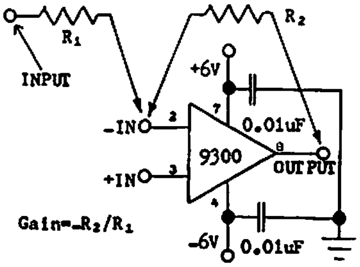

+15v
100k
1N453
7M
-
+
INPUT
OUTPUT

BOOTSTRAPPING STOPS DRIFTS—Germanium diode and selected 7-meg resistor provide bias current compensation for voltage-follower configuration of IC amplifier. Diode bootstrapping to amplifier output provides high input impedance.—R. J. Widlar, Linear IC's: Compensating For Drift, *Electronics*, Feb. 5, 1968, p 90–93.

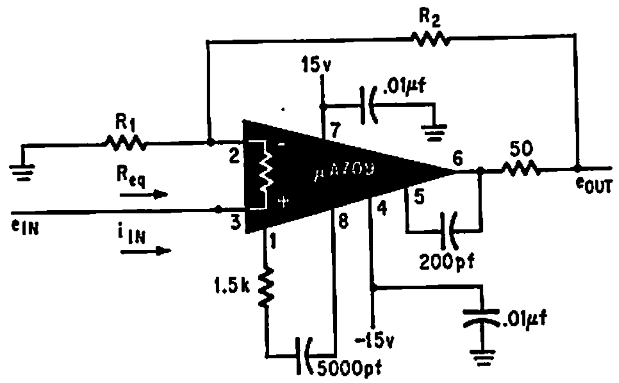

+6 V
15 pF
3.3 K
9
10
13
VOUT
4
Ro 1K
VIN
CA3008 OR CA3008A
12
3
2
1
14
6
15 pF
3.3 K
-6 V
Rr = 300
Cr = 0.013 μF
Ro 1 K
Rf = 9 K
Cn 68 pF
Rn 2.7 K



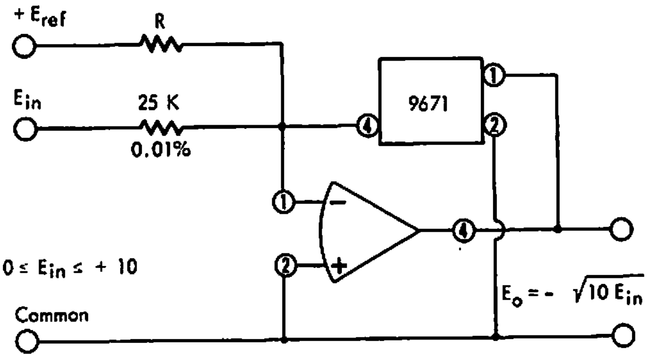
SYNTHESIZING PEAKED RESPONSE—Noninverting IC opamp duplicates transfer function expressed by equation given in book, to give peaked response shown.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 250.


R1
R2
INPUT
+6V
-IN
+IN
2
3
7
4
8
9300
0.01uF
OUTPUT
Gain=-R2/R1
-6V
0.01uF

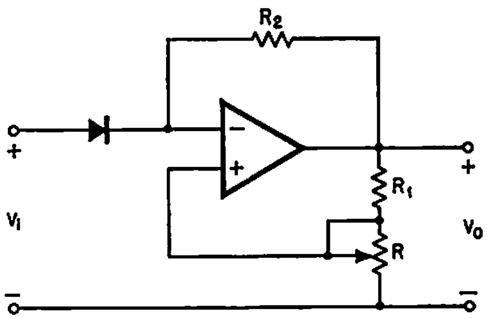
ADJUSTABLE-GAIN AMPLIFIER—Gain depends on ratio of values used for R2 and R1. Circuit requires common ground point. Power supply bypass capacitors should be disc ceramic or equivalent high-frequency types. Use metal-film resistors for maximum bandwidth. OEI 9300 opamp has 6 dB/octave rolloff over entire operating frequency range to 100 MHz.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


R2
15v
.01μf
R1
7
2
6
50
Req
μA709
eIN
iIN
3
8
4
5
eOUT
1
1.5k
200pf
-15v
.01μf
5000pf

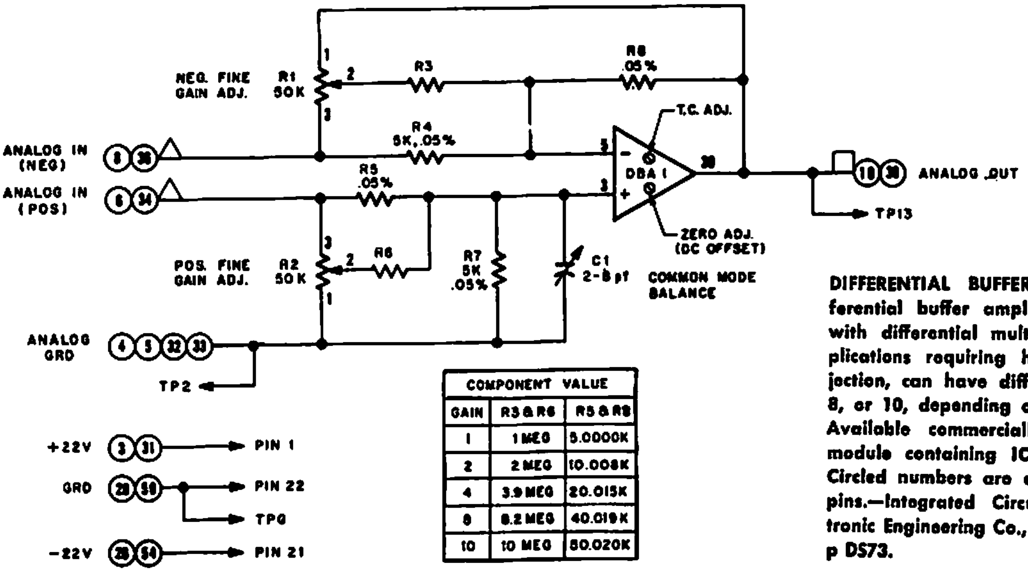
IC BUFFER—Uses Fairchild μA709 opamp to provide any gain from unity to 25,000 without loading source. Closed-loop gain is determined by values used for R1 and R2. Equivalent input resistance can easily be made greater than 10 meg. Article contains 13 other IC opamp application circuits.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


+ Eref
R
Ein
25 K
0.01%
9671
①
②
④
①
②
④
0 ≤ Ein ≤ + 10
Common
Eo = - √10 Ein

SQUARE-ROOT CIRCUIT—Burr-Brown 9671 squaring module is placed in feedback path of standard opamp, to produce at output the square root of an input signal between zero and 10 V. Accuracy is poor for small input amplitudes.—Negative Input General Purpose Squaring Module, Burr-Brown Research, Tucson, Ariz., PDS-180A, 1968.

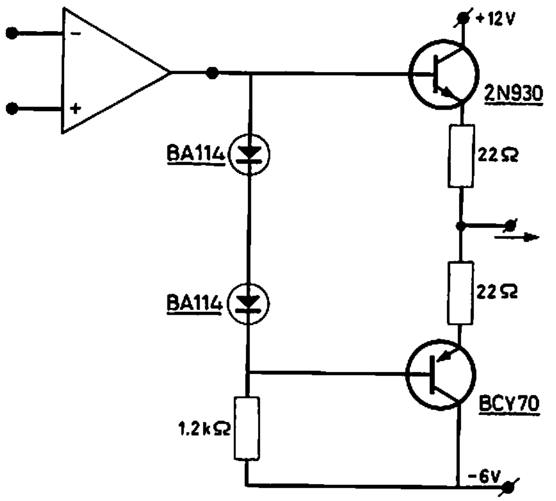


ANTILOG OPAMP—Extends logarithmic relation between forward current and voltage of silicon diode by canceling bulk resistance effect of diode at higher currents. Opamp is Fairchild μA702; R is 20, R1 is 500, and R2 is 1K. Common mode rejection of opamp makes grounding of reference terminals unnecessary.—S. Franco, Op Amp Log Circuit Eliminates Diode Bulk-Resistance Effects, *Electronics*, June 9, 1969, p 101.


NEG. FINE GAIN ADJ.
R1 50K
R3
R8 .05%
T.C. ADJ.
R4 5K, .05%
ANALOG IN (NEG)
ANALOG IN (POS)
R5 .05%
DBA 1
ANALOG OUT
TP13
ZERO ADJ. (DC OFFSET)
POS. FINE GAIN ADJ.
R2 50K
R6
R7 5K .05%
C1 2-8 pf
COMMON MODE BALANCE
ANALOG GRD
TP2
+22V
PIN 1
GRD
PIN 22
TPO
−22V
PIN 21

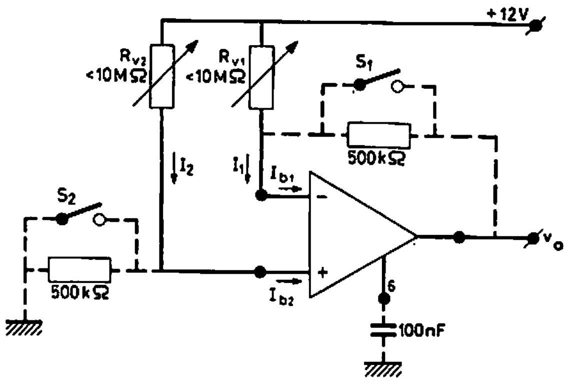
COMPONENT VALUE		
GAIN	R3 & R6	R5 & R8
1	1 MEG	5.0000K
2	2 MEG	10.008K
4	3.9 MEG	20.015K
8	8.2 MEG	40.019K
10	10 MEG	80.020K

DIFFERENTIAL BUFFER—General-purpose differential buffer amplifier, designed for use with differential multiplexer and other applications requiring high common-mode rejection, can have differential gains of 1, 4, 8, or 10, depending on resistor values used. Available commercially as D-4083 plug-in module containing IC and all components. Circled numbers are etched board connector pins.—Integrated Circuit Logic Cards, Electronic Engineering Co., Santa Ana, Cal., 1969, p DS73.



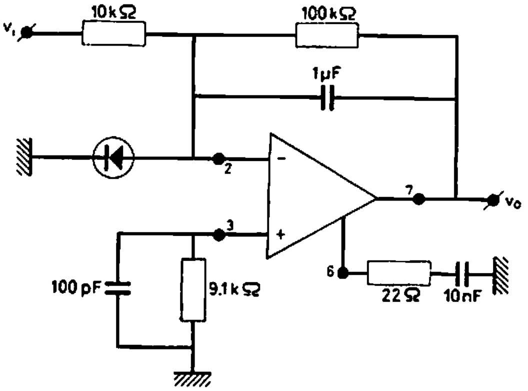
-
+
+12V
2N930
BA114
22Ω
BA114
22Ω
BCY70
1.2kΩ
-6V

BOOSTING OUTPUT CURRENT—Adding complementary pair of emitter-followers to Philips TAA241 difference amplifier gives higher output current. Emitter resistors are used to prevent thermal runaway.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.



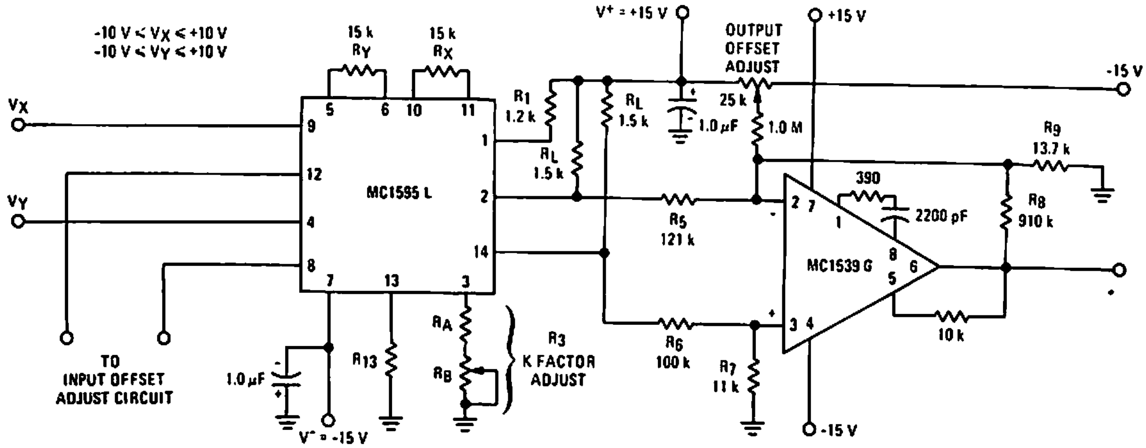
+12V
R_{v2}
<10MΩ
R_{v1}
<10MΩ
S_1
500kΩ
S_2
I_2
I_1
I_{b1}
500kΩ
I_{b2}
6
100nF
v_o

ERROR COMPENSATION—Uses Philips TAA241 difference amplifier with provision for compensating errors introduced by bias or offset current. Potentiometer adjustment procedure is given in report.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.



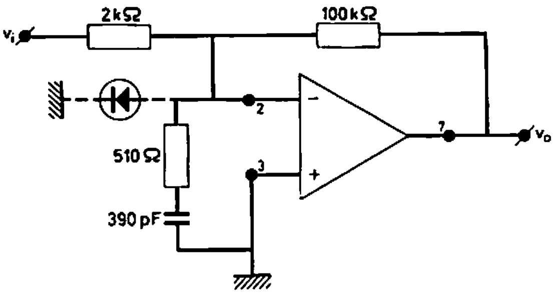
v_i
10kΩ
100kΩ
1μF
2
3
7
v_o
6
100pF
9.1kΩ
22Ω
10nF

DIFFERENCE AMPLIFIER AS INTEGRATOR—Uses Philips TAA241 difference amplifier in connection that prevents feedback capacitor from being continuously charged by offset voltage. Circuit will operate satisfactorily only above its break frequency, which for values shown is 1.6 Hz.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.

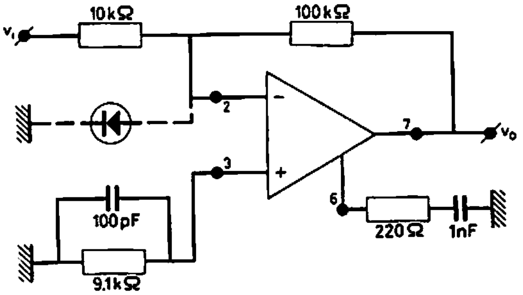


-10 V ≤ VX ≤ +10 V
-10 V ≤ VY ≤ +10 V
15 k RY
15 k RX
VX
VY
MC1595 L
5 6 10 11 9 12 4 8 7 13 3 1 2 14
R1 1.2 k
RL 1.5 k
RL 1.5 k
V+ = +15 V
OUTPUT OFFSET ADJUST
25 k
1.0 μF
1.0 M
+15 V
-15 V
R9 13.7 k
390
2200 pF
R8 910 k
R5 121 k
MC1539 G
10 k
R6 100 k
R7 11 k
-15 V
RA
RB
R3 K FACTOR ADJUST
R13
1.0 μF
V- = -15 V
TO INPUT OFFSET ADJUST CIRCUIT

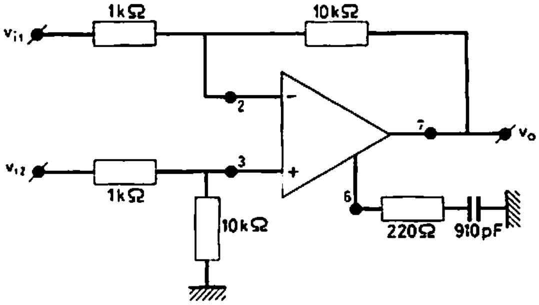
MULTIPLY WITH OPAMP LEVEL SHIFT—Accommodates input voltages from −10 V to +10 V without using 32-V supply. IC multiplier is set up to provide product of input voltages divided by 75, and opamp supplies fixed closed-loop gain of 7.5.—E. Renschler, The Monolithic Multiplier Breakthrough, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 27–36.



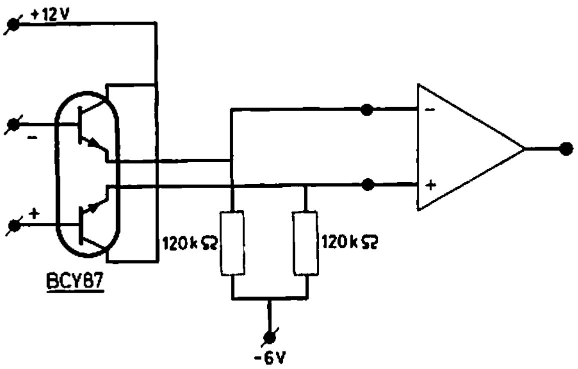
INVERTING AMPLIFIER WITH GAIN OF 50—Full-power frequency is 500 kHz and wideband noise voltage 2 mV rms. Uses Philips TAA241 difference amplifier.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.



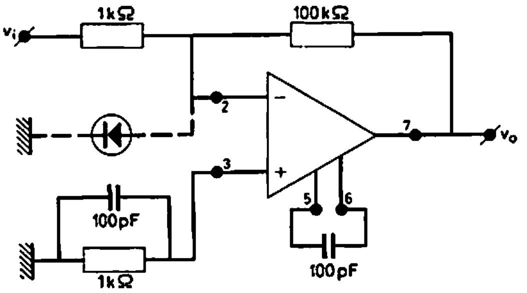
INVERTING AMPLIFIER WITH GAIN OF 10—Full-power frequency is 30 kHz and wideband noise voltage is only 0.5 mV rms. Uses Philips TAA241 difference amplifier.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.



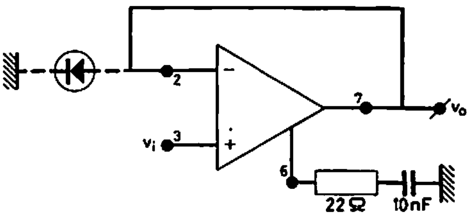
SUBTRACTING AMPLIFIER—Uses Philips TAA-241 difference amplifier in circuit giving gain of 10 that is flat within 1 dB up to 8 MHz.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.



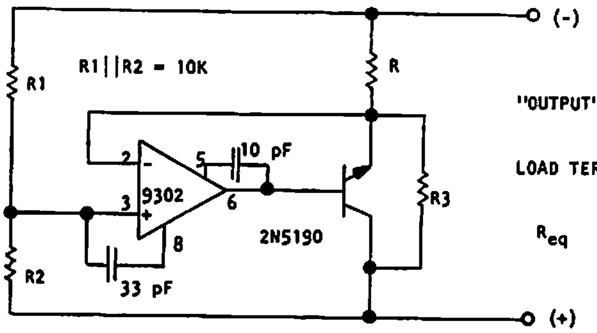
BOOSTING INPUT IMPEDANCE—Pair of emitter-followers ahead of Philips TAA241 difference amplifier increases input impedance and/or permits operation with smaller input current.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.



INVERTING AMPLIFIER WITH GAIN OF 100—Will supply 10 V output at full-power frequency limit of 350 kHz. Wideband noise voltage at output is 1.2 mV rms from 2 Hz to 1 MHz. Uses Philips TAA241 difference amplifier.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.

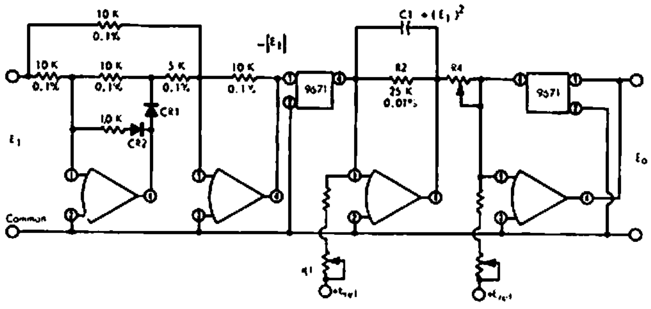


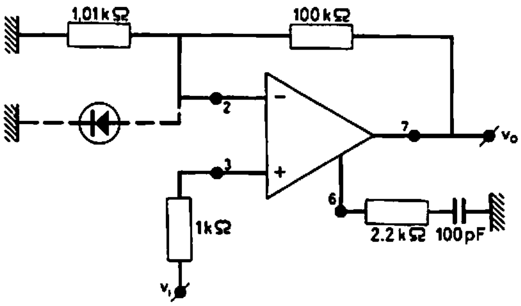
FOLLOWER—Connection shown, for use with Philips TAA241 difference amplifier, gives unity gain. Input impedance is 7 meg and output impedance very low. Can handle signals from +0.5 V to −0.4 V. Response is flat to 2 MHz.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.


(-)
R1
R1||R2 = 10K
R
"OUTPUT"
LOAD TERMINALS
R_eq
2
5
10 pF
3
9302
6
R3
8
2N5190
R2
33 pF
(+)

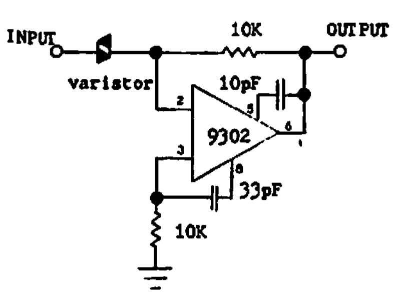
ACTIVE RESISTOR—Two-terminal output has same voltage-current characteristic as fixed resistor. Offers possibility of cost saving, small size, ease of obtaining nonstandard values of resistance, and ability to act as load or ballast at low resistance values. Behaves like shunt regulator. Noninverting input of opamp senses fraction of load voltage and attempts to maintain this voltage (across R) the same as at noninverting input. Bandwidth is 1 MHz. R3 suppresses transients.—An Active Resistor, Optical Electronics, Tucson, Ariz., No. 10148.

ROOT-MEAN-SQUARE CIRCUIT—Operations of square and square-rooting are combined to give rms averaging circuit accepting bipolar inputs. Uses two Burr-Brown 9671 squaring modules combined with four standard opamps. Averaging time of circuit is determined by choice of values for low-pass filter elements R2-C1. Filter bandwidth should be small compared to bandwidth of signal being measured.—Negative Input General Purpose Squaring Module, Burr-Brown Research, Tucson, Ariz., PDS-180A, 1968.

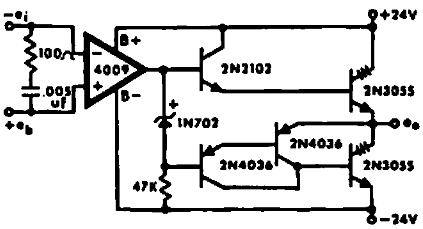

10 K 0.1%
10 K 0.1%
10 K 0.1%
5 K 0.1%
10 K 0.1%
-|E₁|
9671
C1 ∝ (E₁)²
R2 25 K 0.01%
R4
9671
10 K
CR1
CR2
E₁
E₀
Common
R1
+E_ref
+E_ref


1.01kΩ
100kΩ
2
7
v₀
3
6
1kΩ
2.2kΩ
100pF
vᵢ

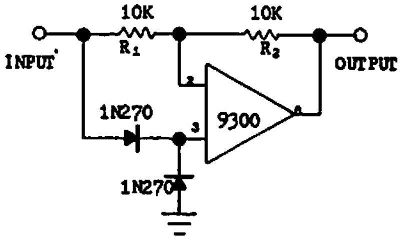
NONINVERTING WITH 100 GAIN—Uses Philips TAA241 difference amplifier. Wideband noise voltage is 1.1 mV rms. Frequency response is flat to 1 MHz.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.


INPUT
10K
OUTPUT
varistor
10pF
2
5
6
3
9302
8
33pF
10K

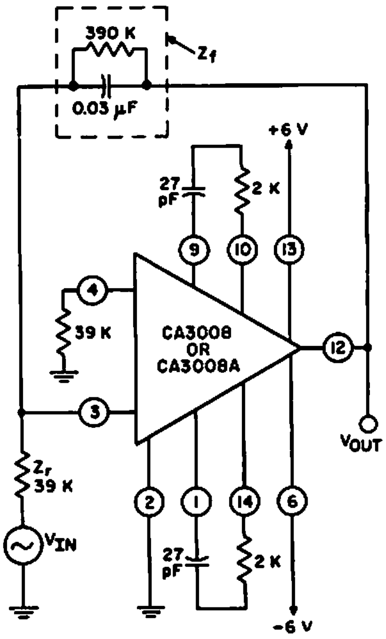
EXPANSION FUNCTION—Thyrite varistor and OEI opamp together give expansion function having exponent greater than unity. By selecting varistor, squaring, cubic, and quadratic functions may be created.—Applying the Model 9302 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10135.


-eᵢ
100
B+
4009
.005 uf
B-
+e_b
2N3102
+24V
2N3055
1N702
47K
2N4036
2N4036
2N3055
e₀
-24V

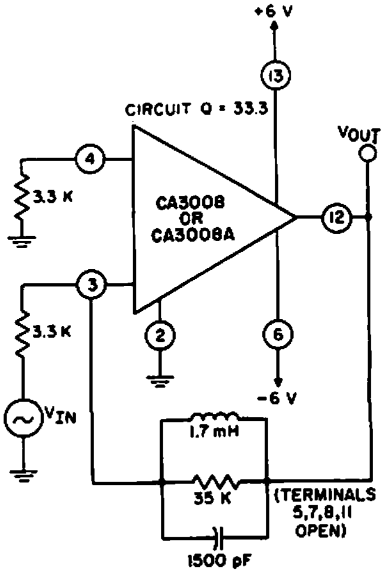
50-W OPERATIONAL POWER AMPLIFIER—Uses pair of silicon transistors in output stage, upper of which is driven by emitter-follower fed by opamp, in Darlington configuration. 320-kHz rolloff network between inputs of opamp ensures stability down to unity gain. Circuit provides closed-loop gain from 2 to about 20.—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.


10K
10K
INPUT
R₁
R₂
OUTPUT
2
1N270
3
9300
1N270

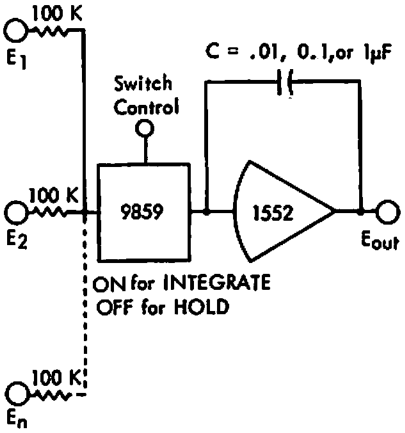
ABSOLUTE-VALUE CIRCUIT—Use of germanium gold-bonded diodes with OEI opamp improves high-frequency operation and low-level signal operation beyond that obtained with silicon diodes. Circuit has positive output, made negative by reversing both diodes. Useful bandwidth is d-c to 100 kHz.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


390 K
Z_f
0.03 μF
+6 V
27 pF
2 K
9
10
13
4
39 K
CA3008 OR CA3008A
12
3
V_{OUT}
Z_r 39 K
V_{IN}
2
1
14
6
27 pF
2 K
-6 V

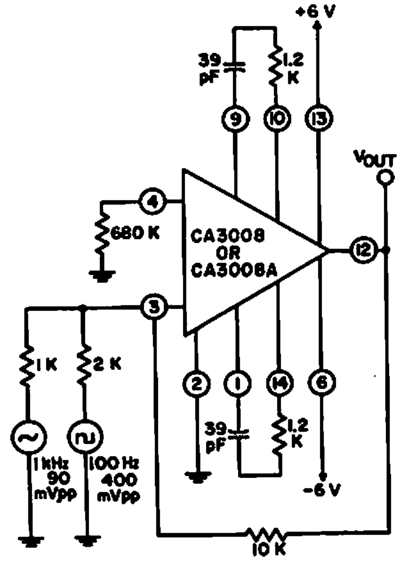
IC OPAMP AS INTEGRATOR—External circuit provides d-c feedback, so offset voltage cannot continuously charge feedback capacitor until amplifier limits. D-c gain is 20 dB. Weighting factor of integration is about 1 ms. —"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 252.


+6 V
13
CIRCUIT Q = 33.3
VOUT
4
3.3 K
CA3008 OR CA3008A
12
3
3.3 K
2
6
-6 V
VIN
1.7 mH
35 K
(TERMINALS 5,7,8,11 OPEN)
1500 pF

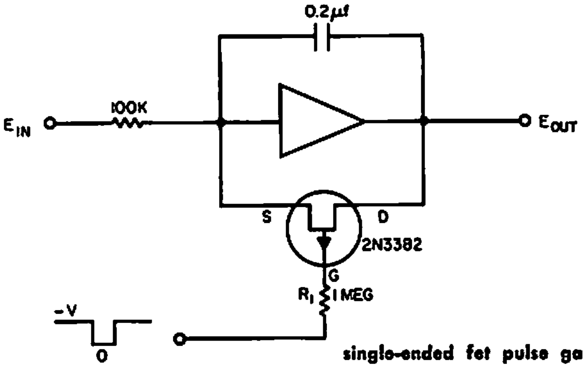
100-KHZ NARROW-BAND—Inverting-type IC opamp is connected as tuned amplifier having peak response shown.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 251.


100 K
E_1
C = .01, 0.1, or 1μF
Switch Control
100 K
9859
1552
E_2
E_{out}
ON for INTEGRATE
OFF for HOLD
100 K
E_n

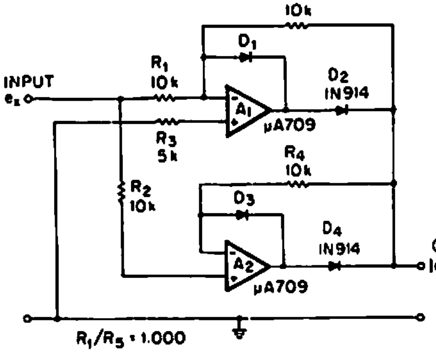
ANALOG INTEGRATOR—Burr-Brown 9859/15 electronic switch feeds opamp to give choice of either integrate or hold modes of operation. With integrate mode (produced by +5 V at switch control), circuit behaves like low fixed resistance and can accommodate input currents up to 1 mA. In hold mode, switch resistance is almost infinite, isolating summing inputs from amplifier. Chief error is due to switching time, which is under 10 μs.—Integrate/Hold Electronic Switch, Burr-Brown Research, Tucson, Ariz., PDS 189, 1967.


+6 V
39 pF
1.2 K
9
10
13
VOUT
4
680 K
CA3008 OR CA3008A
12
3
1 K
2 K
2
1
14
6
39 pF
1.2 K
-6 V
1 kHz 90 mVpp
100 Hz 400 mVpp
10 K

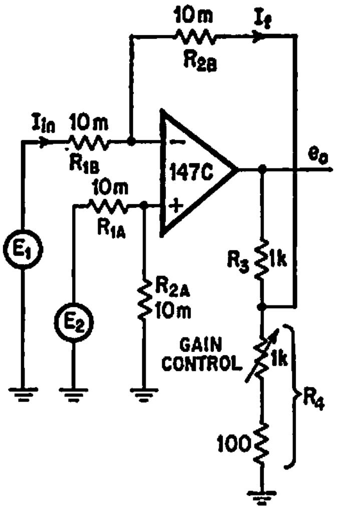
SCALING ADDER—Uses IC opamp with inverting feedback for summing and weighting two different input signals. Weighting is possible because virtual ground existing at junction of feedback resistor and inverting input terminal 3 isolates each signal channel from others.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 254.


0.2μf
E_{IN}
100K
E_{OUT}
S
D
2N3382
G
R_1
1 MEG
-V
0

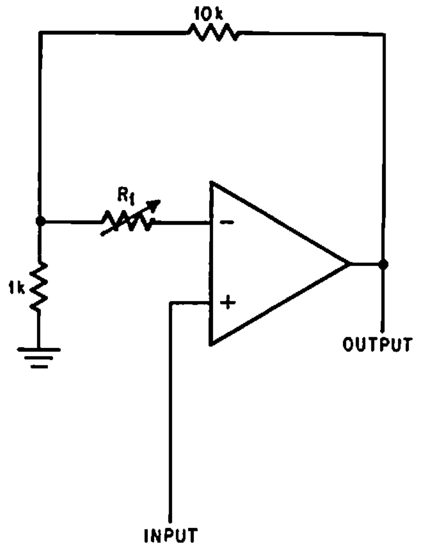
LIMITER AND RESETTER—Electronically variable limiter for opamp has very high input impedance for controlling pulse, while acting as single-ended fet pulse gate for resetting of opamp integrator.—P. A. Ralatos, FET Limits and Resets Operational Amplifiers, *Electronic Design*, Nov. 8, 1965, p 54–56.


R_5 10k
D_1
INPUT e_x
R_1 10k
A_1
D2 IN914
μA709
R_3 5k
R_4 10k
R_2 10k
D_3
D_4 IN914
OUTPUT $|e_x|$
A_2
μA709
$R_1/R_5 = 1.000$

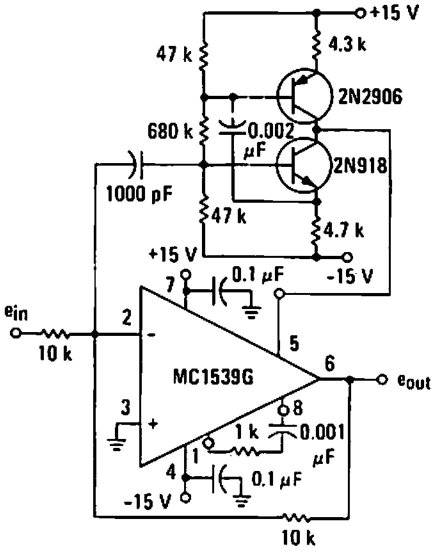
ABSOLUTE VALUE—Provides high accuracy yet requires only one pair of accurately matched resistors (R1 and R5). Opamp A1 serves as inverter and A2 as voltage follower. Input can be up to 1 kHz, which is adequate for analog-digital converter system.—M. A. Smither, Improved Absolute-Value Circuit, *EEE*, March 1969, p 124.


10m
If
R2B
Iin 10m
R1B
10m
R1A
147C
eo
E1
E2
R2A
10m
R3
1k
GAIN CONTROL
1k
R4
100

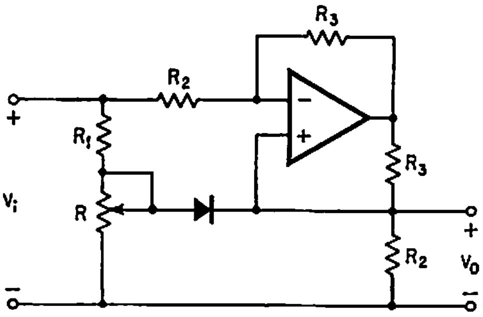
VARIABLE-GAIN IC—Provides continuously adjustable gain with single pot, for matching circuit sensitivity to input signal levels. Input attenuation network R3-R4 minimizes common-mode errors. Circuit gain can be varied from less than unity to very high upper limit. —W. D. Miller, Minimizing Common-Mode Errors in a Variable-Gain Amplifier, *Electronics*, June 23, 1969, p 104.


10k
R1
1k
OUTPUT
INPUT

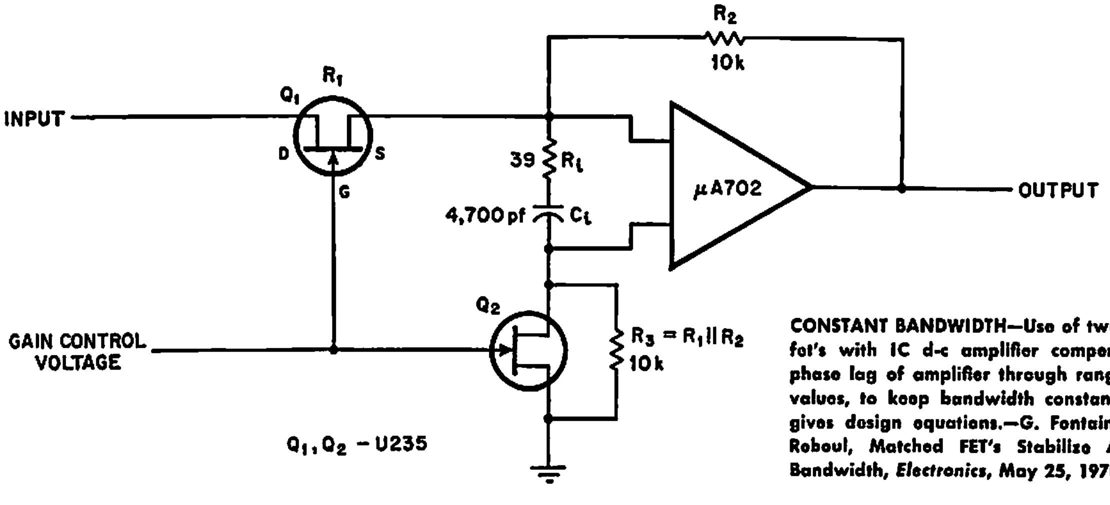
NONINVERTING AMPLIFIER—Variable resistor R1 provides bias current compensation for linear IC that has fixed source impedance. R1 should be three times source impedance. Will handle wide temperature range, and is unaffected by power supply or common mode variations.—R J. Widlar, Linear IC's: Compensating For Drift, *Electronics*, Feb. 5, 1968, p 90–93.


+15 V
47 k
4.3 k
2N2906
680 k
0.002 μF
2N918
1000 pF
47 k
4.7 k
+15 V
-15 V
7
0.1 μF
ein
2
10 k
5
6
eout
MC1539G
3
8
1 k
0.001 μF
1
4
0.1 μF
-15 V
10 k

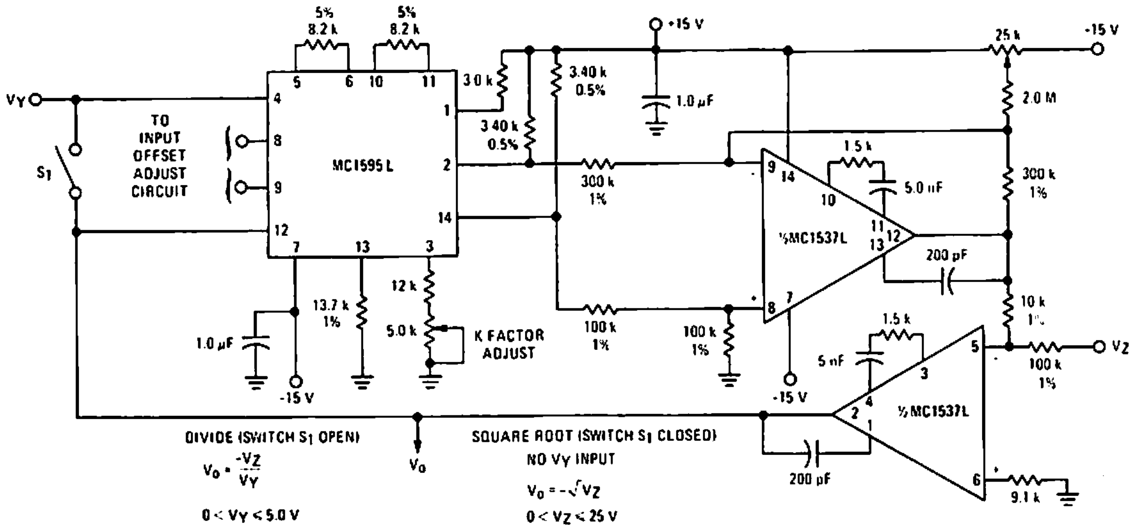
UNITY-GAIN FEED-FORWARD—First two stages of Motorola opamp are bypassed for high frequency and signal is inserted at input to third stage. Gives output of 10 V p-p at 1 MHz. Operating information is given in Motorola Application Note AN-439. —K. Huehne, The Continuing Dominance of the Operational Amplifier, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 5—13.


R3
R2
+
R1
R3
Vi
R
+
R2
V0
−
−

LOG OPAMP—Opamp cancels bulk resistance effect of silicon diode, to permit working with larger forward currents in logarithmic amplifier. Opamp is Fairchild μA702; R1 is 500, R2 and R3 are 1K, and R is 20.. Common mode rejection of opamp makes grounding of reference terminals unnecessary. —S. Franco, Op Amp Log Circuit Eliminates Diode Bulk-Resistance Effects, *Electronics*, June 9, 1969, p 101.

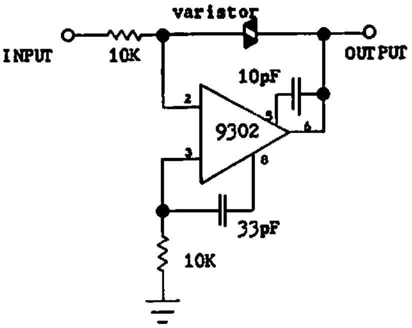

R2
10k
R1
Q1
INPUT
D
S
G
39
Rt
μA702
OUTPUT
4,700 pf
Ct
Q2
GAIN CONTROL VOLTAGE
R3 = R1 ‖ R2
10k
Q1, Q2 − U235

CONSTANT BANDWIDTH—Use of two matched fet's with IC d-c amplifier compensates for phase lag of amplifier through range of gain values, to keep bandwidth constant. Article gives design equations.—G. Fontaine and G. Reboul, Matched FET's Stabilize Amplifier's Bandwidth, *Electronics*, May 25, 1970, p 93.



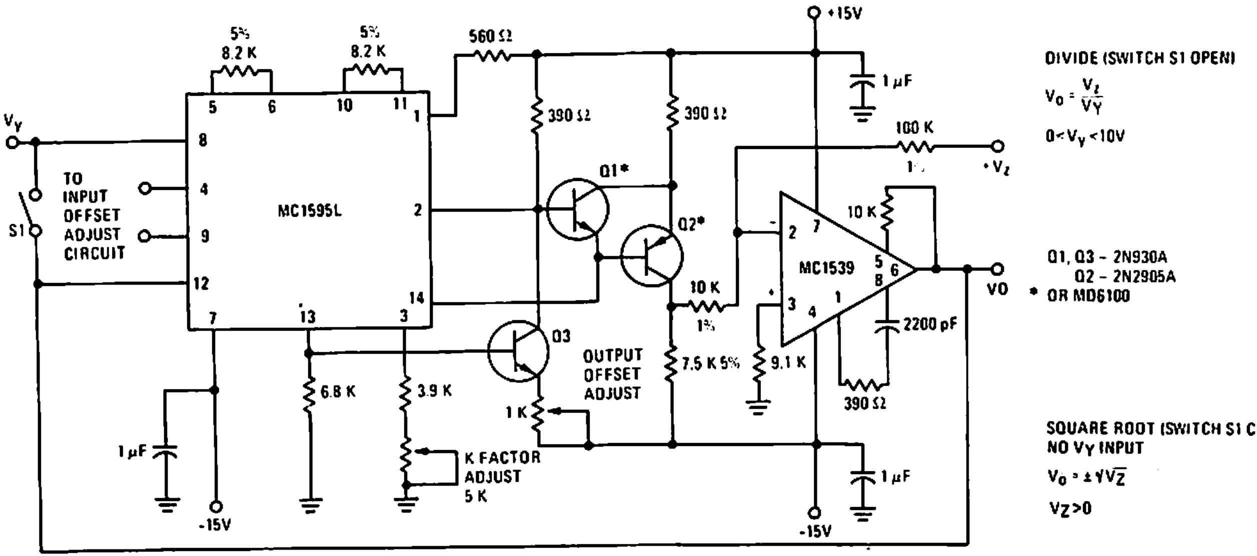
5%
8.2 k
5%
8.2 k
+15 V
25 k
-15 V
VY
TO INPUT OFFSET ADJUST CIRCUIT
S1
MC1595L
30 k
3.40 k 0.5%
3.40 k 0.5%
1.0 μF
2.0 M
1.5 k
5.0 nF
300 k 1%
300 k 1%
½MC1537L
200 pF
10 k 1%
VZ
100 k 1%
13.7 k 1%
12 k
5.0 k
K FACTOR ADJUST
1.0 μF
-15 V
100 k 1%
100 k 1%
-15 V
1.5 k
5 nF
½MC1537L
9.1 k
200 pF
DIVIDE (SWITCH S1 OPEN)
$V_o = \frac{-V_Z}{V_Y}$
$0 < V_Y < 5.0$ V
V_o
SQUARE ROOT (SWITCH S1 CLOSED)
NO VY INPUT
$V_o = -\sqrt{V_Z}$
$0 < V_Z < 25$ V

SQUARE ROOT WITH MULTIPLIER AND DUAL OPAMP—Also performs division of two input voltages, when multiplier is used in opamp feedback loop.—E. Renschler, The Monolithic Multiplier Breakthrough, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 27–36.



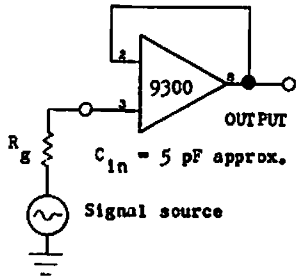
varistor
INPUT
10K
OUTPUT
10pF
9302
33pF
10K

ROOTING FUNCTION—OEI opamp circuit combined with thyrite varistor gives function having exponent less than unity. Opamp permits full 10-V swing with either polarity to 100 kHz but varistor may reduce this bandwidth. Single varistors provide exponents of 0.25 to 0.5, and combination of varistors with or without resistors and diodes gives wide variety of other nonlinear functions.—Applying the Model 9302 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10135.

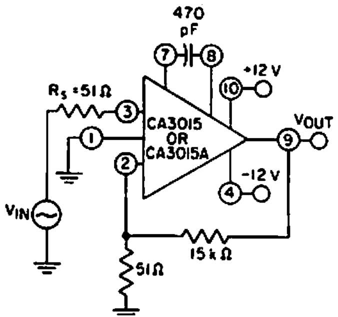


5%
8.2 K
5%
8.2 K
560 Ω
+15V
1 μF
Vy
TO INPUT OFFSET ADJUST CIRCUIT
S1
MC1595L
390 Ω
390 Ω
Q1*
Q2*
100 K
1%
+Vz
10 K
MC1539
VO
10 K 1%
2200 pF
Q3
OUTPUT OFFSET ADJUST
7.5 K 5%
9.1 K
390 Ω
6.8 K
3.9 K
1 K
K FACTOR ADJUST 5 K
1 μF
-15V
1 μF
-15V
DIVIDE (SWITCH S1 OPEN)
$V_o = \frac{V_z}{V_Y}$
$0 < V_y < 10$V
Q1, Q3 - 2N930A
Q2 - 2N2905A
* OR MD6100
SQUARE ROOT (SWITCH S1 CLOSED)
NO VY INPUT
$V_o = \pm\sqrt{V_Z}$
$V_Z > 0$

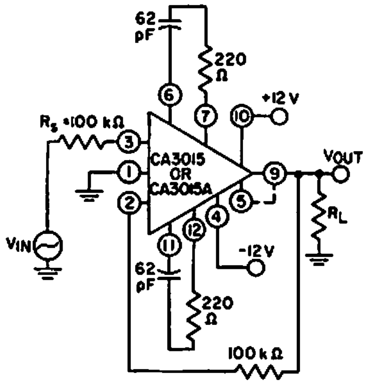
DIVIDE AND SQUARE ROOT—Combination of Motorola opamp and linear four-quadrant multiplier used as feedback element provides functions of division or square root, along with discrete level shift. Operating information is given in Motorola Application Note AN-490.—K. Huehne, The Continuing Dominance of the Operational Amplifier, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 5–13.


9300
2
3
8
OUTPUT
R_g
C_{in} = 5 pF approx.
Signal source

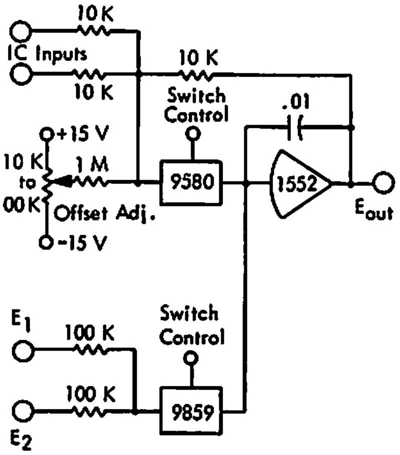
POSITIVE VOLTAGE FOLLOWER—Uses OEI 9300 opamp as unity-gain amplifier serving as buffer for signal source when driving lower-impedance circuit or transmission line. Requires 6-V bipolar supply. With 1,000-ohm generator impedance, bandwidth is above 10 MHz.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


470 pF
7
8
+12 V
10
R_s =51 Ω
3
1
2
CA3015 OR CA3015A
VOUT
9
-12 V
4
VIN
15 k Ω
51 Ω

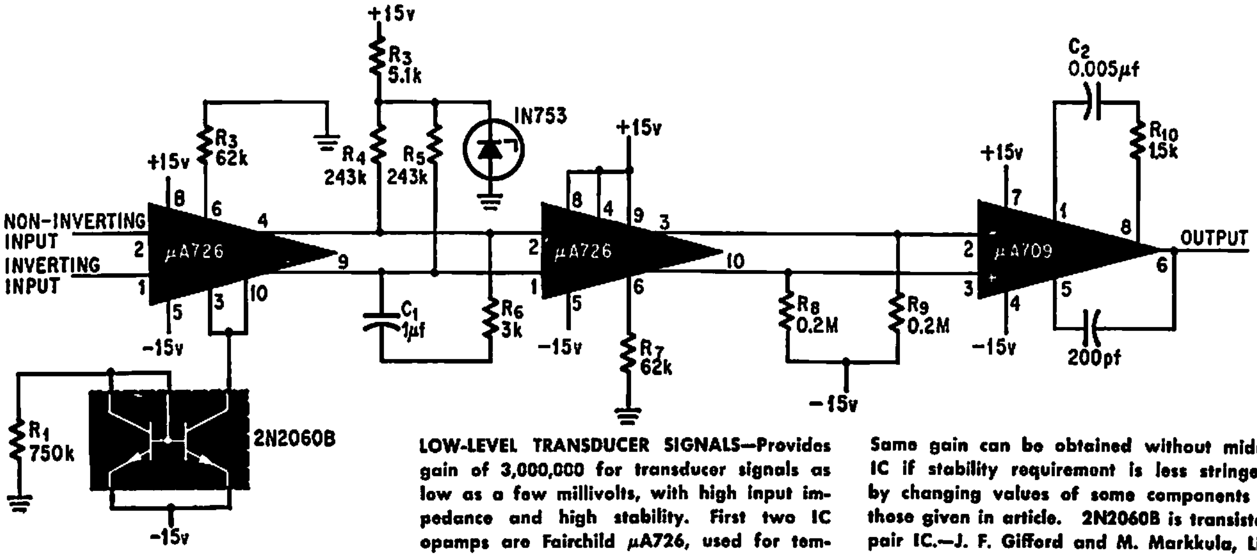
50-DB NONINVERTING—IC opamp with phase-lead compensation has 3-dB bandwidth of 3.5 MHz and unity-gain crossover at 150 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 260.


62 pF
220 Ω
6
7
10
+12 V
R_s =100 kΩ
3
1
2
CA3015 OR CA3015A
9
5
VOUT
R_L
12
4
11
-12V
VIN
62 pF
220 Ω
100 k Ω

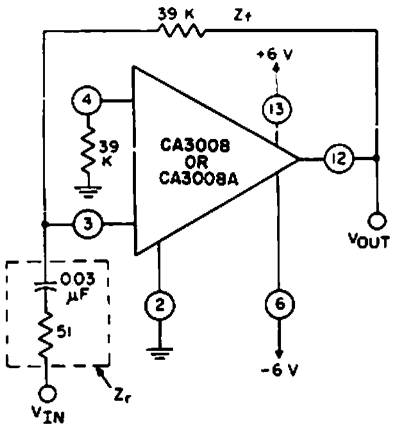
VOLTAGE FOLLOWER—Connection shown for IC opamp, with terminals 5 and 9 shorted, will transform 3.4 V p-p from 100,000-ohm source to 470-ohm load. Higher voltage swing may be obtained by increasing positive supply voltage.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 263.


10K
IC Inputs
10 K
10 K
Switch Control
.01
+15 V
10 K to 100K
1 M
Offset Adj.
-15 V
9580
1552
E_{out}
E_1
100 K
Switch Control
100 K
9859
E_2

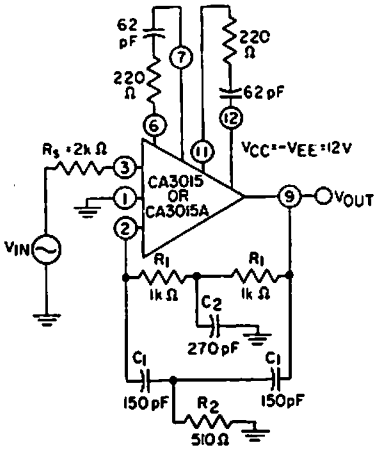
THREE-MODE CONTROL—Uses two electronic switch modules feeding opamp. Reset mode is obtained with 9580 ON (0 V at control) and 9859 OFF (0 V at its control). Compute mode is obtained with 9580 OFF (+5 V at control) and 9859 ON (+5 V). Hold mode is obtained with both switches off.—Integrate/Hold Electronic Switch, Burr-Brown Research, Tucson, Ariz., PDS 189, 1967.


+15v
R_3 5.1k
IN753
+15v
R_3 62k
R_4 243k
R_5 243k
+15v
+15v
C_2 0.005µf
R_{10} 1.5k
NON-INVERTING INPUT
INVERTING INPUT
µA726
µA726
µA709
OUTPUT
C_1 1µf
R_6 3k
-15v
-15v
R_7 62k
R_8 0.2M
R_9 0.2M
-15v
-15v
200pf
R_1 750k
2N2060B
-15v

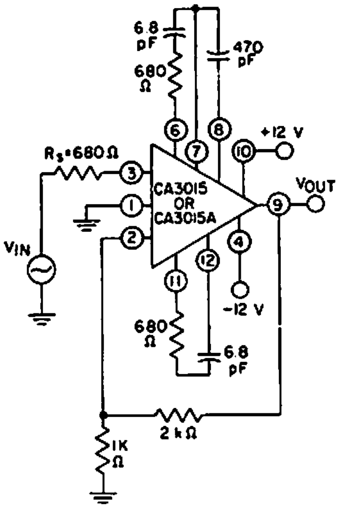
LOW-LEVEL TRANSDUCER SIGNALS—Provides gain of 3,000,000 for transducer signals as low as a few millivolts, with high input impedance and high stability. First two IC opamps are Fairchild µA726, used for temperature stabilization and to prevent loading of high-impedance transducers. Fairchild µA709 opamp at right provides most of gain. Same gain can be obtained without middle IC if stability requirement is less stringent, by changing values of some components to those given in article. 2N2060B is transistor-pair IC.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


39 K
Zf
+6 V
4
39 K
CA3008
OR
CA3008A
13
12
VOUT
3
.003 µF
51
2
6
-6 V
Zr
VIN

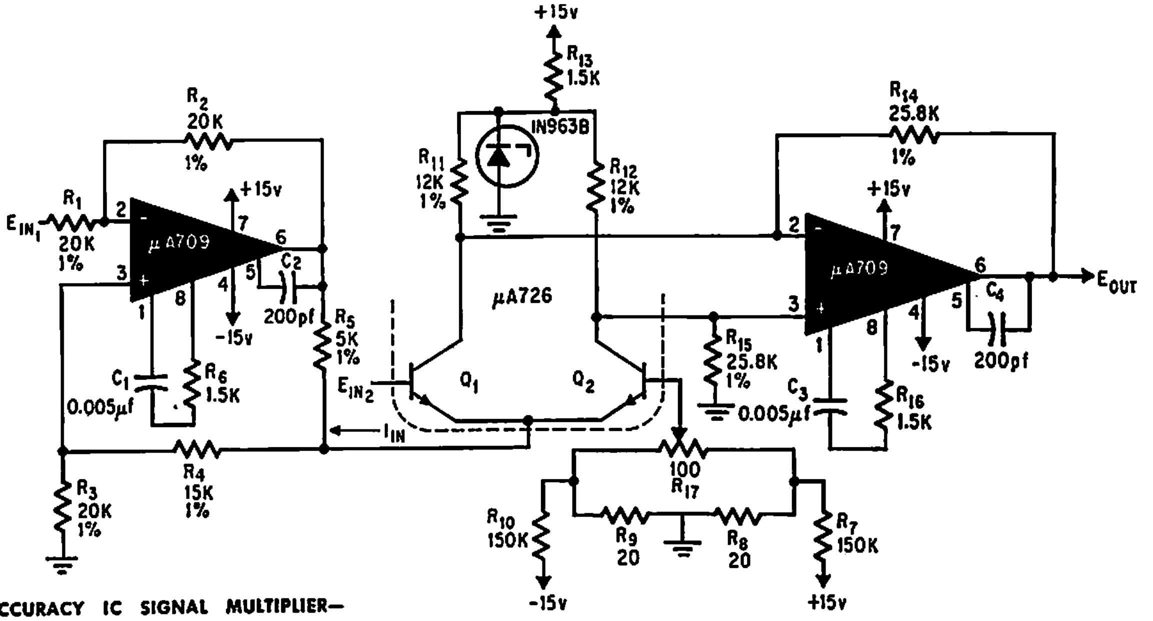
DIFFERENTIATOR—IC opamp with connections shown will serve as differentiating circuit, giving output peak for each side of square-wave input.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 253.


62 pF
220 Ω
7
220 Ω
62 pF
6
11
12
VCC=-VEE=12V
Rs=2kΩ
3
1
2
CA3015
OR
CA3015A
9
VOUT
VIN
R1
1kΩ
R1
1kΩ
C2
270pF
C1
150pF
C1
150pF
R2
510Ω

TWIN-T BANDPASS—With values shown, gain is peak of 33 dB at 1 MHz and 3-dB bandwidth is about 0.1 MHz with twin-T network in feedback loop.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 261.


6.8 pF
680 Ω
470 pF
6
7
8
+12 V
10
Rs=680Ω
3
1
2
CA3015
OR
CA3015A
9
VOUT
VIN
4
-12 V
11
12
680 Ω
6.8 pF
1K Ω
2kΩ

10-DB GAIN AT 42 MHZ—Uses noninverting IC opamp with phase-lead and phase-lag compensation. Response peaks about 2 dB at 20 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 261.

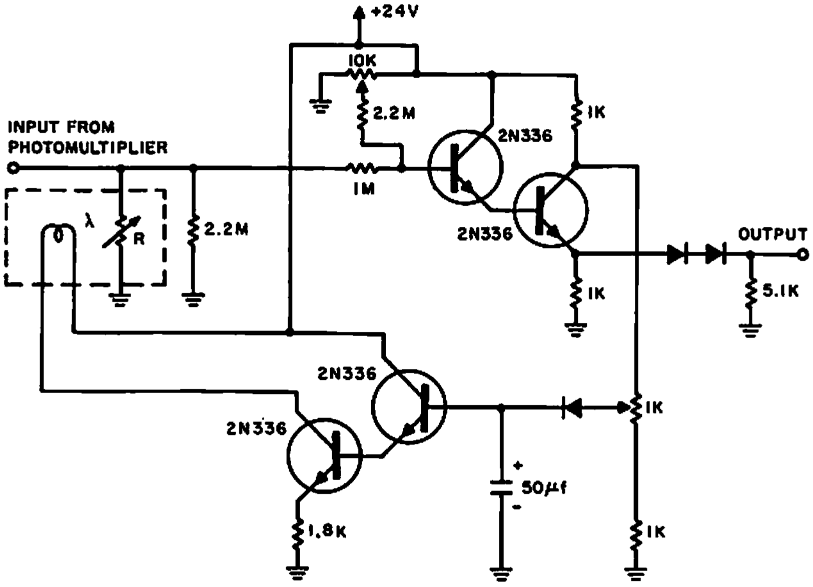

+15v
R13
1.5K
1N963B
R11
12K
1%
R12
12K
1%
R2
20K
1%
R14
25.8K
1%
EIN1
R1
20K
1%
µA709
+15v
2
3
7
6
4
5
1
8
C2
200pf
-15v
R5
5K
1%
C1
0.005µf
R6
1.5K
µA726
EIN2
Q1
Q2
IIN
R15
25.8K
1%
C3
0.005µf
µA709
+15v
2
3
7
6
4
5
1
8
-15v
C4
200pf
EOUT
R16
1.5K
R4
15K
1%
R3
20K
1%
100
R17
R10
150K
R9
20
R8
20
R7
150K
-15v
+15v

HIGH-ACCURACY IC SIGNAL MULTIPLIER—First Fairchild µA709 IC opamp supplies current proportional to one positive input voltage. Other input is fed directly to base of Q1 in differential pair of µA726 IC that multiplies. Second µA709 converts resulting output current to voltage having desired scale factor, with low output impedance.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.

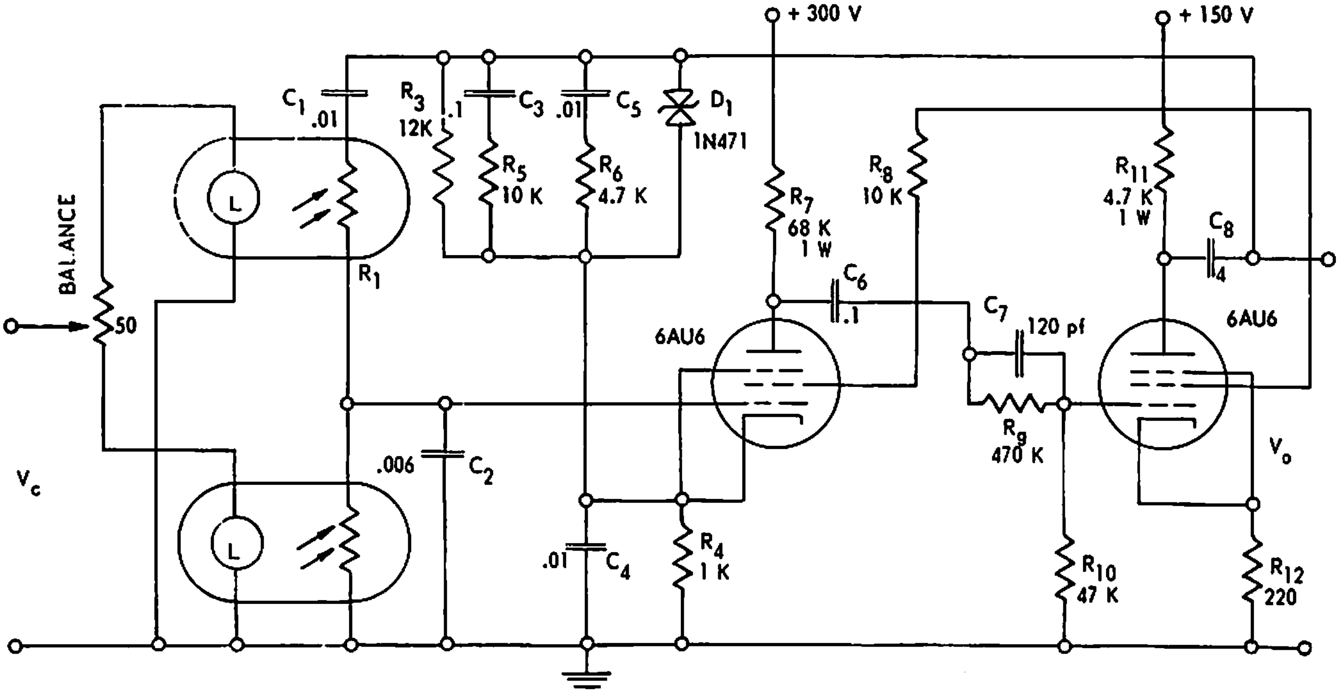
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 57

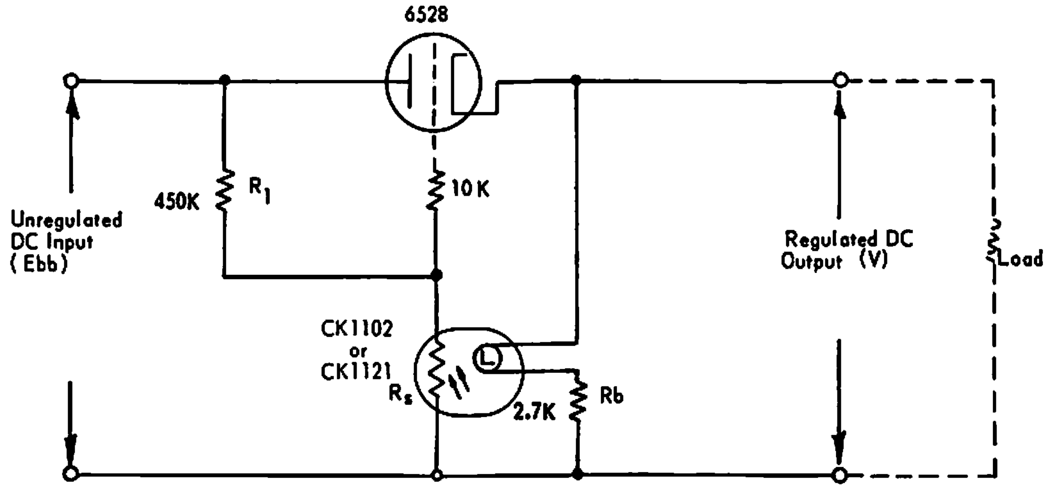
Optoelectronic Circuits


+24V
10K
2.2M
IK
2N336
INPUT FROM PHOTOMULTIPLIER
IM
λ
R
2.2M
2N336
OUTPUT
IK
5.IK
2N336
2N336
IK
+
50µf
-
1.8K
IK

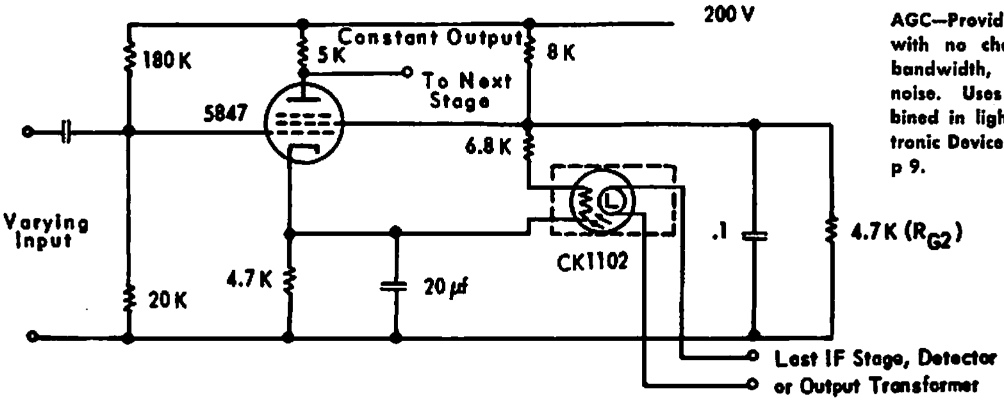
FAX PHOTOMULTIPLIER AMPLIFIER—Raytheon Raysistor lamp-photoconductor, similar to CK1116 but with extremely small filaments for fast response (dashed box), improves response speed of baseband photomultiplier amplifier for AN/GXC-5 portable facsimile system that transmits graphic material. Diodes can be 1N2069.—H. Weisbecker, Designing a Feedback System? Control It With a Photo Emitter-Sensor, *Electronic Design*, Aug. 30, 1965, p 32 and 34–35.


+ 300 V
+ 150 V
C1 .01
R3 12K
.1
C3
.01
C5
D1
1N471
R5 10 K
R6 4.7 K
BALANCE
50
L
R1
R7 68 K 1 W
R8 10 K
R11 4.7 K 1 W
C8
4
C6 .1
C7 120 pf
6AU6
6AU6
R9 470 K
.006
C2
Vc
Vo
L
.01
C4
R4 1 K
R10 47 K
R12 220

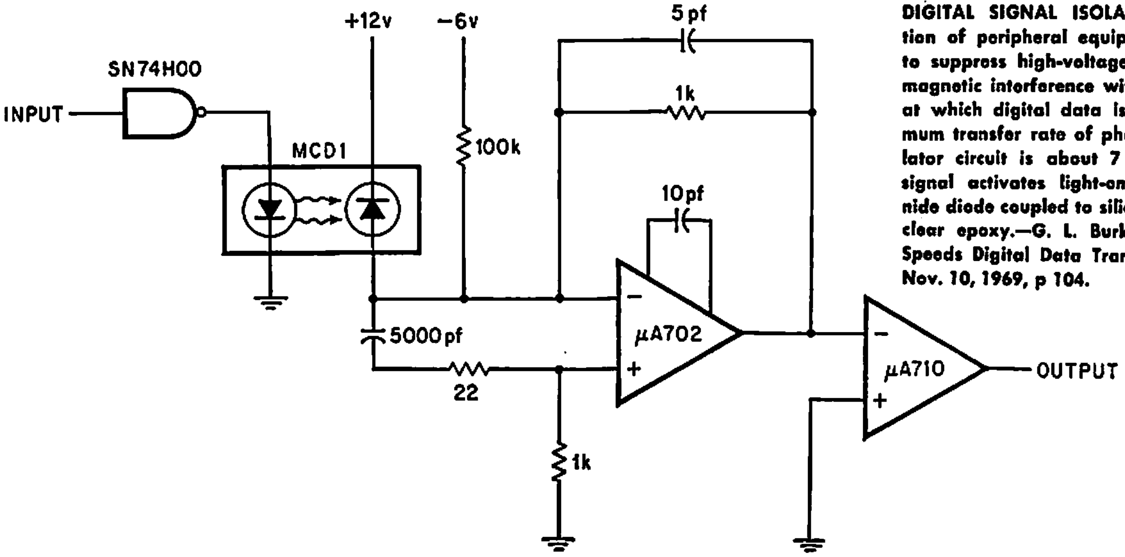
WIEN-BRIDGE VCO—Changing d-c control voltage applied to lamps of CK1102 or CK-1112 Raysistor pair changes values of photocell resistances in arms of bridge, to vary output frequency over range of 10 Hz to 50 kHz. Output has constant amplitude within 1 dB and is reasonably sinusoidal.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 20.


6528
Unregulated
DC Input
(Ebb)
450K
R1
10K
CK1102
or
CK1121
Rs
2.7K
Rb
Regulated DC
Output (V)
Load

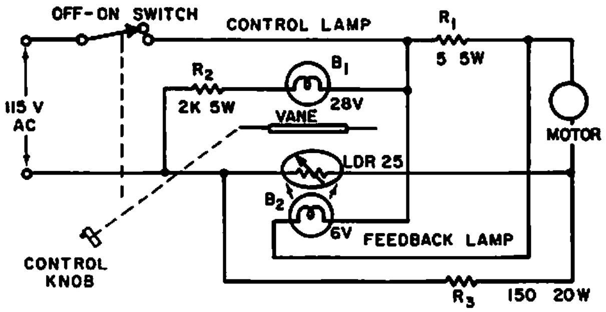
RAYSISTOR CONTROL—Uses combination lamp and photocell in single package to sense output voltage and apply appropriate controlled voltage to grid of series regulator triode. Report gives design calculations. Good regulation is obtained for 100 V d-c output when input varies from 200–400 V.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 13.


200 V
180 K
5K
Constant Output
8 K
To Next
Stage
5847
6.8 K
Varying
Input
CK1102
.1
4.7 K (RG2)
20 K
4.7 K
20 μf
Last IF Stage, Detector
or Output Transformer

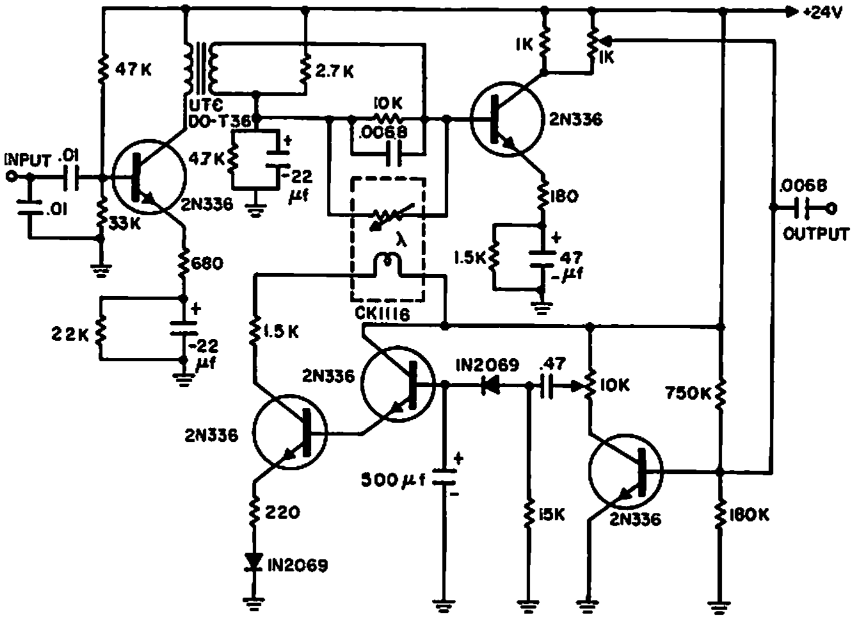
AGC—Provides 20 dB dynamic control range, with no change in frequency response or bandwidth, good isolation, and no added noise. Uses light source and photocell combined in light-tight case.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 9.


+12v
−6v
5 pf
SN74H00
INPUT
1k
MCD1
100k
10pf
μA702
5000 pf
22
1k
μA710
OUTPUT

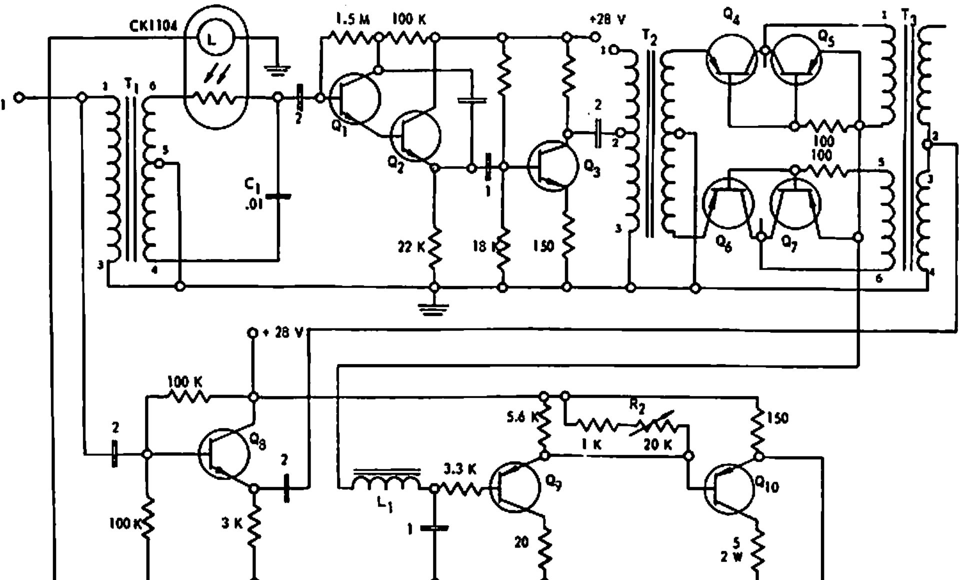
DIGITAL SIGNAL ISOLATOR—Provides isolation of peripheral equipment from computer to suppress high-voltage effects and electromagnetic interference without affecting speed at which digital data is transmitted. Maximum transfer rate of photodiode-coupled isolator circuit is about 7 MHz. Digital input signal activates light-emitting gallium arsenide diode coupled to silicon diode detector by clear epoxy.—G. L. Burkart, Optical Isolator Speeds Digital Data Transmission, *Electronics*, Nov. 10, 1969, p 104.


OFF-ON SWITCH
CONTROL LAMP
R_1
5 5W
R_2
2K 5W
B_1
28V
VANE
115 V AC
MOTOR
LDR 25
B_2
6V
FEEDBACK LAMP
CONTROL KNOB
R_3
150 20W

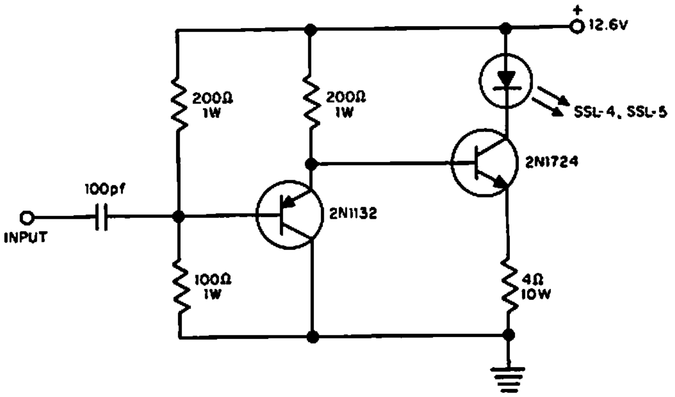
PHOTOELECTRIC APPLIANCE CONTROL—Low-cost speed control for small universal motor in kitchen appliances or for lamp loads up to 60 W requires only cadmium sulfide cell, lamp, and knob-controlled vane. Additional 6-V lamp provides optoelectronic feedback for speed regulation. Performance equals that of two scr's back-to-back.—Bargain Components, *Electronic Design*, Oct. 12, 1964, p 44–45.


+24V
47K
UTC DO-T36
2.7K
10K
.0068
1K
1K
2N336
INPUT
.01
.01
47K
22 μf
33K
2N336
180
1.5K
47 μf
.0068
OUTPUT
680
λ
CK1116
22K
22 μf
1.5K
2N336
IN2069
.47
10K
750K
2N336
500μf
2N336
220
IN2069
15K
2N336
180K

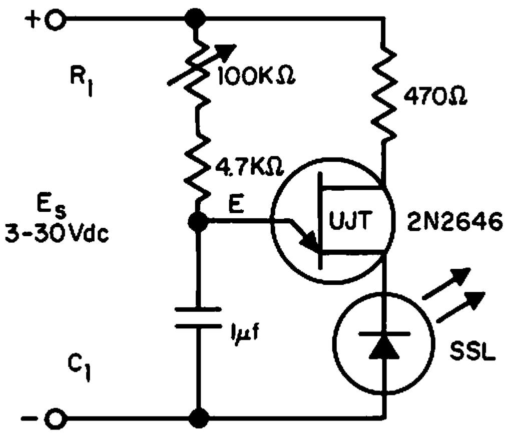
BACKGROUND CONTROL FOR A-M FAX—Raytheon CK1116 lamp-photoconductor (dashed box) and Darlington in feedback loop provide background control for a-m facsimile signal generated in AN/GXC-5 portable facsimile system for transmitting graphic material. Also generates audio frequency-shift signal between 1,500 and 2,300 Hz, below 2,400-Hz a-m carrier. Output may be transmitted by radio or over phone lines. Article gives design equations.—H. Weisbecker, Designing a Feedback System? Control It With a Photo Emitter-Sensor, *Electronic Design*, Aug. 30, 1965, p 32 and 34–35.


CK1104
L
e_1
T_1
1
6
5
3
4
2
C_1
.01
1.5 M
100 K
Q_1
Q_2
1
22 K
18 K
150
+28 V
Q_3
2
1
2
3
T_2
Q_4
Q_5
100
100
Q_6
Q_7
T_3
1
2
3
4
5
6
+ 28 V
100 K
2
Q_8
2
100 K
3 K
5.6 K
R_2
1 K
20 K
150
L_1
3.3 K
Q_9
1
20
Q_{10}
5
2 W

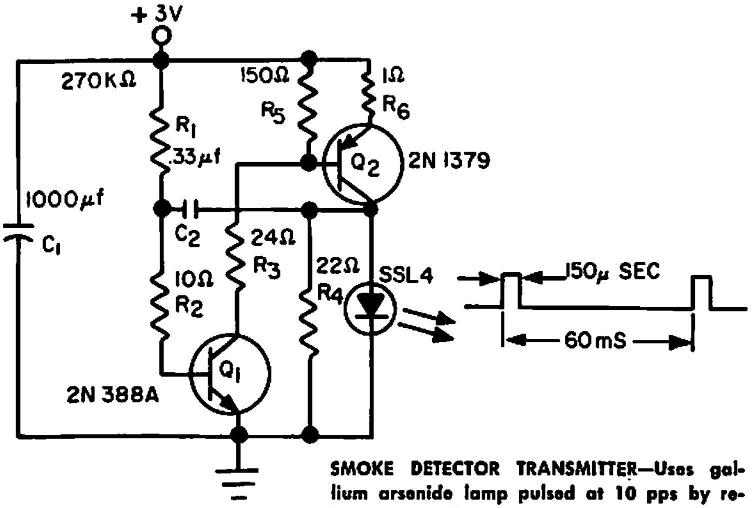
AUDIO PHASE SHIFTER—Raysistor serves as variable resistance in servo loop, to provide constant phase shift of 90 deg within 2 deg from 200 to 2,000 Hz. Initial control voltage applied to Raysistor lamp, value of C1, and operating frequency range are mutually interdependent, and affected by choice of transistors.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 23.


+
12.6V
200Ω
1W
200Ω
1W
SSL-4, SSL-5
2N1724
100pf
INPUT
2N1132
100Ω
1W
4Ω
10W

LIGHT-BEAM MODULATOR—Two-transistor modulator is linear up to 80% modulation of light beam generated by gallium arsenide solid-state lamp. Bandwidth is 30 Hz to 250 kHz.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 8.

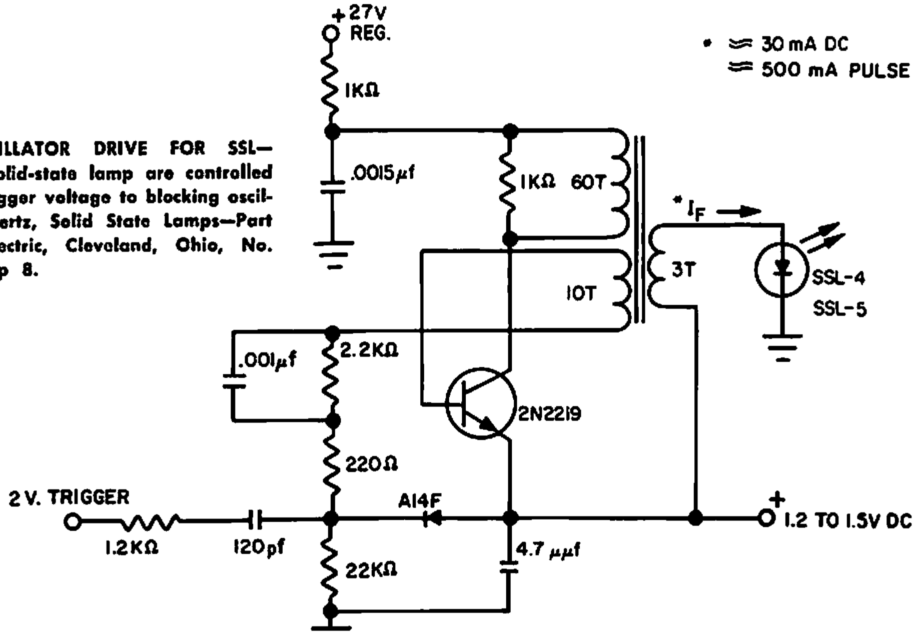

+
R_1
100KΩ
470Ω
4.7KΩ
E_S
3-30Vdc
E
UJT
2N2646
1μf
SSL
C_1
−

LAMP DRIVE—Simple ujt pulse generator gives 20-ms fast-rise pulses for driving solid-state lamps. R1 changes frequency, and C1 changes frequency range and pulse width. With 15-V supply, frequency range is 10 to 200 pps.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 23.

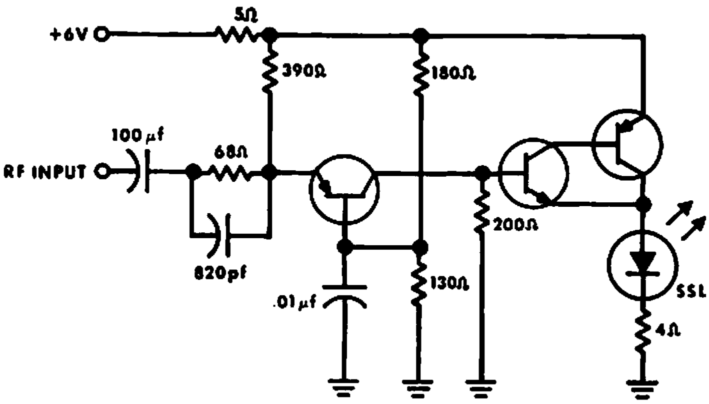

+3V
270KΩ
150Ω
R_5
1Ω
R_6
R_1
.33μf
Q_2
2N 1379
1000μf
C_1
C_2
24Ω
R_3
22Ω
R_4
SSL4
150μ SEC
10Ω
R_2
60mS
Q_1
2N 388A

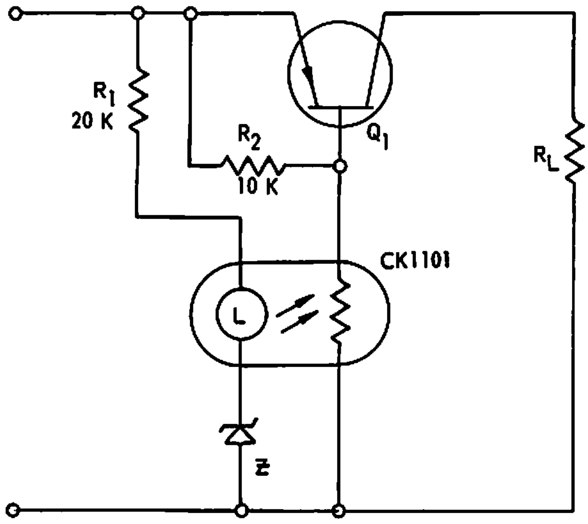
SMOKE DETECTOR TRANSMITTER—Uses gallium arsenide lamp pulsed at 10 pps by relaxation oscillator Q1-Q2. Draws only 0.7 mA from pair of D flashlight cells. Used with four mirrors to provide 8-inch optical path to sensor in receiver.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 31.

BLOCKING-OSCILLATOR DRIVE FOR SSL—Flashes from solid-state lamp are controlled by applying trigger voltage to blocking oscillator.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 8.

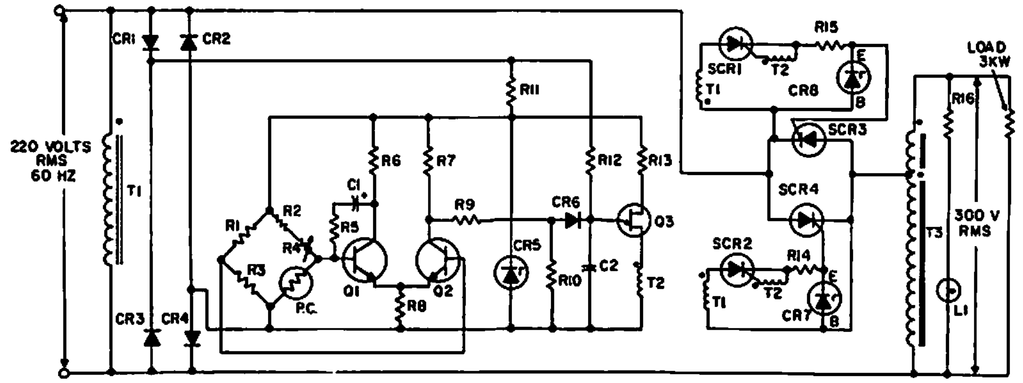

+27V
REG.
1KΩ
• ≈ 30 mA DC
≈ 500 mA PULSE
.0015μf
1KΩ
60T
*I_F
3T
SSL-4
SSL-5
10T
.001μf
2.2KΩ
2N2219
220Ω
2 V. TRIGGER
A14F
+
1.2 TO 1.5V DC
1.2KΩ
120pf
4.7 μμf
22KΩ

LIGHT-BEAM MODULATOR—Gallium arsenide solid-state lamp can be modulated at frequencies up to 100 MHz, depending on SSL used, with conventional r-f transistor power amplifier. Transistor types depend on frequency and on power requirements of SSL used.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 6.


+6V
5Ω
390Ω
180Ω
100μf
68Ω
RF INPUT
820pf
.01μf
130Ω
200Ω
SSL
4Ω


R1
20 K
R2
10 K
Q1
RL
CK1101
L
Z

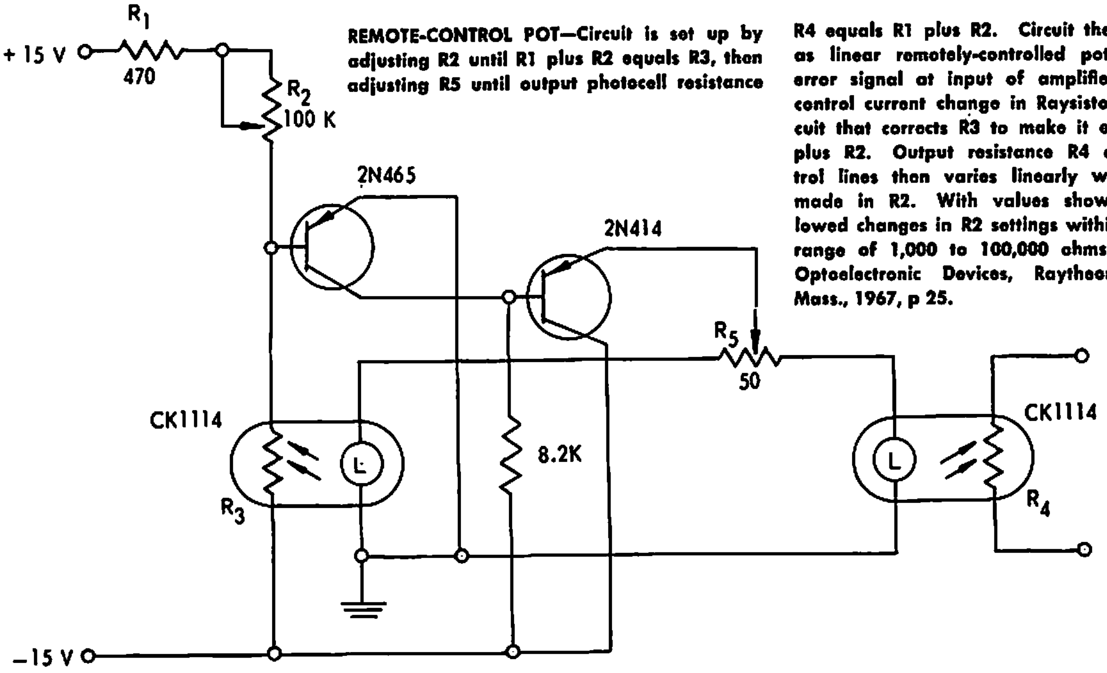
UNDERVOLTAGE PROTECTION—When supply voltage drops below predetermined level established by zener, voltage across neon lamp in Raysistor drops below extinguishing voltage and it goes out, increasing photocell resistance and turning off transistor Q1, to drop load current essentially to zero.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 26.


CR1
CR2
220 VOLTS RMS 60 HZ
T1
R11
R6
R7
C1
R5
R2
R1
R4
R3
P.C.
Q1
Q2
R8
R9
CR5
CR6
R10
C2
R12
R13
Q3
T2
CR3
CR4
SCR1
T1
T2
R15
E
B
CR8
SCR3
SCR4
SCR2
T1
T2
R14
E
CR7
B
LOAD 3KW
R16
T3
300 V RMS
L1

ALL RESISTORS ±10% AND 1/2 WATT EXCEPT WHERE MARKED

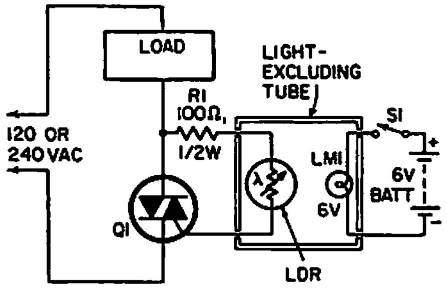
CR1 THRU CR4 - G.E. A13D OR A14D
CR5 - G.E. Z4XL22
CR6 - G.E. A13F OR A14F
CR7 - CR8 - G.E. 16L1423
C1 - 10MF, 25 VDC G.E. 62F204 MINIATURE TUBULAR WET SLUG CAP.
C2 - 0.22 UF, 50 VDC ±10% G.E. 75F3R5-244A
Q1 - Q2 - G.E. 2N2925
Q3 - G.E. 2N2646
SCR1 - SCR2 - G.E. C6U or C106Y
SCR3 - SCR4 - G.E. C135E OR C35E
T1 - 220 V RMS PRIMARY 12 V RMS SECONDARY 100 MA RMS RATED SECONDARY CURRENT
T2 - PULSE TRANSFORMER 1:1:1 ALADDIN PART NO. 90-2398
T3 - TURNS RATIO 1:1.82 4KVA
R1 - 22K
R2 - 2.2K
R3 - 18K
R4 - 10K MULTI-TURN TRIM POT
R5 - 10K
R6 - 2.2K
R7 - 2.2K
R8 - 2.2K
R9 - 5.6K
R10 - 47K
R11 - 8.2K, 10 WATT
R12 - 1.5MEG
R13 - 1K
R14 - R15 - 220 OHM
R16 - 9K ±5%, 14 WATTS

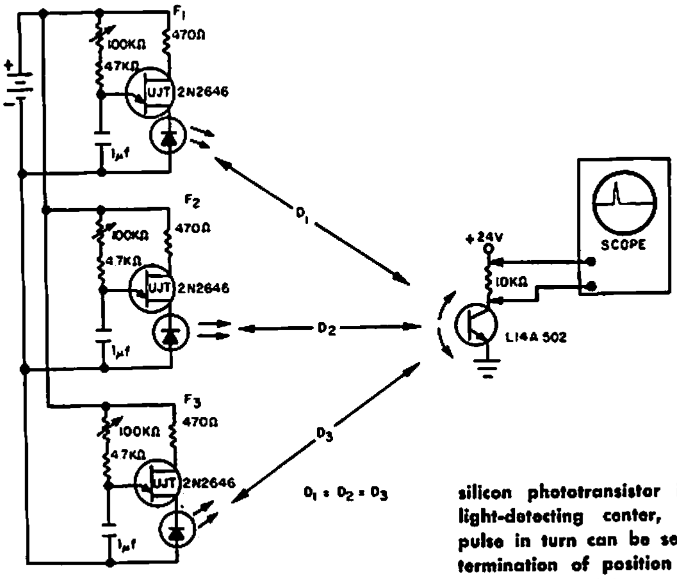
3-KW A-C VOLTAGE REGULATOR—Holds a-c load voltage constant at 300 V for a-c line drop from 220 V to 190 V, and allows output to drop only 1.5 V for input jump to 250 V. Lamp L1 across load, sealed into photocell PC as GE PL5B1, gives sensing of phase-controlled true rms load voltage, which is initially adjusted to desired 300 V by trimpot R4 in bridge. Article describes circuit operation in detail, tells how to adapt for soft-start during initial transient condition when circuit is turned on, and shows how to use as current regulator.—J. L. Brookmire, AC Voltage or Current Regulator Featuring Closed-Loop Feedback Control, General Electric, Syracuse, N.Y., No. 200.46, 1966.


R1
+15 V
470
R2
100 K
2N465
2N414
R5
50
CK1114
R3
L
8.2K
CK1114
R4
-15 V

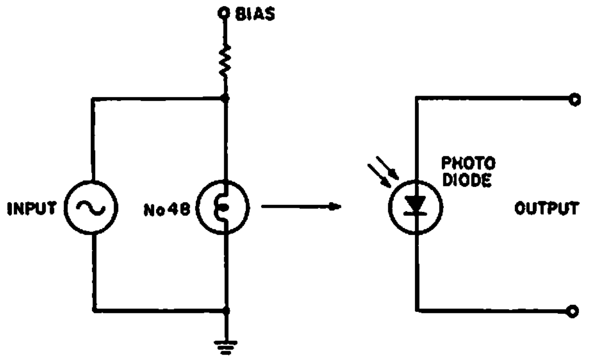
REMOTE-CONTROL POT—Circuit is set up by adjusting R2 until R1 plus R2 equals R3, then adjusting R5 until output photocell resistance R4 equals R1 plus R2. Circuit then operates as linear remotely-controlled pot in which error signal at input of amplifier produces control current change in Raysistor lamp circuit that corrects R3 to make it equal to R1 plus R2. Output resistance R4 across control lines then varies linearly with change made in R2. With values shown, R4 followed changes in R2 settings within 5% over range of 1,000 to 100,000 ohms.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 25.

ISOLATED-INPUT TRIGGER FOR TRIAC—6-V lamp, which may be energized remotely from battery, is sealed in box with cadmium sulfide photocell. When lamp is on, photocell triggers triac just after start of each half-cycle, to give full-wave switching of loads up to 6 A. Use RCA 40429 triac for 120 V and 40430 for 240 V.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.

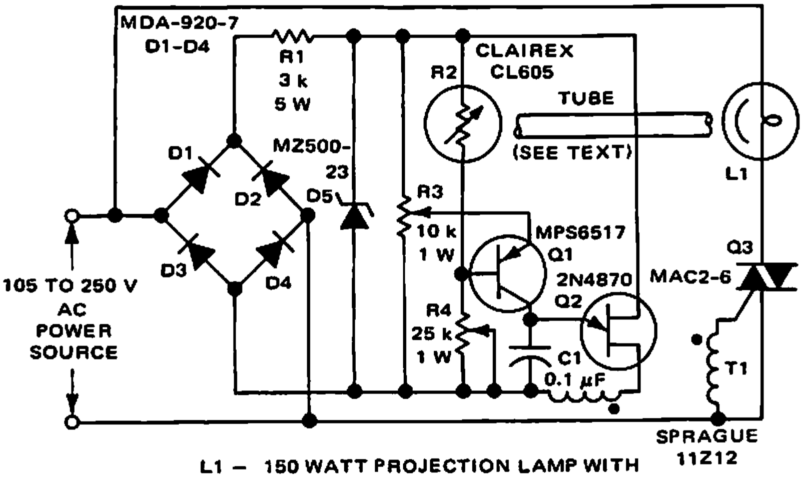

LOAD
LIGHT-EXCLUDING TUBE
RI 100Ω, 1/2W
SI
+
LMI
6V
6V BATT
-
120 OR 240VAC
QI
λ
LDR


+
F1
100KΩ
470Ω
47KΩ
UJT
2N2646
1μf
F2
100KΩ
470Ω
4.7KΩ
UJT
2N2646
1μf
F3
100KΩ
470Ω
47KΩ
UJT
2N2646
1μf
D1
D2
D3
D1 = D2 = D3
+24V
10KΩ
SCOPE
L14A 502

POSITION DETECTOR—Three ujt oscillator circuits each drive solid-state lamp SSL-5C at different pulsing rate. As L14A502 planar silicon phototransistor is rotated about its light-detecting center, each radiated light pulse in turn can be seen on scope, for determination of position of phototransistor.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 22.

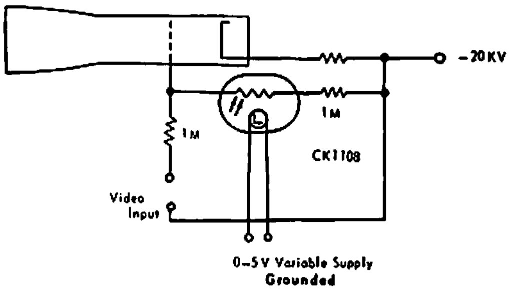

BIAS
INPUT
No48
PHOTO DIODE
OUTPUT

OPTICAL DOUBLER—Provides complete circuit isolation along with frequency doubling. Range is from d-c to 500 Hz for lamp shown, to 2 kHz for No. 2128 lamp, and to 10 kHz for pinlite. With switched d-c bias that extinguishes lamp on negative half-cycle, programmed output of f or 2f can be obtained. Distortion is low.—R. Dobkin, Simple Low-Frequency Doubler Provides Isolation, *Electronic Design*, Dec. 21, 1964, p 54–55.

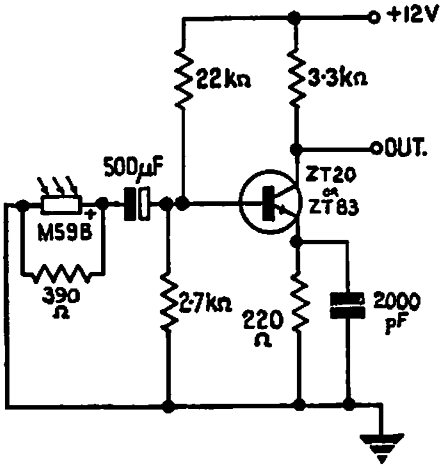

MDA-920-7
D1-D4
R1
3 k
5 W
R2
CLAIREX
CL605
TUBE
(SEE TEXT)
L1
D1
MZ500-
23
D2
D5
R3
10 k
1 W
MPS6517
Q1
2N4870
Q2
MAC2-6
Q3
D3
D4
105 TO 250 V
AC
POWER
SOURCE
R4
25 k
1 W
C1
0.1 μF
T1
SPRAGUE
11Z12

L1 — 150 WATT PROJECTION LAMP WITH BUILT-IN REFLECTOR MIRROR

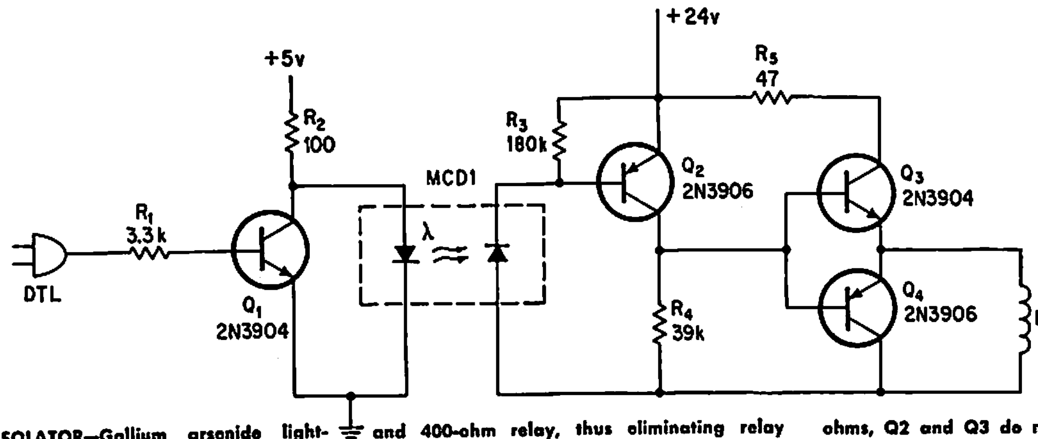
100-V REGULATOR FOR PROJECTION LAMP—Holds rms voltage across 150-W lamp within 2% of 100 V rms for all input voltages between 105 and 250 V a-c. Uses photoelectric feedback to firing circuit Q1-Q2 which controls conduction angle of triac Q3. Photocell senses red glow of back of reflector inside lamp, as heated by filament, to get integration of light output by mass of reflector and thereby eliminate 60-Hz modulation of filament.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–27.


–20KV
1M
1M
CK1108
Video
Input
0–5 V Variable Supply
Grounded

AUTOMATIC CONTRAST CONTROL—When lamp of Raysistor is energized by amplified video signal, automatic contrast control is obtained over range of 60 dB along with up to 25 kV isolation. Lamp filament provides automatic averaging effect because of its thermal inertia.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 15.


+12V
22kΩ
3·3kΩ
OUT.
500μF
ZT20
or
ZT83
M59B
390
Ω
2·7kΩ
220
Ω
2000
pF

TAPE READER FOR PULSED LIGHT CIRCUITS—Designed for use with gallium arsenide and gallium phosphide lamps that can be pulsed at high repetition rates, to give low-drift performance of chopper amplifier without using chopper transistor. With low duty cycle, higher peak light intensities can be obtained than are available from fixed light sources. Can also be used for reading punched cards. —Silicon Photocell Applications, Ferranti Ltd., Oldham, Lancs., England, No. 9, 5/67, p 10.

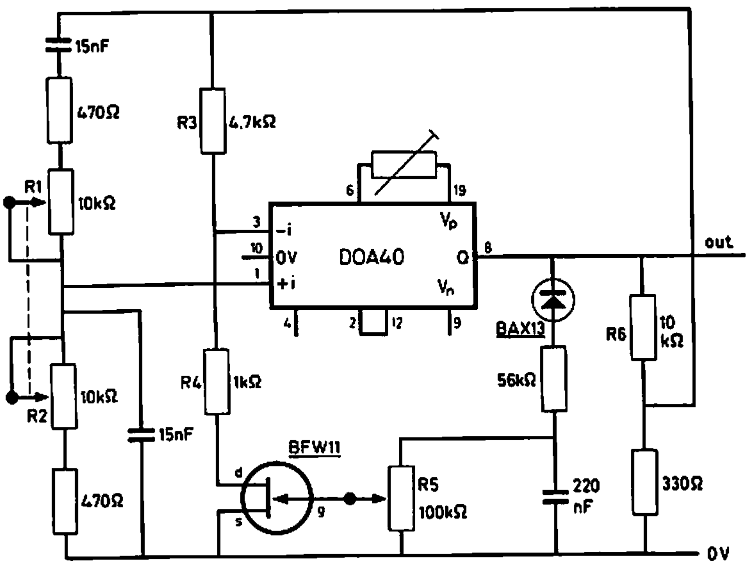

+24v
R5
47
+5v
R2
100
R3
180k
Q2
2N3906
Q3
2N3904
MCD1
λ
R1
3.3k
DTL
Q1
2N3904
R4
39k
Q4
2N3906
K1

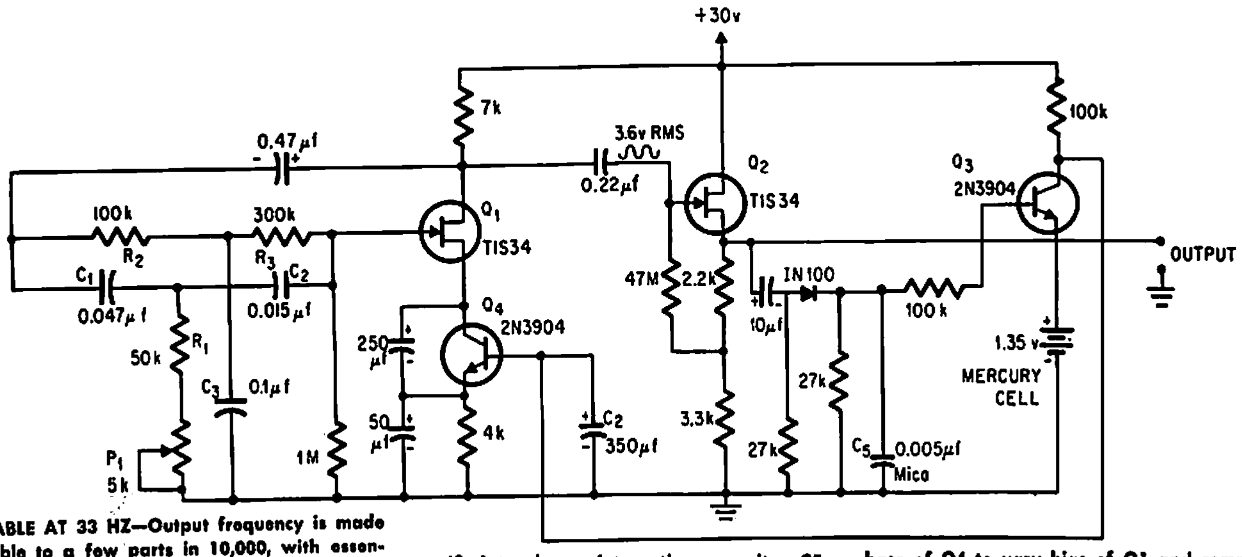
RELAY ISOLATOR—Gallium arsenide light-emitting diode, optically coupled to silicon p-i-n photodiode, combine to produce complete electrical isolation between IC driver and 400-ohm relay, thus eliminating relay noise and spikes. With no light reaching photodiode detector through light pipe, photodiode is at maximum impedance of 5 gigohms, Q2 and Q3 do not conduct and relay is not energized.—W. Otsuka, Photodiode Coupled Pair Isolates DTL from a Relay, *Electronics*, July 21, 1969, p 82.

CHAPTER 58

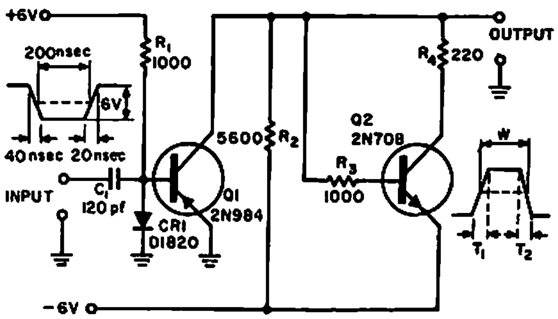
Oscillator Circuits—A-F

1—15 KHZ WIEN BRIDGE—Uses Philips DOA40 IC opamp. With 12-V supply, output is 18 V p-p sine wave (about 6 V rms). Ganged pots in two branches of bridge control frequency. When set at 2,000 Hz, output did not drift more than 2 Hz during 8 hours of operation.—Wien Bridge Oscillator Using the DOA40, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 27.


15nF
470Ω
R1
10kΩ
10kΩ
R2
470Ω
15nF
R3
4.7kΩ
R4
1kΩ
6
19
3
10
1
-i
0V
+i
DOA40
Vp
Vn
Q
8
4
2
12
9
out
BAX13
56kΩ
R6
10 kΩ
BFW11
d
s
g
R5
100kΩ
220 nF
330Ω
0V

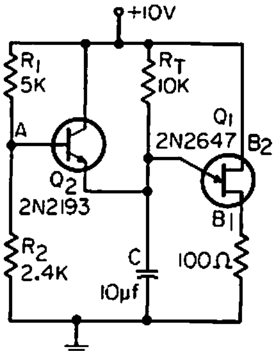

+30v
7k
0.47μf
3.6v RMS
0.22μf
Q2
TIS34
Q3
2N3904
100k
100k
R2
300k
R3
Q1
TIS34
C1
C2
0.047μf
0.015μf
OUTPUT
47M
2.2k
IN100
10μf
100k
Q4
2N3904
250 μf
1.35 v
MERCURY CELL
50k
R1
C3
0.1μf
27k
P1
5k
1M
50 μf
4k
C2
350μf
3.3k
27k
C5
0.005μf
Mica

STABLE AT 33 HZ—Output frequency is made stable to a few parts in 10,000, with essentially constant output voltage, by adding negative feedback to fet oscillator Q1 having unbalanced parallel-T network. Output of Q1 at 33 Hz is fed through buffer Q2 and rectified to charge integrating capacitor C5. Voltage across C5 is compared to stable d-c reference (1.35-V mercury cell) in difference amplifier Q3 and error signal is applied to base of Q4 to vary bias of Q1 and compensate for output amplitude variations.—L. Mourlam, Jr., Feedback Loop Stabilizes FET Oscillator, *Electronics*, Sept. 4, 1967, p 97.

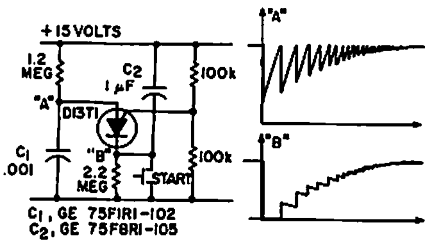

+6V
200nsec
6V
40nsec 20nsec
R1 1000
INPUT
C1 120pf
CR1 D1820
Q1 2N984
5600 R2
Q2 2N708
R3 1000
R4 220
OUTPUT
W
T1 T2
-6V

0–10 MHZ TRANSFORMERLESS BLOCKING—Furnishes narrow fast-rise pulse from low-impedance output, with value of C1 determining width of pulse. Requires −6 V trigger with fall time below 40 ns. Operates from d-c to above 10 MHz.—C. A. Karrfalt, Blocking Oscillator Operates Without Transformer, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 190–191.

	NO LOAD	220pf LOAD
W	56 nsec	70 nsec
T_1	12 nsec	25 nsec
T_2	15 nsec	99 nsec

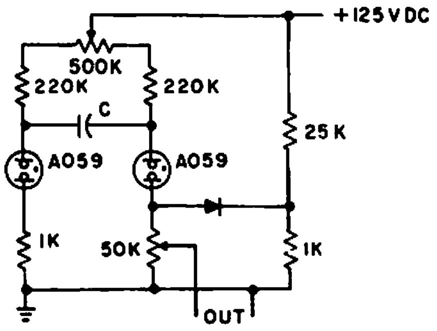

+10V
R1 5K
RT 10K
A
Q1 2N2647
B2
Q2 2N2193
B1
R2 2.4K
C 10μf
100Ω

ELIMINATING UJT START-UP ERROR—Addition of transistor to basic ujt oscillator compensates for timing error due to time taken to charge capacitor during first cycle after power is applied. Q2 saturates when power is applied, charging C rapidly. Q2 is then cut off, and current then flows into C conventionally through timing resistor Rt.—J. V. Crowling, Modified UJT Oscillator Has No Timing Error, *EEE,* Dec. 1966, p 120–121.

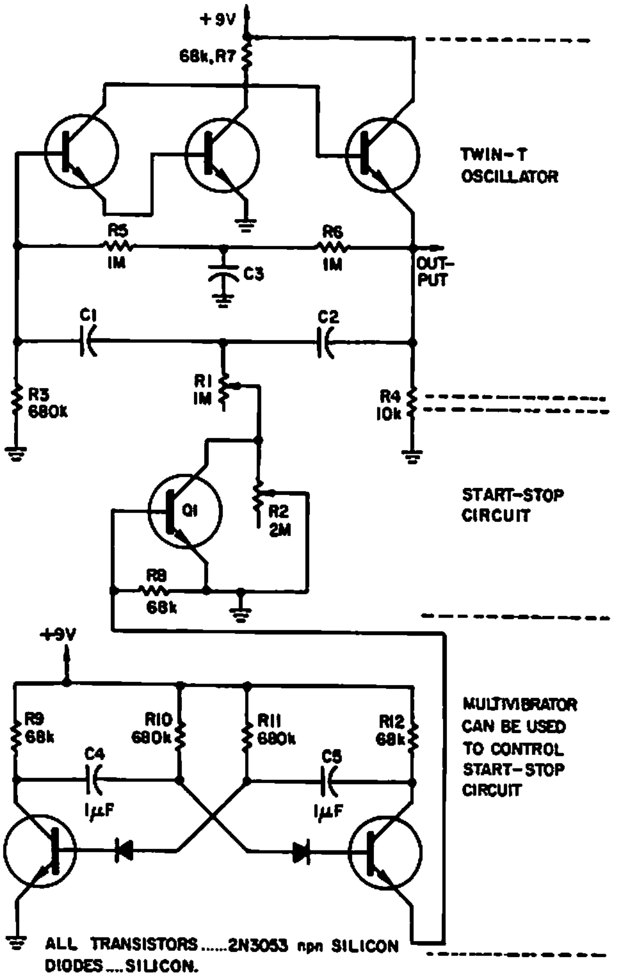

+15 VOLTS
1.2 MEG
C2 1 μF
100k
"A"
D13T1
C1 .001
"B"
2.2 MEG
START
100k
"A"
"B"

C1, GE 75F1R1-102
C2, GE 75F8R1-105

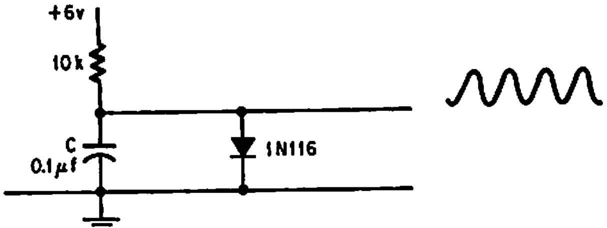
CHIRP OSCILLATOR—Uses D13T1 programmable ujt. Oscillation starts when switch is open, with decreasing amplitude as shown, and stops in about 1 s or until switch is closed.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 9.


+125 VDC
500K
220K
220K
C
25K
A059
A059
1K
50K
1K
OUT

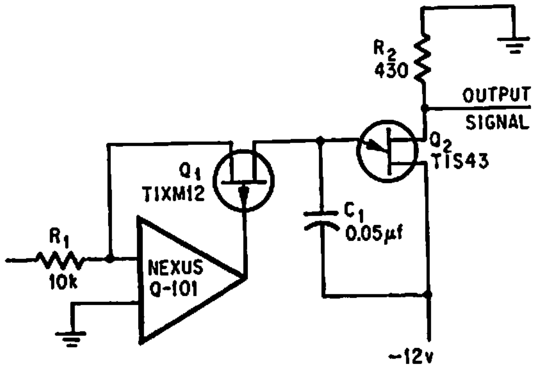
1–10 HZ NEON—Simple subaudio dual relaxation oscillator uses close-tolerance neon lamps. Clamping diode type is not critical.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 35.


+9V
68k,R7
TWIN-T OSCILLATOR
R5 1M
R6 1M
C3
OUTPUT
C1
C2
R3 680k
R1 1M
R4 10k
Q1
R2 2M
START-STOP CIRCUIT
R8 68k
+9V
R9 68k
R10 680k
R11 680k
R12 68k
C4 1μF
C5 1μF
MULTIVIBRATOR CAN BE USED TO CONTROL START-STOP CIRCUIT
ALL TRANSISTORS......2N3053 npn SILICON
DIODES....SILICON.

KEYED TWIN-T—Produces 1 pps of 160-Hz signal when C1 and C2 are 1,000 pF and C3 is 2,000 pF. Amount of regeneration in oscillator is determined by R1 and R2 in series; these are adjusted so circuit will not oscillate unless R2 is short-circuited by Q1. Rate at which oscillation builds up will then depend on setting of R1, and rate of decay by setting of R2. Mvbr turns Q1 on and off.—D. E. Johnson, Circuit Keys Twin-T Oscillator Without Generating Transients, *Electronic Design,* Aug. 16, 1969, p 246 and 248.

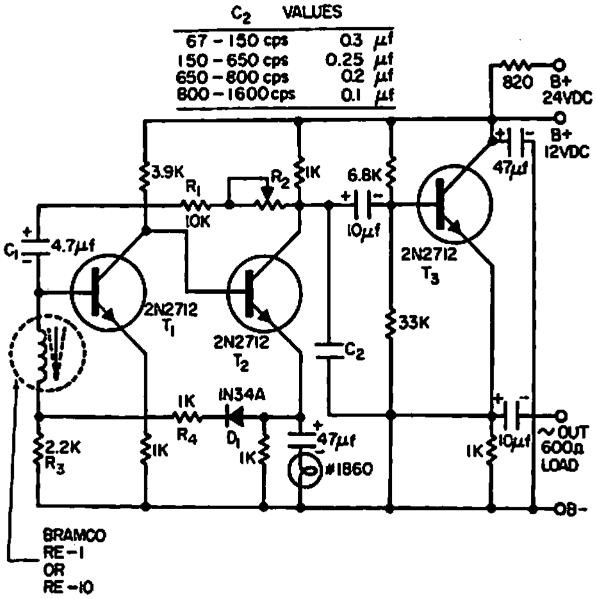

+6v
10k
C
0.1μf
1N116

CRYOGENIC-DIODE OSCILLATOR—Low-cost cryogenic diode cooled by liquid nitrogen exhibits negative resistance required for relaxation oscillator operating in range of 30 Hz to 30 kHz, depending on value of C. Output amplitude ranges from 0.4 to 1.5 V, depending on diode used. Stability is excellent.—E. Elad, Low Temperature Triggers Diode Relaxation Oscillator, *Electronics*, Aug. 21, 1967, p 90.


R2
430
OUTPUT
SIGNAL
Q1
TIXM12
Q2
TIS43
C1
0.05μf
R1
10k
NEXUS
Q-101
-12v

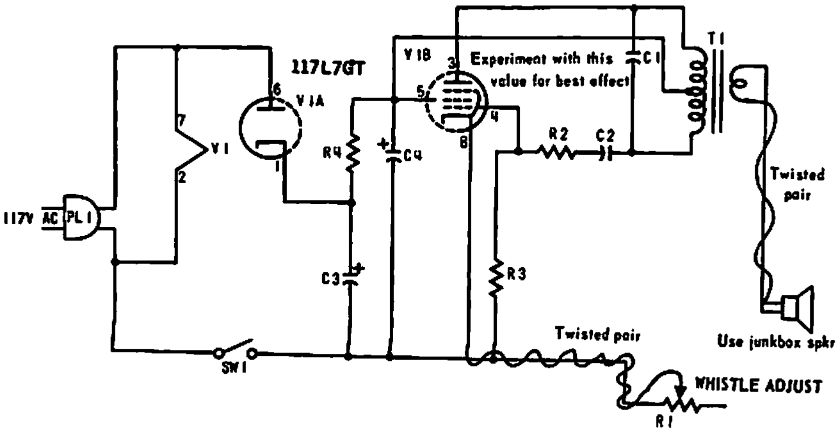
CONSTANT-CURRENT CHARGING—IC opamp with fet supplies charging current for ujt relaxation oscillator Q2, to give differential linearity better than 0.1% for output frequency varying from 0 to 1,400 Hz.—J. M. Kootsey, FET and IC Keep Oscillator Linear, *Electronics*, Aug. 19, 1968, p 84.

REED-CONTROLLED AUDIO—Resonant-reed relay stabilizes two-stage feedback oscillator T1-T2. Frequency depends on C2 and relay; ranges obtained with different values for C2 and either of two Bramco relays are given. Oscillator buildup time is 0.1 to 60 s after random noise starts reed oscillating, depending on frequency and feedback setting.—Resonant Reed Stabilizes Audio Oscillator Frequency, *Electronic Design*, Nov. 29, 1965, p 76–77.

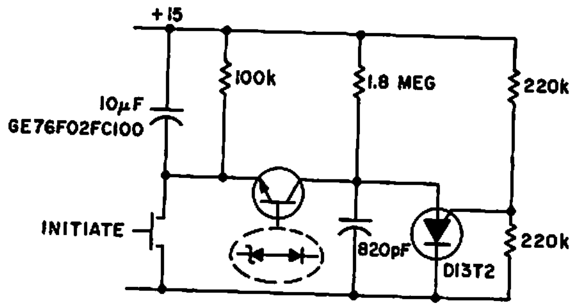


C_2	VALUES
67 - 150 cps	0.3 μf
150 - 650 cps	0.25 μf
650 - 800 cps	0.2 μf
800 - 1600 cps	0.1 μf

820
B+
24VDC
B+
12VDC
47μf
3.9K
R1
10K
R2
1K
6.8K
10μf
C1
4.7μf
2N2712
T1
2N2712
T2
2N2712
T3
33K
C2
1K
R4
1N34A
D1
47μf
#1860
2.2K
R3
1K
1K
1K
10μf
~OUT
600Ω
LOAD
B-
BRAMCO
RE-1
OR
RE-10

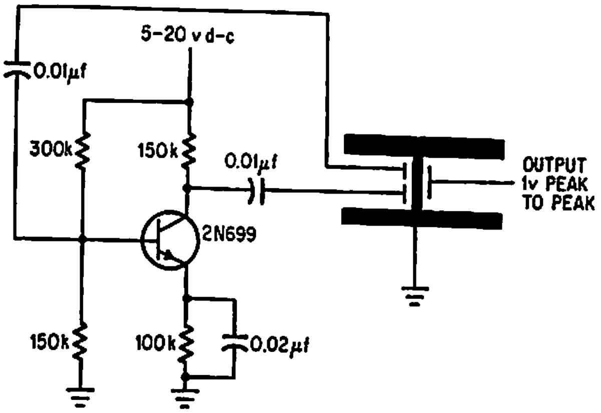

117L7GT
V1A
V1
V1B
Experiment with this
value for best effect
C1
T1
R4
C4
R2
C2
117V AC
PL1
C3
R3
SW1
Twisted pair
Twisted
pair
Use junkbox spkr
WHISTLE ADJUST
R1

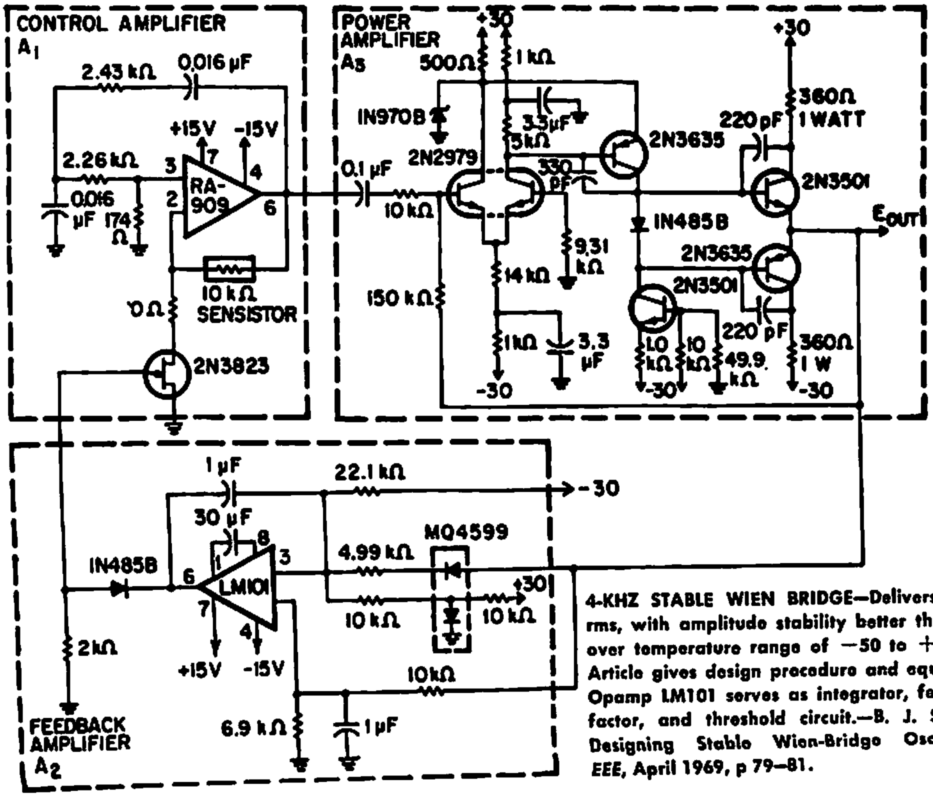
TRAIN WHISTLE—R1, which may be remotely located, determines tone of whistle. Place it near train controls, with speaker at other end of track layout. T1 is audio output transformer with 5K primary and 4 or 8 ohm secondary. Other values are: C1 0.047 μF, but try other values for best tone; C2 0.015 μF; C3-C4 20 μF; R1 2K pot; R2 2.7K; R3 39K; R4 270.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 107.


+15
10μF
GE76F02FC100
100k
1.8 MEG
220k
INITIATE
820pF
D13T2
220k

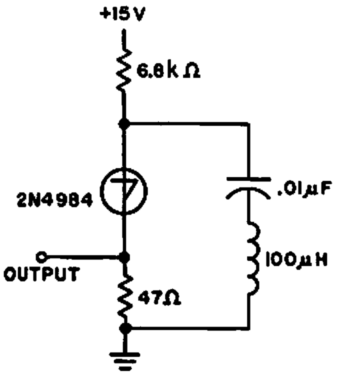
PRE-TIMED 1-KHZ OSCILLATOR—Circuit uses D13T2 programmable ujt as 1-kHz oscillator. Timing section is formed by 2N2926 transistor (used as zener), 100K resistor, and 10-μF capacitor. When power is applied, D13T2 latches up. Pushing INITIATE switch charges capacitor to full 15 V. Circuit then oscillates until capacitor discharges to point where D13T2 latches up again.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 9.

A-F TONES WITH H RESONATOR—Twintron H-shaped piezoelectric resonator with Q of 4,000 is used with single transistor to generate audio tone that can be tuned from 20 kHz down to fraction of hertz. Over 1,000 stations can be connected to tone communication system, each having its distinct tone frequency for actuating Twintron receiving resonator at central station. One application is automatic reading of electric meters in private homes with tones transmitted over telephone lines.—H. Baker and J. R. Cressey, H-Shaped Resonators Signal Upturn in Tone Telemetering, *Electronics*, Oct. 2, 1967, p 99–106.

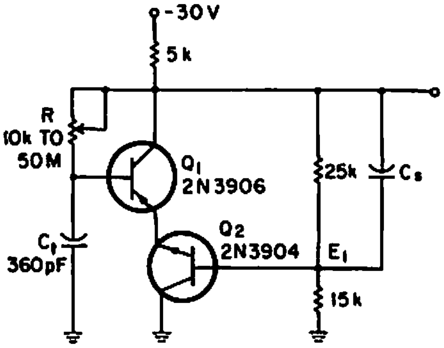

5–20 v d-c
0.01μf
300k
150k
0.01μf
2N699
OUTPUT
1v PEAK
TO PEAK
150k
100k
0.02μf


CONTROL AMPLIFIER
A1
2.43 kΩ
0.016 μF
+15V
-15V
2.26 kΩ
3
7
4
RA-909
2
6
0.016 μF
174 Ω
10 kΩ SENSISTOR
10 Ω
2N3823
POWER AMPLIFIER
A3
+30
500Ω
1 kΩ
IN970B
3.3 μF
5kΩ
2N2979
0.1 μF
10 kΩ
330 pF
2N3635
+30
360Ω 1 WATT
220 pF
2N3501
IN485B
EOUT
9.31 kΩ
14 kΩ
2N3635
2N3501
150 kΩ
1kΩ
3.3 μF
-30
1.0 kΩ
10 kΩ
49.9 kΩ
-30
220 pF
360Ω 1 W
-30
1 μF
22.1 kΩ
-30
30 μF
8
MQ4599
IN485B
6
1
3
4.99 kΩ
LM101
+30
7
4
10 kΩ
10 kΩ
2kΩ
+15V
-15V
10kΩ
FEEDBACK AMPLIFIER
A2
6.9 kΩ
1 μF

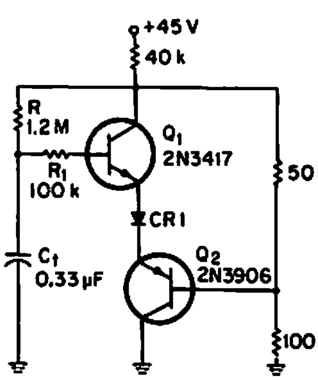
4-KHZ STABLE WIEN BRIDGE—Delivers 15 V rms, with amplitude stability better than 1% over temperature range of −50 to +100 C. Article gives design procedure and equations. Opamp LM101 serves as integrator, feedback factor, and threshold circuit.—B. J. Skehan, Designing Stable Wien-Bridge Oscillators, *EEE*, April 1969, p 79–81.


+15V
6.8kΩ
2N4984
.01μF
100μH
OUTPUT
47Ω

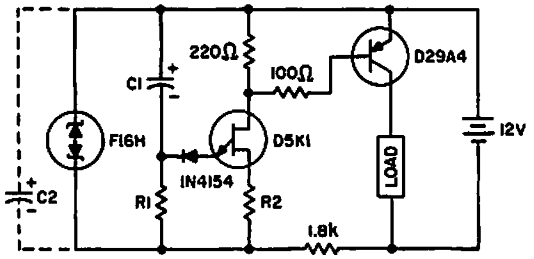
10 KHZ WITH SUS—Capacitor charges until 8-V switching voltage of silicon unilateral switch is reached. Sus then switches on, and resulting discharge through inductor causes current to ring. When ringing current drops below holding current, sus opens and charging cycle repeats. May also be used with 2N4989 sus.—Silicon Unilateral Switch 2N-4984/2N4985, General Electric, Syracuse, N.Y., No. 65.27, 1967.


-30V
5k
R
10k TO
50M
Q1
2N3906
25k
Cs
Ct
360pF
Q2
2N3904
E1
15k

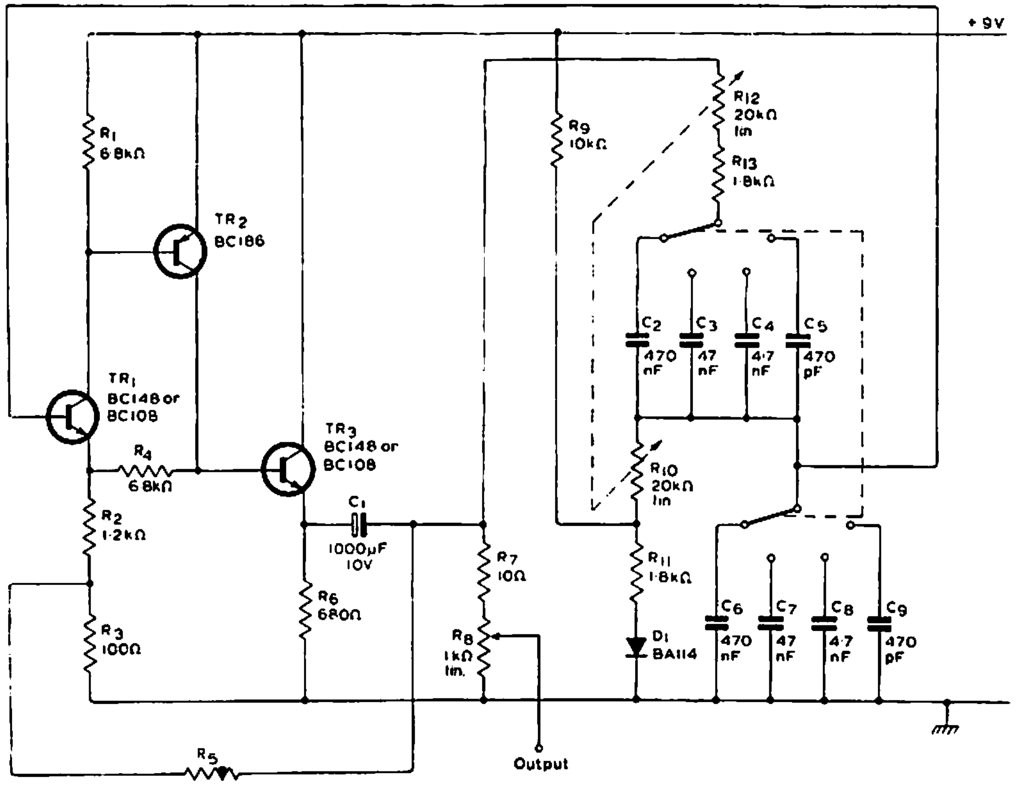
5,000:1 FREQUENCY RANGE—Simple modification of basic relaxation oscillator greatly increases range over which frequency is controlled by R. Q1 draws base current only from timing capacitor Ct, speeding transition from blocking to conduction.—G. R. Latham IV, A 5000:1 Frequency-Range Oscillator, *EEE*, April 1970, p 101—102.


+45V
40k
R
1.2M
Q1
2N3417
R1
100k
50k
CR1
Ct
0.33μF
Q2
2N3906
100k

2-HZ RELAXATION—Discharge time of Ct is increased by placing R1 in series with base of Q1 in modification of relaxation oscillator, to permit generating frequencies down to 2 Hz without increasing size of R to point where it is affected by high humidity. Temperature stability may be as poor as 10%, but this is adequate for many low-frequency applications.—G. R. Latham IV, A 5000:1 Frequency-Range Oscillator, *EEE*, April 1970, p 101—102.

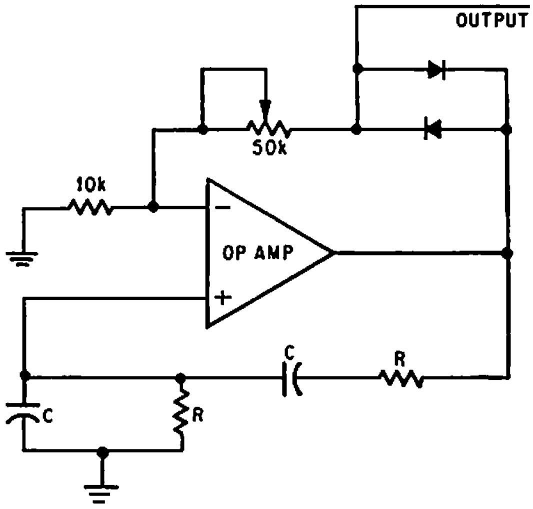

220Ω
D29A4
C1
100Ω
F16H
D5K1
LOAD
12V
1N4154
C2
R1
R2
1.8k

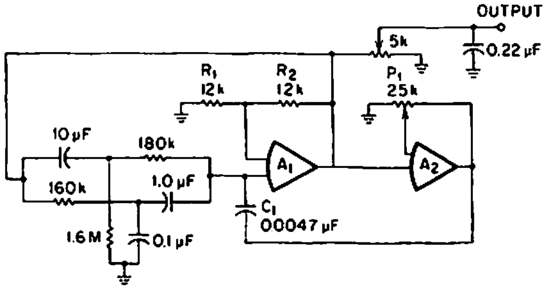
0.1-HZ RELAXATION—Delivers 20-ms-wide pulse every 10 s. R1 is 100K; R2 is 220 ohms, adjusted for optimum temperature compensation. C1 and C2 are 100-μF 20-V solid tantalum.—Silicon Complementary Unijunction Transistor D5K1, General Electric, Syracuse, N.Y., No. 60.15, 1967.


+9V
R1
6·8kΩ
TR2
BC186
R9
10kΩ
R12
20kΩ
lin
R13
1·8kΩ
C2
470
nF
C3
47
nF
C4
4·7
nF
C5
470
pF
TR1
BC148 or
BC108
R4
6·8kΩ
TR3
BC148 or
BC108
R10
20kΩ
lin
R2
1·2kΩ
C1
1000μF
10V
R7
10Ω
R11
1·8kΩ
R6
680Ω
R3
100Ω
R8
1kΩ
lin.
D1
BA114
C6
470
nF
C7
47
nF
C8
4·7
nF
C9
470
pF
R5
Output

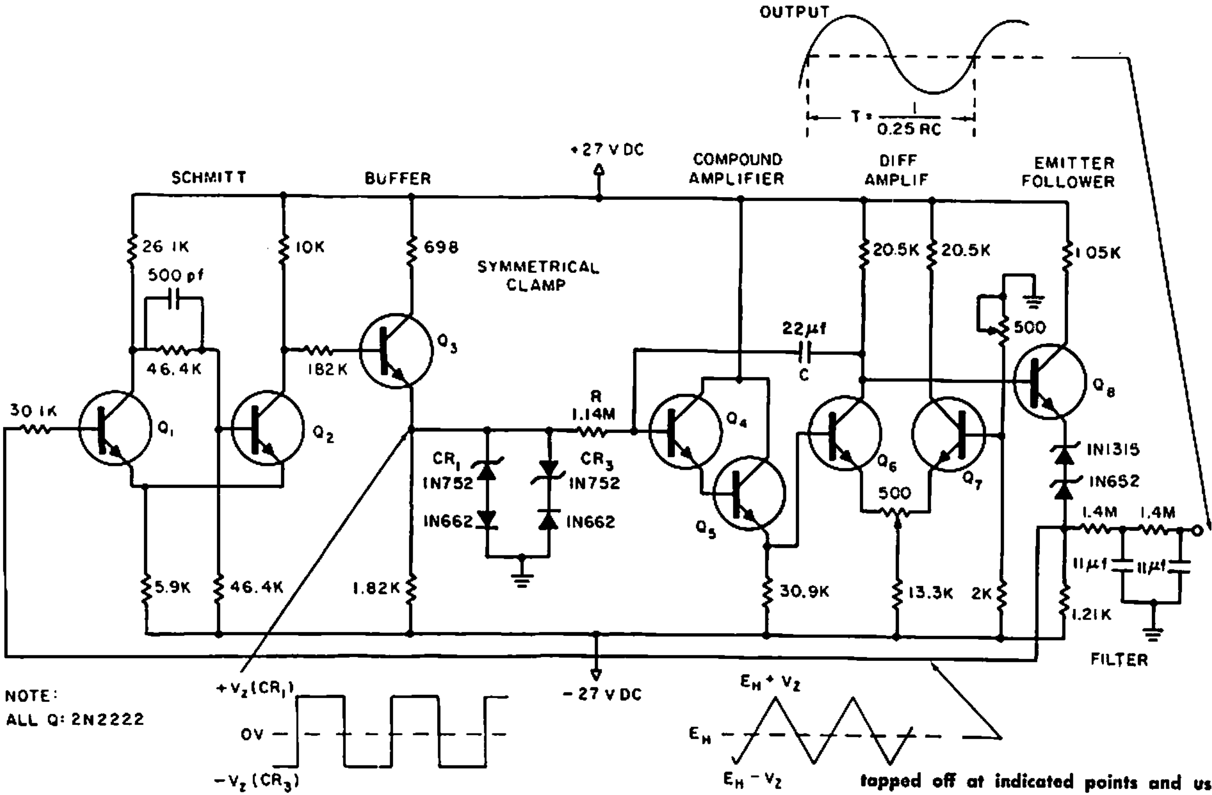
15—200,000 HZ AUDIO SIGNAL GENERATOR—Wien-bridge oscillator supplies 1-V rms output over entire frequency range, which is covered in four bands: 15—200 Hz; 150—2,000 Hz; 1,500—20,000 Hz; 15,000—200,000 Hz. Will operate with any supply voltage from 6 to 10 V. R5 is STC type R53 thermistor.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 178.

STABILIZING AUDIO OSCILLATOR—Arrangement acts as pulse-excited tuned circuit, with no need to make adjustment for loop gain of unity as normally required with IC opamp sine-wave oscillator. When output voltage is low, negative feedback loop is open and amplifier gain is high. Output then tends to increase rapidly because positive feedback path is closed. As soon as one diode conducts, gain drops to value determined by negative feedback loop. Pot regulates output amplitude. Frequency is determined by values of R and C in Wien bridge.—L. Molyneux, Op Amp Sine Wave Oscillator Uses Diodes for Stability, *Electronics*, March 17, 1969, p 97.

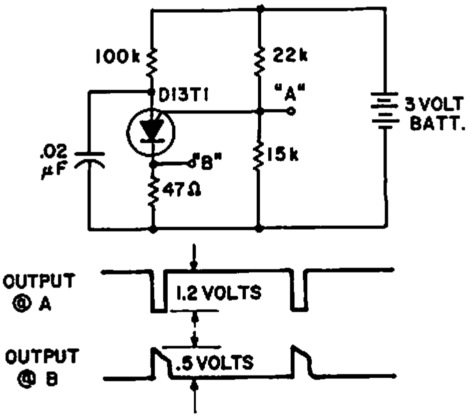

OUTPUT
50k
10k
−
OP AMP
+
C
R
C
R


OUTPUT
5k
0.22 µF
R1 12k
R2 12k
P1 25k
10 µF
180k
160k
1.0 µF
A1
A2
C1 .00047 µF
1.6M
0.1 µF

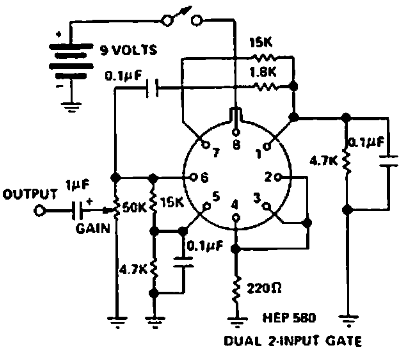
1-HZ SINE-WAVE—Twin-T network with two opamps generates very low frequencies with low distortion and stable amplitude. Oscillator runs free for most of each cycle, but is pushed for short time as output approaches zero from either direction.—J. Potzick, Low-Frequency Sine-Wave Oscillator, *EEE*, March 1970, p 130.


OUTPUT
T = 1/0.25 RC
+27 V DC
SCHMITT
BUFFER
COMPOUND AMPLIFIER
DIFF AMPLIF
EMITTER FOLLOWER
26.1K
500 pf
46.4K
10K
698
SYMMETRICAL CLAMP
182K
Q1
Q2
Q3
30.1K
R 1.14M
CR1 1N752
CR3 1N752
1N662
1N662
22µf C
Q4
Q5
20.5K
20.5K
500
Q6
Q7
500
1.05K
Q8
1N1315
1N652
1.4M
1.4M
11µf
11µf
5.9K
46.4K
1.82K
30.9K
13.3K
2K
1.21K
FILTER
−27 V DC
NOTE: ALL Q: 2N2222
+Vz (CR1)
0V
−Vz (CR3)
EH + Vz
EH
EH − Vz

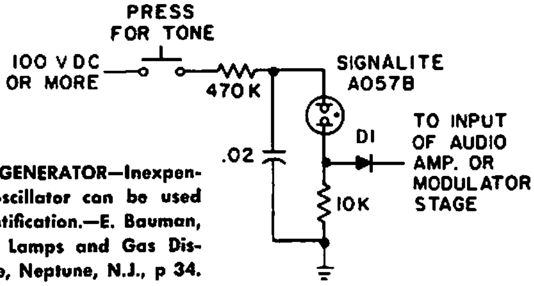
SINUSOIDAL SUBAUDIO—Frequency of five-stage oscillator network is determined by values of R and C in diode integrator circuit that couples differential amplifier to high-input-impedance compound amplifier. Square-waves and triangular waves may be tapped off at indicated points and used for long time delays or very slow cro traces.—J. N. Bequette, Sub-Audio Sinusoids Generated by Integrator Feedback Loop, *Electronic Design*, June 7, 1965, p 38.


100k
22k
D13T1
"A"
3 VOLT BATT.
.02 µF
"B"
15k
47Ω
OUTPUT @ A
1.2 VOLTS
OUTPUT @ B
.5 VOLTS

3-V RELAXATION OSCILLATOR—Operates from two flashlight cells, generating 1 kHz with choice of two different waveforms shown. Uses D13T1 programmable ujt, which is low-power triode thyristor. Battery drain is low.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 8.


9 VOLTS
0.1µF
15K
1.8K
0.1µF
4.7K
OUTPUT
1µF
50K
GAIN
15K
0.1µF
4.7K
220Ω
HEP 580
DUAL 2-INPUT GATE
1
2
3
4
5
6
7
8

1,000-HZ IC—Features adjustable sine-wave output from 0 to 2 V p-p, fixed at about 1,000 Hz, for general audio testing.—"Tips on Using IC's," Motorola, Phoenix, Ariz., HMA-32, 1968.

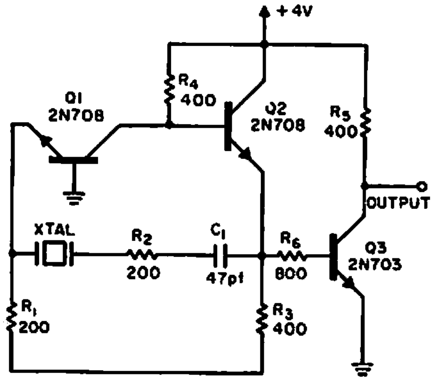

PRESS FOR TONE
100 VDC OR MORE
470K
SIGNALITE A057B
D1
TO INPUT OF AUDIO AMP. OR MODULATOR STAGE
.02
10K

TRANSMITTER TONE GENERATOR—Inexpensive neon relaxation oscillator can be used for on-the-air tone identification.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 34.

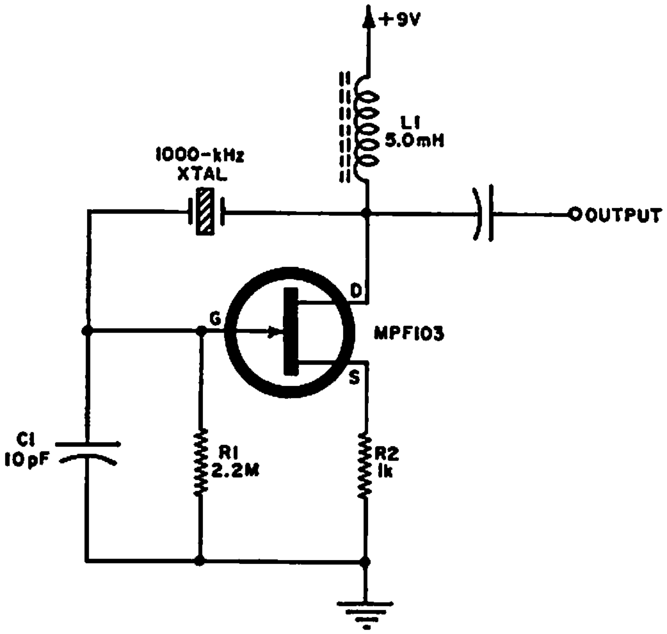
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 59

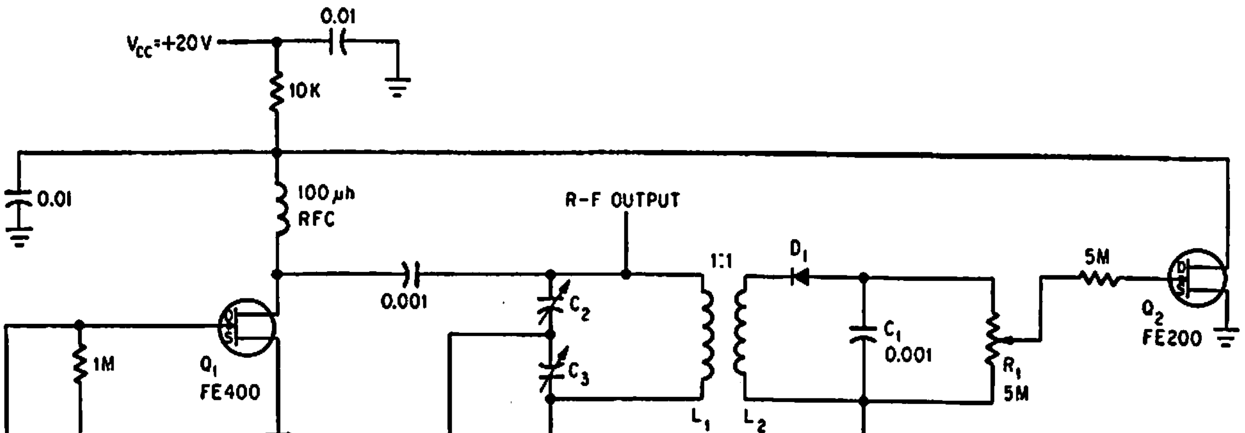
Oscillator Circuits—R-F


+4V
Q1
2N708
R4
400
Q2
2N708
R5
400
OUTPUT
XTAL
R2
200
C1
47pf
R6
800
Q3
2N703
R1
200
R3
400

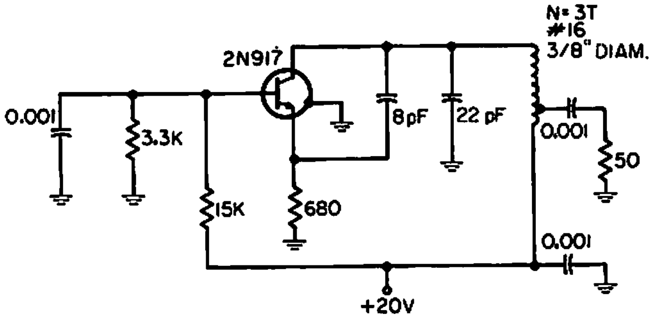
8-MHZ THIN-FILM CRYSTAL—Article gives step-by-step procedure for adapting crystal oscillator to version shown, suitable for thin-film hybrid construction using attached active devices (crystal and transistors), then gives instructions for constructing circuit by deposition through masks in vacuum chamber.—L. W. Sumney and C. E. Holland, Fabricate Your Own Thin-Film Oscillator, *Electronic Design*, March 30. 1964, p 52–56.


+9V
L1
5.0mH
1000-kHz
XTAL
OUTPUT
D
G
S
MPF103
C1
10pF
R1
2.2M
R2
1k

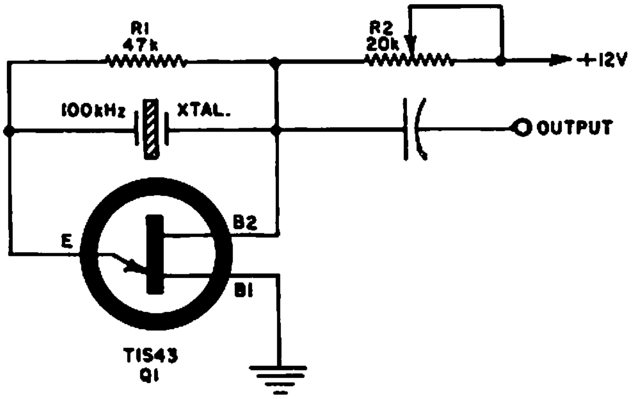
1-MHZ PIERCE—With high-activity crystal, clean sine-wave output is obtained. Without loading, drain current should be about 30 μA; higher current, above 500 μA, is due to parasitic oscillations—the chief drawback of this simple circuit.—F. H. Tooker, FET Sine-Wave Crystal Oscillators, *Electronics World*, June 1969, p 33 and 83.


V_{CC}=+20V
0.01
10K
0.01
100μh
RFC
R-F OUTPUT
1:1
D1
5M
Q2
FE200
0.001
C2
C3
C1
0.001
R1
5M
1M
Q1
FE400
L1
L2
0.001

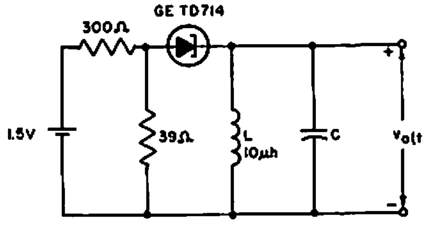
SUBAUDIO TO GHZ WITH FET—Features of manually tuned circuit shown are low cost, load leveling for constant-voltage output, low noise, stability, tunability and sweepability over wide frequency range, and unloaded output up to 15 V peak-to-peak in 300 to 400 MHz range.—T. F. Prosser, FET's Produce Stable Oscillators, *Electronics*, Oct. 3, 1966, p 102–103.


N=3T
#16
3/8" DIAM.
2N917
0.001
3.3K
15K
680
8pF
22 pF
0.001
50
0.001
+20V

BIPOLAR-TRANSISTOR 100-MHZ—Chief drawback of conventional silicon transistor oscillator is relatively large change in frequency with temperature, as compared to fet oscillator at same frequency. Total drift is about 70 kHz from nominal 100 MHz for 70 C temperature change.—C. L. Farell, Designing FET Oscillators, *EEE*, Jan. 1967, p 86–90.

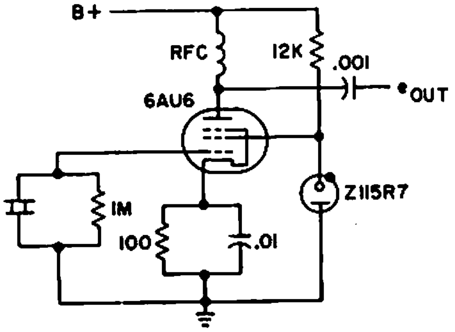

R1
47k
R2
20k
+12V
100kHz
XTAL.
OUTPUT
E
B2
B1
TIS43
Q1

UJT CRYSTAL—Useful for generating 100 kHz when efficiency and waveform purity are relatively unimportant. Both are affected by supply voltage, adjusted here by R2.—F. H. Tooker, Ujt Sine-Wave Generators, *Electronics World*, Feb. 1969, 82.

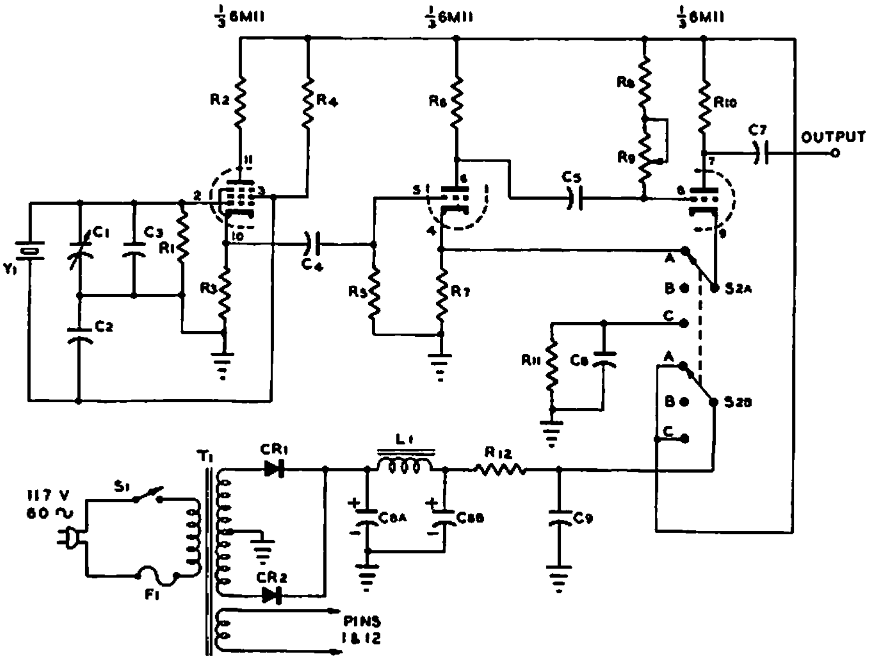

GE TD714
300Ω
1.5V
39Ω
L
10μh
C
+
$V_{o(t)}$
-

$$f_o \approx \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

TUNNEL-DIODE OSCILLATOR—Simple parallel LC oscillator gives good sine-wave output, though limited to relatively low power.—W. R. Spofford, Jr., Applications For The New Low Cost TD 700 Series Tunnel Diodes, General Electric, Syracuse, N.Y., No. 90.66, 1967, p 6.


B+
RFC
12K
.001
OUT
6AU6
1M
100
.01
Z115R7

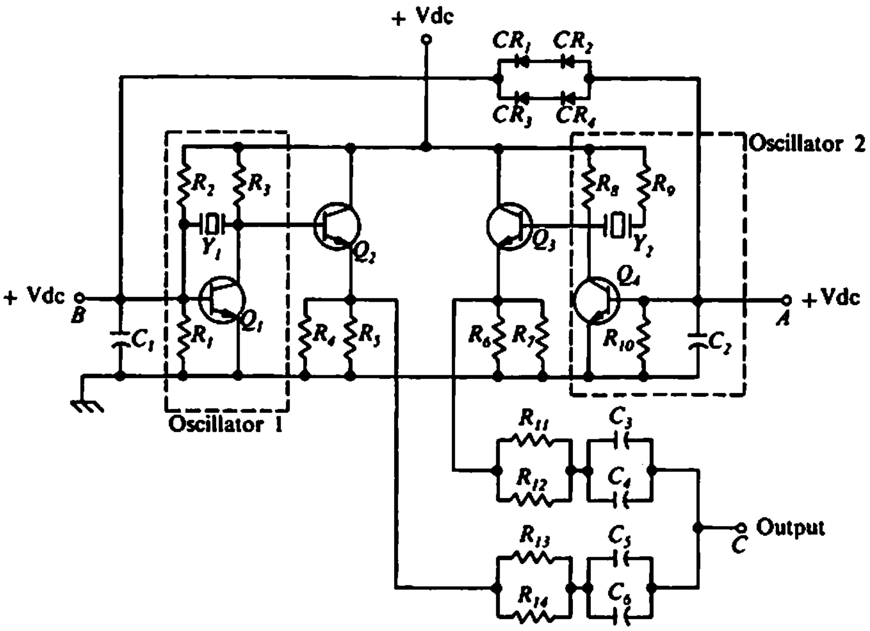
OSCILLATOR REGULATOR—Prevents frequency drift and output level changes in crystal oscillator due to power supply voltage variations. Neon lamp regulates to within 1 V of 115 V. Plate supply should be about 150 V to insure breakdown of regulator.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 80.

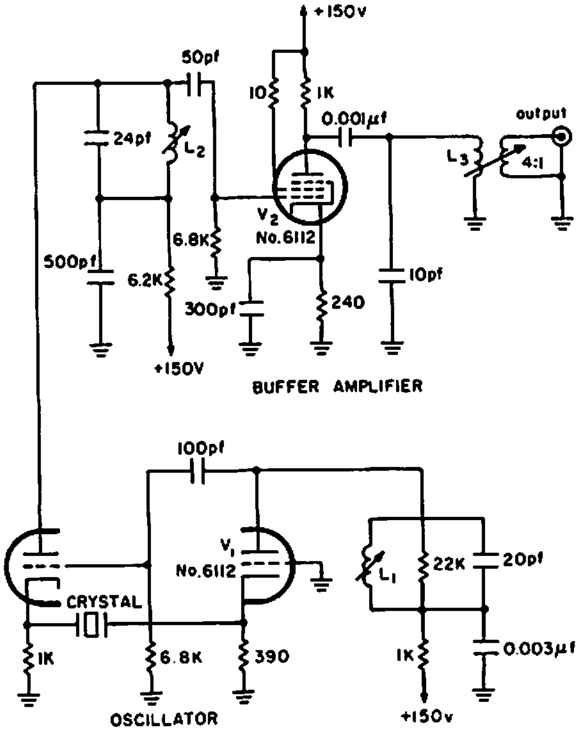

1/3 6M11
1/3 6M11
1/3 6M11
R2
R4
R6
R8
R9
R10
C7
OUTPUT
C5
C1
C3
R1
R3
C4
C2
Y1
R5
R7
S2A
S2B
A
B
C
R11
C6
T1
CR1
CR2
L1
R12
C8A
C8B
C9
117 V
60 ~
S1
F1
PINS
1&12

C_1—50 pf variable
C_2—150 pf
C_3—50 pf
C_4—25 pf
C_5—100 pf
C_6—0.001 μf
C_7—25 pf
C_8—20 μf, 20 μf, 350 volts
C_9—0.005 μf
CR_1—1N1697
CR_2—1N1697
F_1—1 ampere fuse
L_1—16 henry, 50 milliampere choke
R_1—470 K
R_2—150 K
R_3—3.3 K
R_4—100 K
R_5—470 K
R_6—100 K
R_7—1 K
R_8—2.2 Meg.
R_9—2 Meg. potentiometer
R_{10}—5.6 K
R_{11}—10 K
R_{12}—2.7 K
S_1—SPST toggle switch
S_2—two-pole, three position rotary switch
  Position A—100 Kc
  Position B—Off
  Position C—20 Kc
T_1—Power transformer: primary; 117 volts, 60 cycles: secondary 1; 6.3 volts, 1.0 amperes: secondary 2; 500 volts, center tapped, 20 milliamperes.
Y_1—100 Kc crystal

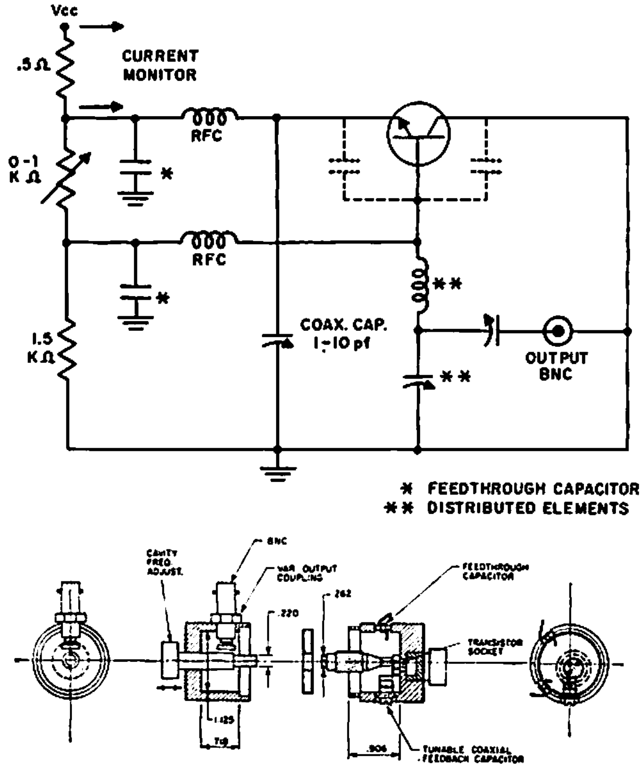
100 AND 20 KHZ FREQUENCY STANDARD—Uses single compactron and single 100-kHz crystal with switch that provides optional 20-kHz output from frequency divider connection.—"Essential Characteristics," General Electric, Owensboro, Ky., 1969, p 352.

DUAL REDUNDANT OSCILLATOR—Maintains critical oscillator operation by automatic switching between two identical crystal oscillators, either of which will supply correct frequency and output amplitude to next stage or module. Oscillator 1 is prime and under normal conditions feeds its signal through amplifier Q2 to point C. If the amplitude of oscillator 1 drops below selected value, bias is removed from oscillator 2 so it can take over. All transistors are 4210AA and all diodes 1N658. Other values are: R1 and R10 120K; R2 2 meg; R3 and R8 10K; R4-R7 2K; R9 1.8 meg; R11-R14 3.9K; C1 220 pF; C2 120 pF; C3-C6 0.01 µF.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 14.

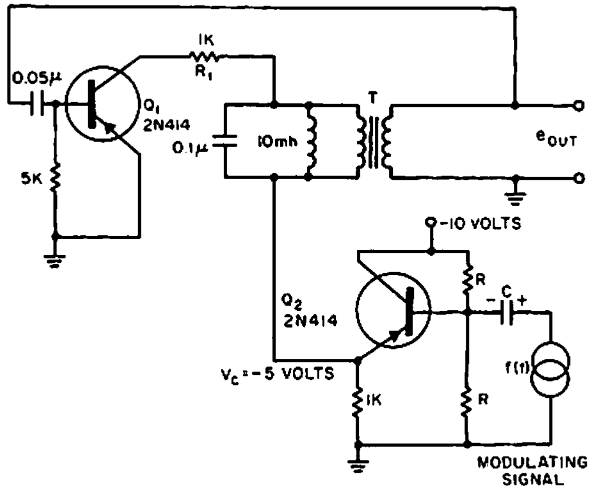

+ Vdc
CR1 CR2
CR3 CR4
Oscillator 2
R2 R3
Y1
Q2
Q3
R8 R9
Y2
Q4
+ Vdc
B
Q1
C1
R1
R4 R5
R6 R7
R10
C2
+Vdc
A
Oscillator 1
R11 C3
R12 C4
Output
C
R13 C5
R14 C6


+150V
50pf
10
1K
0.001µf
output
24pf
L2
L3
4:1
V2
No.6112
6.8K
500pf
6.2K
300pf
240
10pf
+150V
BUFFER AMPLIFIER
100pf
V1
No.6112
L1
22K
20pf
CRYSTAL
1K
6.8K
390
1K
0.003µf
OSCILLATOR
+150v

PHASED-RADAR VHF OSCILLATOR—Cathode-coupled crystal oscillator and buffer amplifier were developed for use in binary combination of oscillators and mixers for generating large number of discrete frequencies required in electronic scanning radar. Gives excellent reliability and stability in range of 10 to 70 MHz, with undesired second harmonic over 30 dB below fundamental.—G. F. Ross, Binary Generation of Frequencies Saves on Hardware, *Electronic Design*, Nov. 23, 1964, p 38–42 and 44–47.


Vcc
CURRENT MONITOR
.5Ω
0-1 KΩ
RFC
*
RFC
*
1.5 KΩ
COAX. CAP. 1-10 pf
**
**
OUTPUT BNC
* FEEDTHROUGH CAPACITOR
** DISTRIBUTED ELEMENTS
BNC
CAVITY FREQ. ADJUST.
VAR. OUTPUT COUPLING
FEEDTHROUGH CAPACITOR
TRANSISTOR SOCKET
TUNABLE COAXIAL FEEDBACK CAPACITOR

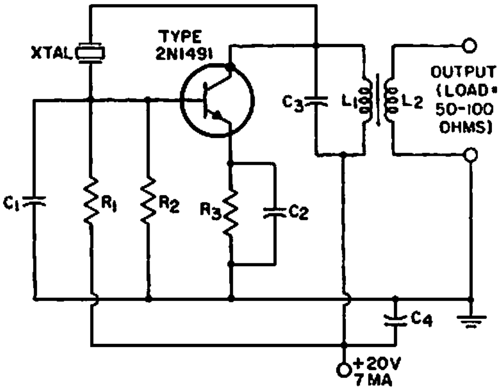
600–1,100 MHZ POWER OSCILLATOR—Uses coaxial cavity for which equivalent circuit is shown below. Suitable for pulse or c-w operation. Either 2N3533 or 2N3866 overlay type of uhf transistor may be used. Article covers design and includes performance graphs.—O. L. Meyer and D. C. Auth, Overlay UHF Transistors as CW and Pulsed Power Oscillators, *Microwave Journal*, Aug. 1969, p 59–66.



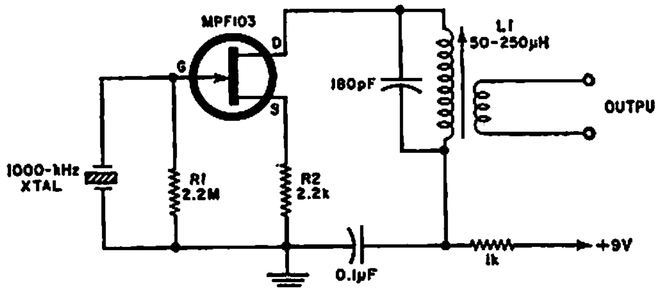
IK
R1
0.05μ
Q1
2N414
5K
0.1μ
10mh
T
eOUT
-10 VOLTS
R
C
Q2
2N414
VC=-5 VOLTS
IK
R
f(t)
MODULATING SIGNAL

MULTI-PURPOSE A-M OSCILLATOR—Amplitude-modulated oscillator operates as collector-modulated class B amplifier for studying properties of a-m systems. Carrier frequency is 5 kHz. Values of biasing resistors R depend on impedance of modulating signal generator, and C depends on modulating frequency.—R. Brander and L. S. Bobrow, Low Cost 2-Stage Circuit Forms Versatile AM Oscillator, *Electronic Design*, May 10, 1965, p 42 and 44.

27-MHZ CRYSTAL—Provides stable 4-mW output from common-emitter circuit, using positive feedback from collector to base through crystal. Values: R1 9.1K; R2 680; R3 200; C1 20 pF; C2, C4 0.01 μF; C3 22 pF; L1 15 turns No. 22 enamel on CTC LS5 form with powdered iron slug; L2 2 turns No. 18 enamel on cold end of L1; XTAL 27 MHz.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 507.



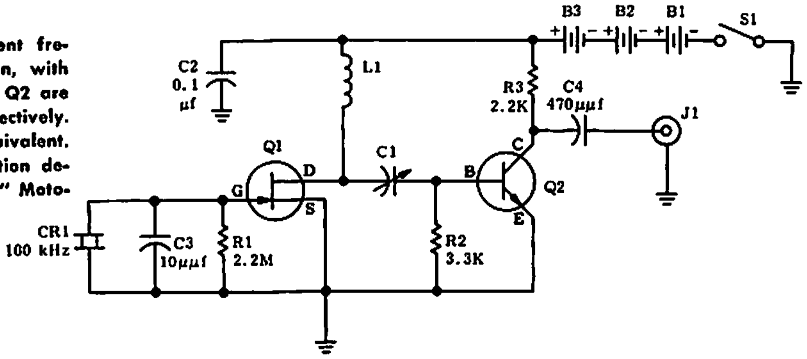
XTAL
TYPE 2N1491
C3
L1
L2
OUTPUT (LOAD= 50-100 OHMS)
C1
R1
R2
R3
C2
C4
+20V 7 MA



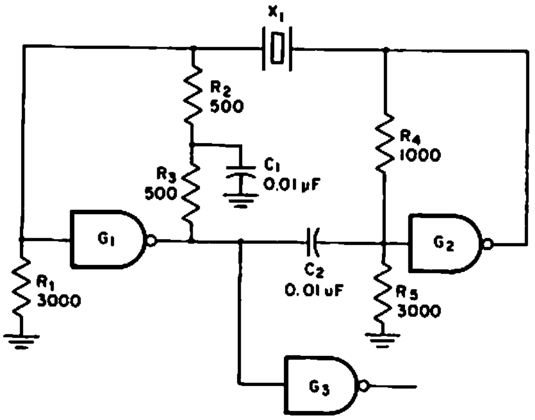
MPF103
D
G
S
L1 50-250μH
180pF
OUTPUT
1000-kHz XTAL
R1 2.2M
R2 2.2k
0.1μF
1k
+9V

1-MHZ TUNED-DRAIN FET—Uses link output. Puts out clean sine wave when core of L1 is adjusted to tune drain tank slightly higher than crystal frequency, so drain current is minimum of about 150 μA unloaded.—F. H. Tooker, FET Sine-Wave Crystal Oscillators, *Electronics World*, June 1969, p 33 and 83.

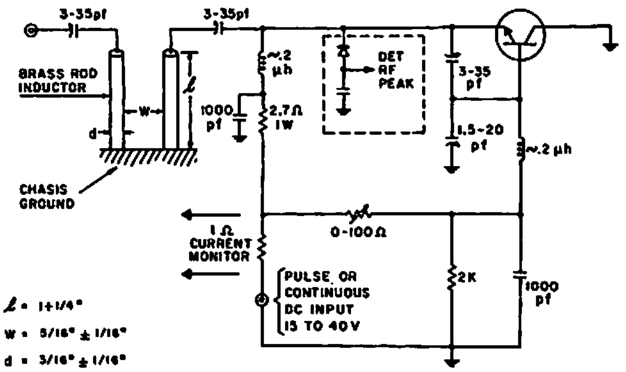
100-KHZ CRYSTAL FET—Offers excellent frequency stability at low current drain, with harmonics out to 100 MHz. Q1 and Q2 are Motorola HEP-801 and HEP-50 respectively. Choke L1 is Miller 6304 or equivalent. Article gives construction and calibration details.—"Field Effect Transistor Projects," Motorola, Phoenix, Ariz., 1966, p 48–56.



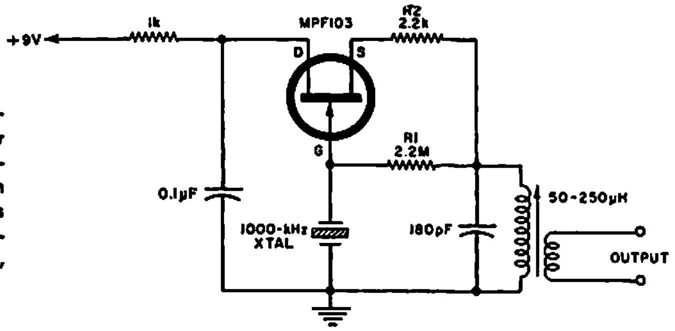
B3
B2
B1
S1
C2 0.1 μf
L1
R3 2.2K
C4 470μμf
J1
Q1
D
C1
B
C
Q2
G
S
E
CR1 100 kHz
C3 10μμf
R1 2.2M
R2 3.3K


X1
R2 500
R3 500
C1 0.01 μF
R4 1000
G1
G2
C2 0.01 uF
R1 3000
R5 3000
G3

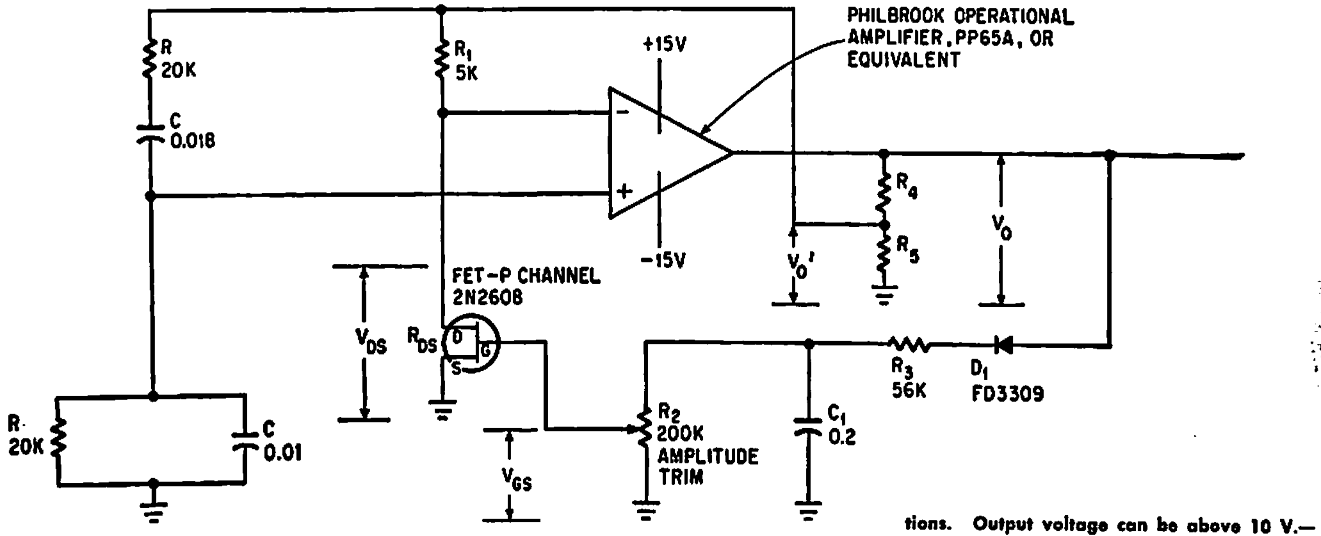
1–3 MHZ THREE-GATE CRYSTAL—Any gates in DTL/TTL families can be used if they are buffer type with low output impedance in high or low state. 932 buffer was used in circuit. Frequency stability is essentially that of crystal, which operates in series mode on fundamental frequency. May be powered by 5 V of logic gates or any other value between 3.8 and 7 V d-c. Output is square wave with about 40% duty cycle.—S. D. Culp, Crystal Oscillator, *EEE*, July 1970, p 87.


3-35pf
3-35pf
BRASS ROD INDUCTOR
W
d
ℓ
CHASIS GROUND
~.2 μh
1000 pf
2.7Ω 1W
DET RF PEAK
3-35 pf
1.5-20 pf
~.2 μh
1Ω CURRENT MONITOR
0-100Ω
PULSE OR CONTINUOUS DC INPUT 15 TO 40V
2K
1000 pf
ℓ = 1+1/4"
w = 5/16" ± 1/16"
d = 3/16" ± 1/16"

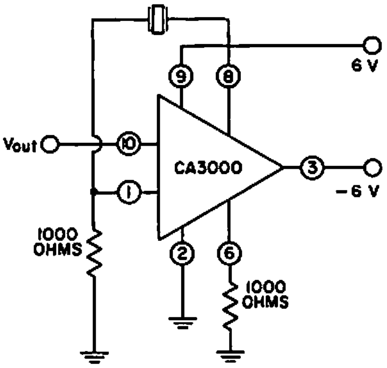
350–750 MHZ POWER OSCILLATOR—Tunable lumped-circuit oscillator for pulsed or c-w operation can use either 2N3553 or 2N3866 overlay type of uhf transistor. Article covers design and includes performance graphs. —O. L. Meyer and D. C. Auth, Overlay UHF Transistors as CW and Pulsed Power Oscillators, *Microwave Journal*, Aug. 1969, p 59–66.


+9V
1k
MPF103
D
S
R2 2.2k
G
R1 2.2M
0.1μF
1000-kHz XTAL
180pF
50-250μH
OUTPUT

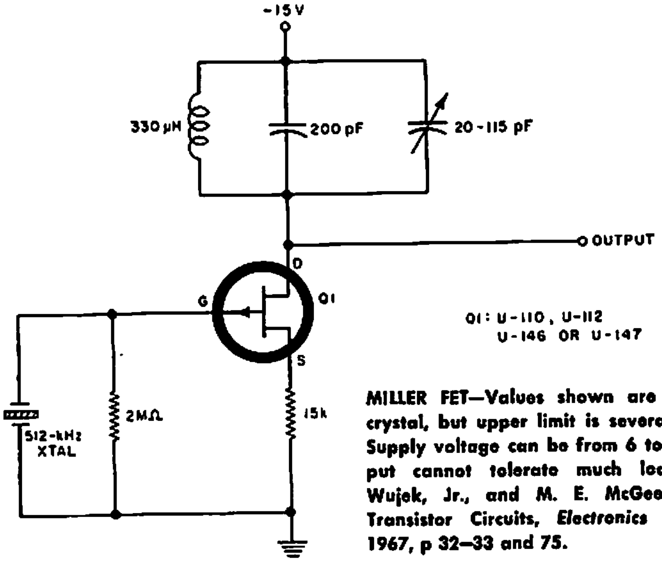
1-MHZ GROUNDED-DRAIN COLPITTS FET—Adjusting core of output transformer for minimum drain current gives cleanest sine-wave output. Grounded-drain configuration makes circuit less susceptible to stray fields and capacitances.—F. H. Tooker, FET Sine-Wave Crystal Oscillators, *Electronics World*, June 1969, p 33 and 83.


PHILBROOK OPERATIONAL AMPLIFIER, PP65A, OR EQUIVALENT
R 20K
C 0.018
R1 5K
+15V
-15V
R4
R5
V0
V0'
FET-P CHANNEL 2N2608
VDS
RDS
D
G
S
R3 56K
D1 FD3309
R 20K
C 0.01
VGS
R2 200K AMPLITUDE TRIM
C1 0.2

FET STABILIZES OPAMP BRIDGE OSCILLATOR—Arrangement provides distortionless output over full range from d-c to 100 kHz. Depends on fact that an fet acts like linear variable resistance when its drain-source voltage approaches zero. Article gives design equations. Output voltage can be above 10 V.—J. J. Panico, FET Stabilizes Amplitude Of Wien Bridge Oscillator, *Electronics*, Oct. 3, 1966, p 107.

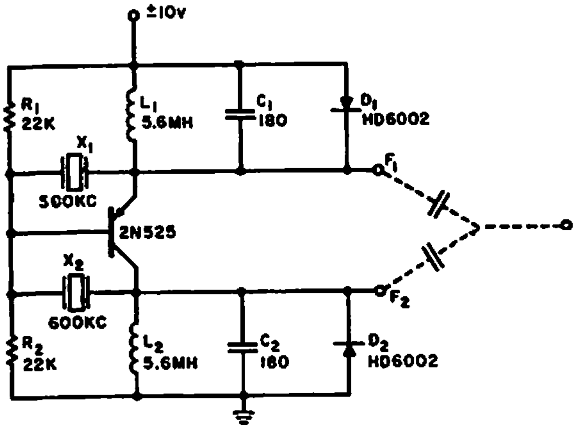

6 V
Vout
CA3000
-6 V
1000 OHMS
1000 OHMS
9
8
10
1
3
2
6

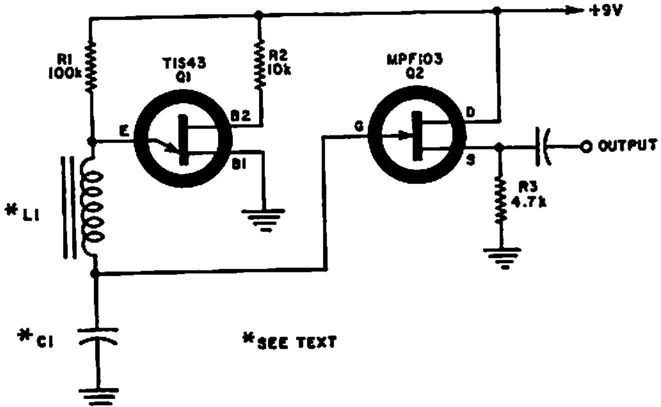
CRYSTAL IC—Use of two external resistors and quartz crystal with IC d-c amplifier gives crystal oscillator operating up to 1 MHz depending on crystal used. Output is taken from collector that is not connected to crystal (terminal 10), and has waveform about halfway between sine and square wave.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 125.


-15V
330 µH
200 pF
20-115 pF
OUTPUT
D
G
Q1
S
2MΩ
15k
512-kHz XTAL
Q1: U-110, U-112
U-146 OR U-147

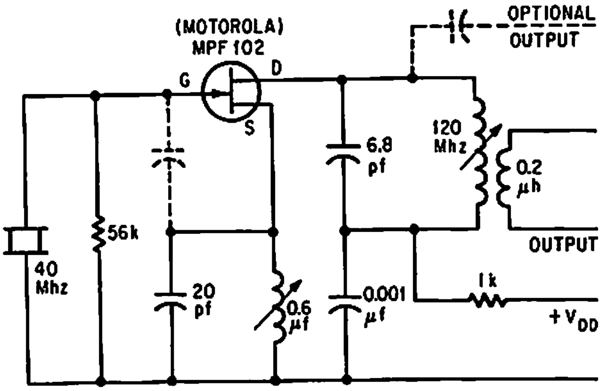
MILLER FET—Values shown are for 512-kHz crystal, but upper limit is several megahertz. Supply voltage can be from 6 to 22 V. Output cannot tolerate much loading.—J. H. Wujek, Jr., and M. E. McGee, Field-Effect Transistor Circuits, *Electronics World*, May 1967, p 32–33 and 75.

TWO-FREQUENCY CRYSTAL OSCILLATOR—With negative voltage applied to supply terminal, transistor operates in inverted mode and 500-kHz crystal X1 determines output frequency. With positive supply, 600-kHz crystal determines output frequency. Adding capacitors as shown by dashed lines gives single output terminal. Frequencies may be remotely selected.—J. M. Tewksbury, Bilateral Crystal Oscillator Has Two-Frequency Output, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 179.

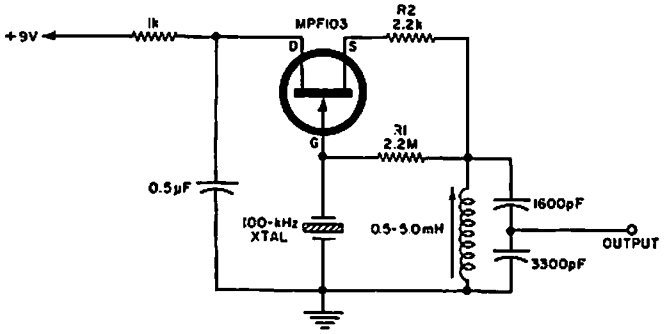

±10V
R1 22K
L1 5.6MH
C1 180
D1 HD6002
X1
500KC
F1
2N525
X2
600KC
F2
R2 22K
L2 5.6MH
C2 180
D2 HD6002


+9V
R1 100k
TIS43 Q1
R2 10k
MPF103 Q2
E
B2
B1
G
D
S
OUTPUT
R3 4.7k
*L1
*C1
*SEE TEXT

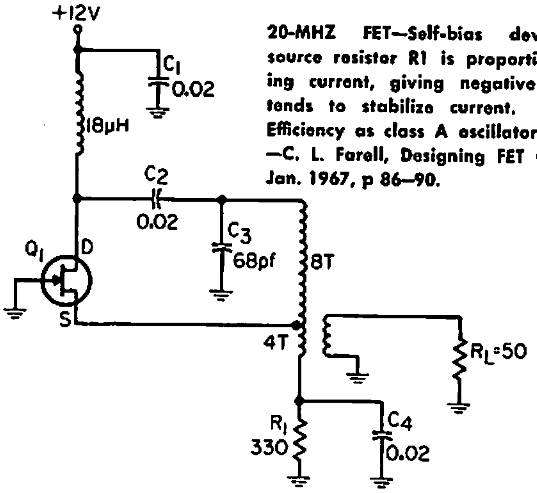
400-HZ UJT SINE-WAVE—Output frequency ranges from 100 Hz to 100 kHz, depending on L1 and C1. For 400-Hz sine-wave output with acceptable waveform purity, C1 is 0.047 µF and L1 is 3-H a-f choke.—F. H. Tooker, Improving Sawtooth Linearity, *Electronics World*, Feb. 1969, p 84.


(MOTOROLA)
MPF 102
G
D
S
OPTIONAL OUTPUT
6.8 pf
120 Mhz
0.2 µh
OUTPUT
56k
40 Mhz
20 pf
0.6 µf
0.001 µf
1k
+V_DD

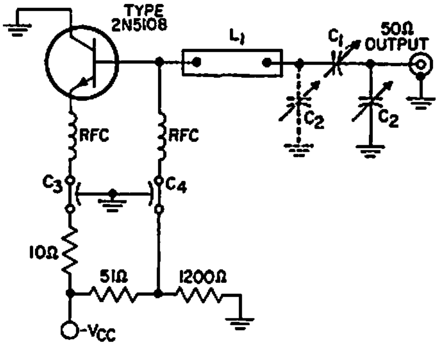
FET IN CRYSTAL TRIPLER—High gate-to-source impedance of fet minimizes crystal loading in vhf-uhf oscillator-multiplier. Tank circuit in source lead is tuned to about 0.7 times 40-MHz fundamental of crystal.—F. B. Cupp, FEB Cuts Down Crystal Loading, *Electronics*, Sept. 18, 1967, p 111.


+9V
1k
MPF103
R2
2.2k
D
S
G
R1
2.2M
0.5μF
100-kHz XTAL
0.5-5.0mH
1600pF
3300pF
OUTPUT

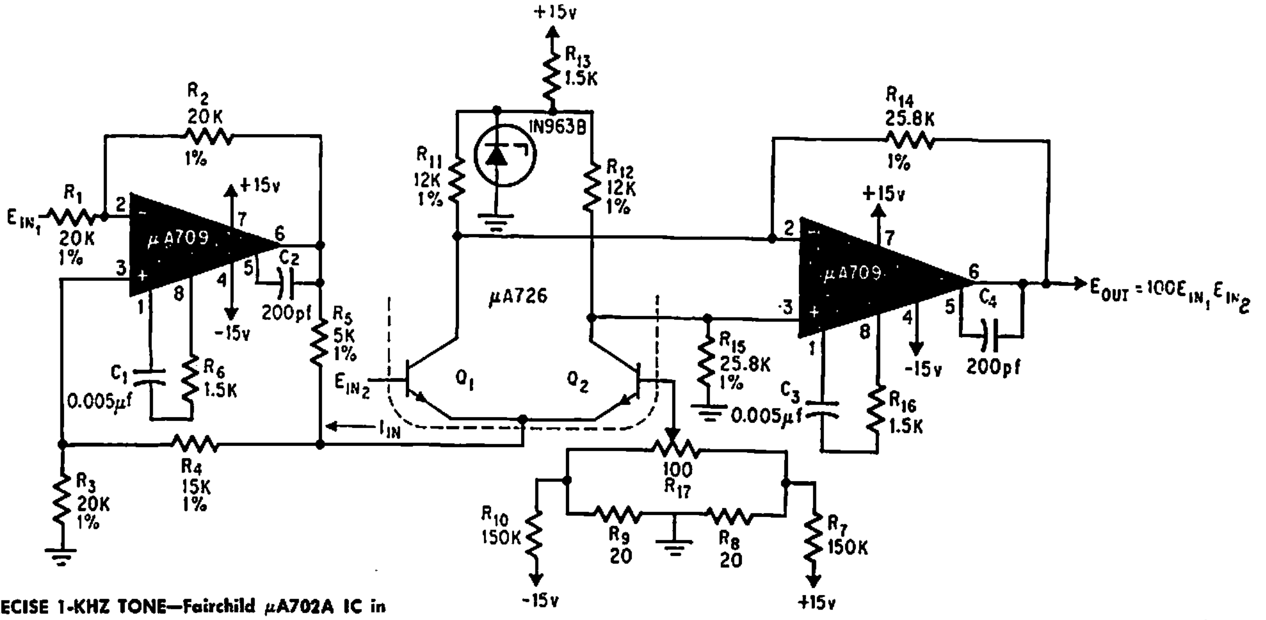
100-KHZ GROUNDED-DRAIN COLPITTS FET— Sine-wave output is cleanest when tank coil is adjusted for minimum drain current. Useful as signal source for time-base generators in digital counter.—F. H. Tooker, FET Sine-Wave Crystal Oscillators, *Electronics World*, June 1969, p 33 and 83.


+12V
C1
0.02
18μH
C2
0.02
C3
68pf
8T
Q1
D
S
4T
RL=50
R1
330
C4
0.02

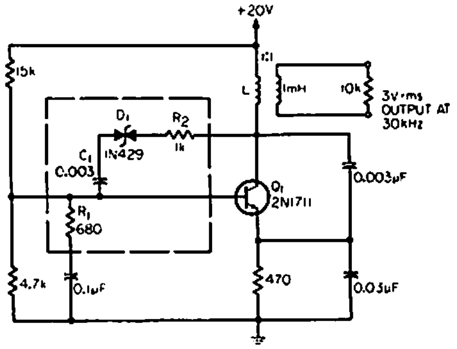
20-MHZ FET—Self-bias developed across source resistor R1 is proportional to operating current, giving negative feedback that tends to stabilize current. Fet is 2N3823. Efficiency as class A oscillator is about 35%. —C. L. Farell, Designing FET Oscillators, *EEE*, Jan. 1967, p 86–90.


TYPE 2N5108
L1
C1
50Ω OUTPUT
C2
C2
RFC
RFC
C3
C4
10Ω
51Ω
1200Ω
-VCC

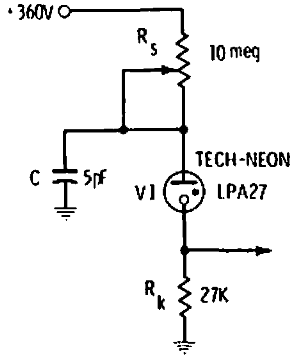
1.68-GHZ L-BAND OSCILLATOR—Collector of transistor connects directly to ground plane of stripline circuit board. Power output is over 0.3 W at 20% efficiency when operating from 25-V d-c supply. L1 is 0.75-inch section of 50-ohm microstripline; can be operated at any frequency from 1 to 2 GHz by changing length of L1 slightly. With 0.8-inch line, frequency is 1.5 GHz. Values: C1, C2 0.35–3.5 pF piston; C3, C4 470 pF; RFC 5 turns No. 28 on 0.125" form.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 364.


+15v
R13
1.5K
1N963B
R2
20K
1%
R11
12K
1%
R12
12K
1%
R14
25.8K
1%
EIN1
R1
20K
1%
2
3
μA709
+15v
7
6
4
5
8
1
C2
200pf
-15v
C1
0.005μf
R6
1.5K
R5
5K
1%
μA726
EIN2
Q1
Q2
IIN
R4
15K
1%
R3
20K
1%
R15
25.8K
1%
C3
0.005μf
+15v
2
3
7
μA709
6
5
4
8
1
C4
200pf
-15v
R16
1.5K
EOUT = 100EIN1 EIN2
100
R17
R10
150K
R9
20
R8
20
R7
150K
-15v
+15v

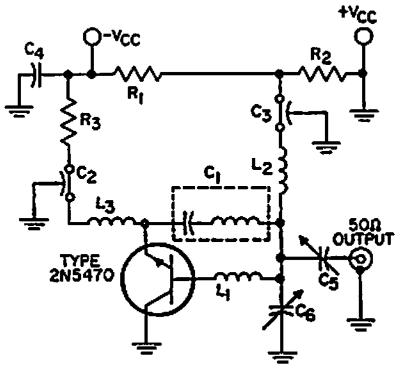
PRECISE 1-KHZ TONE—Fairchild μA702A IC in fet circuit provides agc to minimize instabilities and prevent limiting. Can be used as precision tone generator, timing signal generator, or for computation. Negative feedback through R3 stabilizes gain and makes it independent of IC characteristics. Positive feedback to noninverting input is made equal to negative feedback by agc, to give undistorted 8-V sine-wave output.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


+20V
15k
L
1mH
10k
3V-rms OUTPUT AT 30kHz
D1
R2
1k
C1
1N429
0.003
Q1
2N1711
0.003μF
R1
680
4.7k
0.1μF
470
0.03μF

30-KHZ CONSTANT-AMPLITUDE—Zener D1 stabilizes operating conditions and output amplitude of emitter-feedback oscillator. Distortion in sine-wave output is less than 1%, and amplitude stability for combined variations of 0–65 C temperature change, 18-22 V d-c supply voltage change, and load change from 10K to infinity is less than 5%. —M. Feller, Amplitude-Stabilized Oscillator, *EEE*, April 1967, p 139–140.

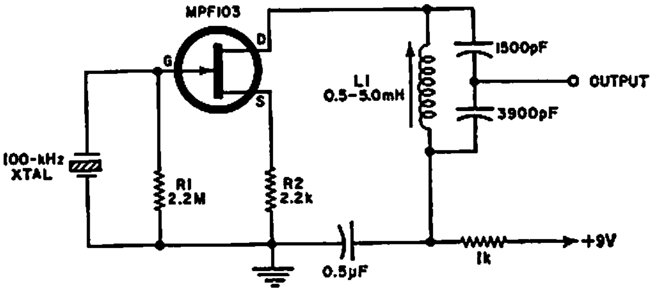

+360V
R_s
10 meg
C
5pF
V1
TECH-NEON
LPA27
R_k
27K

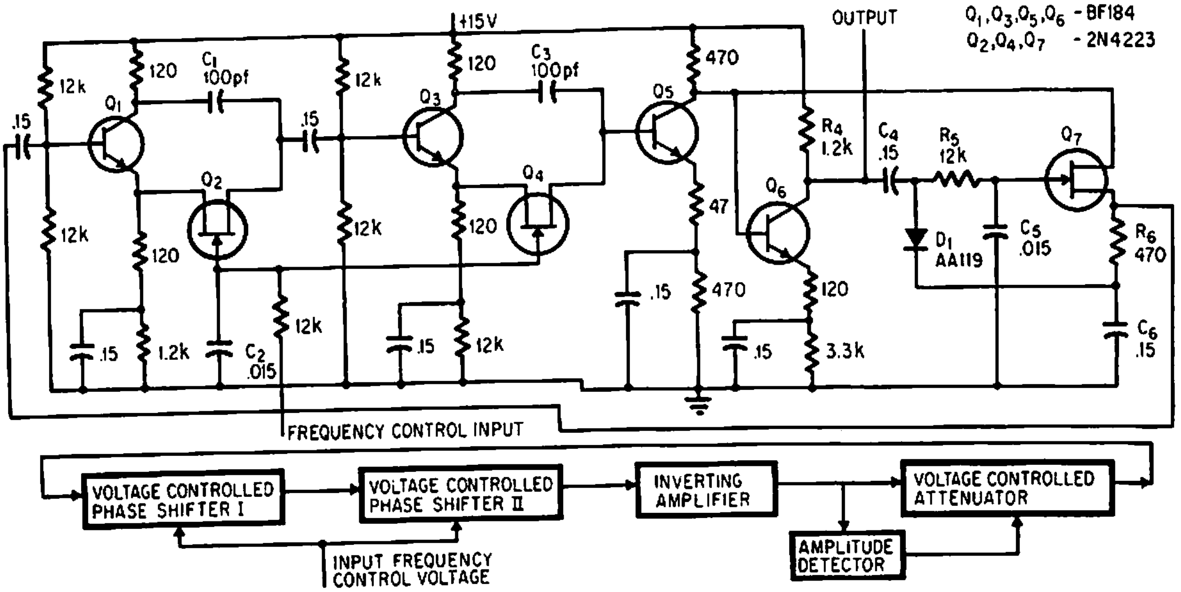
30–40 KHZ NEON—Neon chosen has very fast deionization time to maintain high-frequency stability. Sine-wave amplitude varies from 1 to 14 V into 1-meg load.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 41.


C4
-Vcc
R1
+Vcc
R2
R3
C3
C2
L2
L3
C1
TYPE 2N5470
50Ω OUTPUT
L1
C5
C6

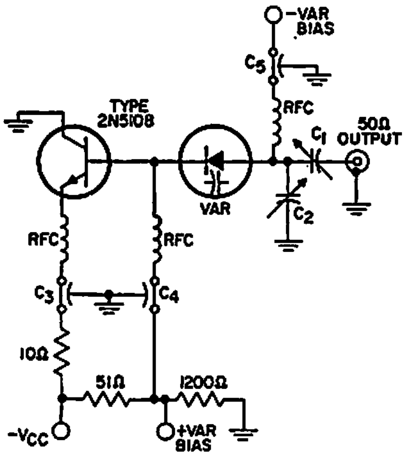
1.8–2.3 GHZ TUNABLE—With 24-V supply, delivers 0.3 W at 16% efficiency with Hartley oscillator circuit. Values: R1 51; R2 1.2K; R3 10; C1 0.82 pF; C2, C3 100 pF; C4 0.01 pF; C5, C6 0.35–3.5 pF; L1 0.05" length No. 22 wire.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 365.

SPLIT-DRAIN FET—Tuned-drain tuned-gate crystal oscillator puts out clean sine wave when L1 is set for minimum drain current of about 150 μA unloaded.—F. H. Tooker, FET Sine-Wave Crystal Oscillators, *Electronics World*, June 1969, p 33 and 83.

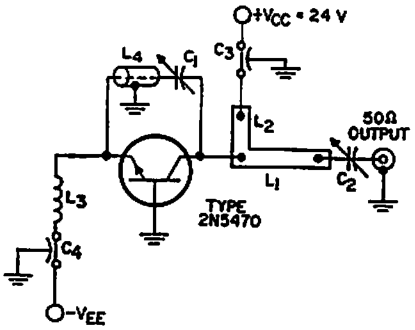

MPF103
G
D
S
L1
0.5–5.0mH
1500pF
OUTPUT
3900pF
100-kHz XTAL
R1
2.2M
R2
2.2k
0.5μF
1k
+9V


+15V
OUTPUT
Q1,Q3,Q5,Q6 - BF184
Q2,Q4,Q7 - 2N4223
12k
120
C1
100pf
Q1
.15
Q2
12k
120
1.2k
.15
C2
.015
12k
12k
Q3
120
C3
100pf
Q4
120
12k
.15
12k
Q5
470
47
.15
470
R4
1.2k
Q6
120
.15
3.3k
C4
.15
R5
12k
D1
AA119
C5
.015
Q7
R6
470
C6
.15
FREQUENCY CONTROL INPUT
VOLTAGE CONTROLLED PHASE SHIFTER I
VOLTAGE CONTROLLED PHASE SHIFTER II
INVERTING AMPLIFIER
VOLTAGE CONTROLLED ATTENUATOR
AMPLITUDE DETECTOR
INPUT FREQUENCY CONTROL VOLTAGE

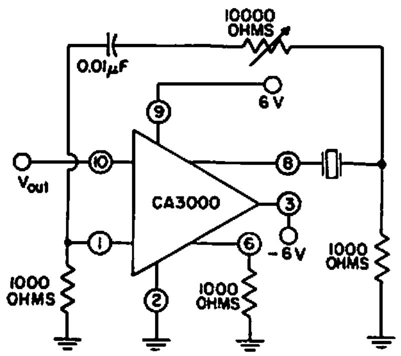
0.5–5 MHZ FET-TUNED R-C—Field-effect transistors acting as variable resistors tune R-C oscillator over decade range with control voltage of 4.8 to 7.2 V. Oscillator output amplitude is constant within 1 dB. Other frequency ranges can be obtained by changing capacitor values. Two phase shifters, phase inverter, amplifier, and attenuator are connected in loop. Circuit oscillates at frequency in which total phase shift is 360 deg. Voltage-controlled attenuator Q7 is driven by amplitude detector Q6 to provide constant output voltage.—K. van der Geer, FET's Tune RC Oscillator Over Decade Range, *Electronics*, Feb. 17, 1969, p 96.


-VAR BIAS
C5
TYPE 2N5108
RFC
C1
50Ω OUTPUT
VAR
C2
RFC
RFC
C3
C4
10Ω
51Ω
1200Ω
-VCC
+VAR BIAS

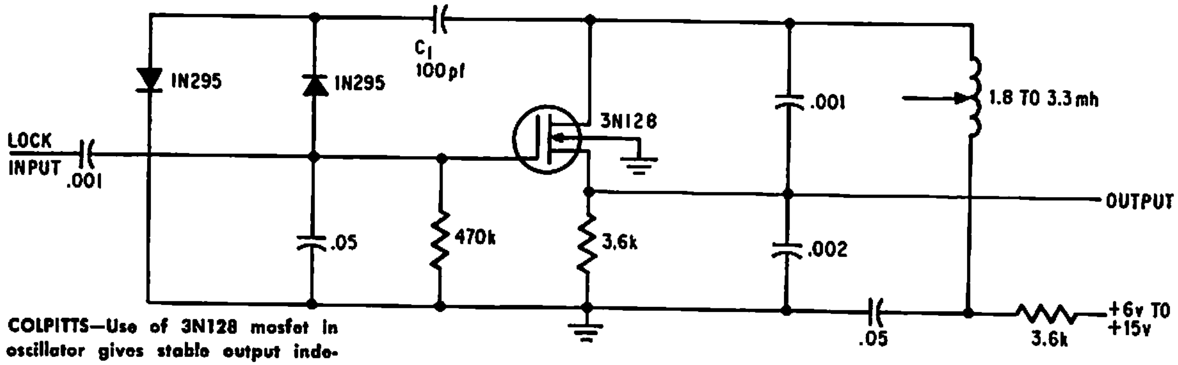
1—1.5 GHZ VARACTOR-TUNED—Delivers 600 mW over entire range when tuned with high-Q varactor diode having control range of 0 to 22 V and transistor collector supply of 28 V. Values: C1, C2 1–7 pF piston; C3-C5 470 pF; RFC 0.1 μH.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 365.


+VCC = 24 V
C3
L4
C1
L2
50Ω OUTPUT
L3
L1
C2
TYPE 2N5470
C4
-VEE

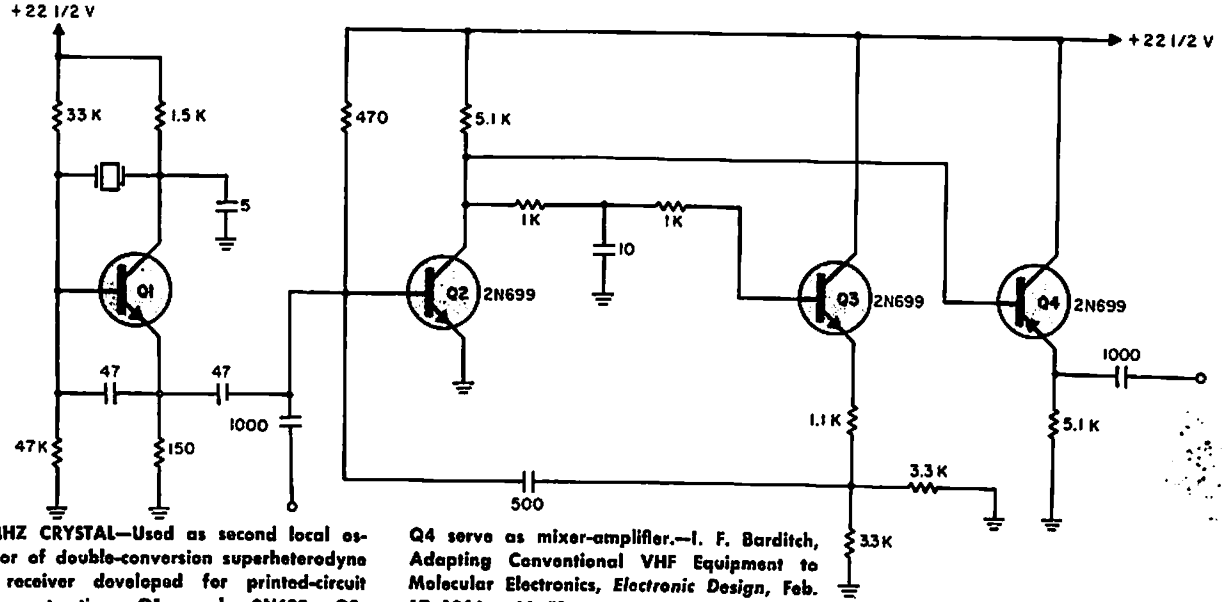
1.8–2.2 GHZ COLPITTS—Phase-resonant loop L4-C1 provides necessary feedback. With 24-V supply, power output is about 0.3 W. Values: C1, C2 0.35–3.5 pF; C3, C4 100 pF; L1, L2 microstripline (dimensions given in book); L3 5 turns; L4 50-ohm coax 1.5" long. —"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 366.


10000 OHMS
0.01μF
6V
9
10
8
Vout
CA3000
3
1
6
-6V
1000 OHMS
2
1000 OHMS
1000 OHMS

VARIABLE-FEEDBACK CRYSTAL IC—Adjustable feedback path for IC d-c amplifier permits adjusting crystal oscillator to give pure sine wave. Frequency depends on crystal used, and can be up to 1 MHz. Collector tuning (terminal 10) will extend frequency range above 10 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 125.


LOCK INPUT
.001
IN295
IN295
C1 100pf
3N128
.001
1.8 TO 3.3mh
OUTPUT
.05
470k
3.6k
.002
.05
3.6k
+6v TO +15v

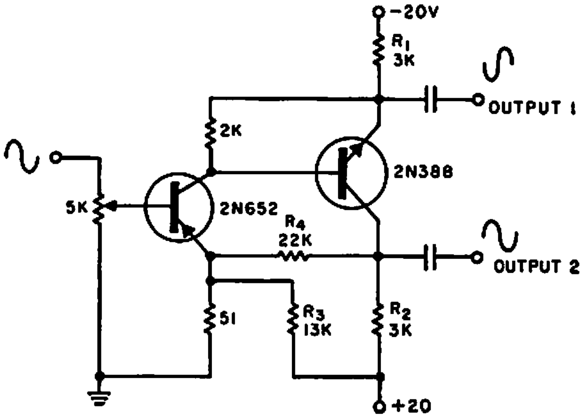
MOSFET COLPITTS—Use of 3N128 mosfet in Colpitts oscillator gives stable output independently of load and supply voltage changes, and improves waveform symmetry. Circuit can be frequency-locked to external oscillator through input coupling capacitor.—N. H. Brown, MOS FET Stabilizes Oscillator's Output, *Electronics*, Feb. 3, 1969, p 80.


+22 1/2 V
33 K
1.5 K
5
Q1
47
47
1000
47K
150
470
5.1 K
1K
10
1K
Q2
2N699
Q3
2N699
Q4
2N699
+22 1/2 V
1000
1.1 K
5.1 K
3.3 K
500
33K

30-MHZ CRYSTAL—Used as second local oscillator of double-conversion superheterodyne f-m receiver developed for printed-circuit card construction. Q1 can be 2N699. Q2-Q4 serve as mixer-amplifier.—I. F. Barditch, Adapting Conventional VHF Equipment to Molecular Electronics, *Electronic Design*, Feb. 17, 1964, p 44–51.

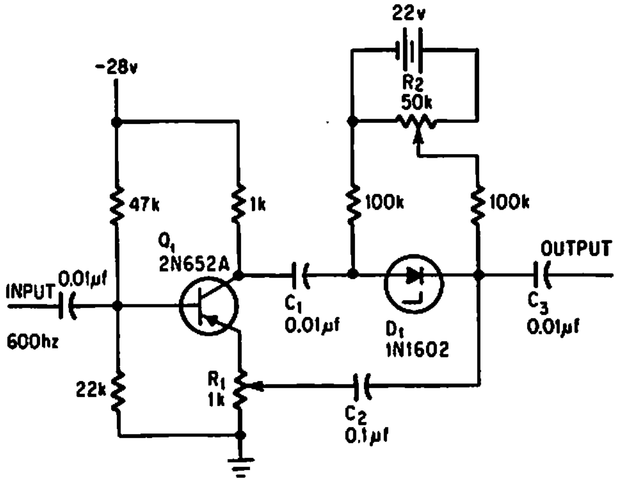
CHAPTER 60

Phase Control Circuits



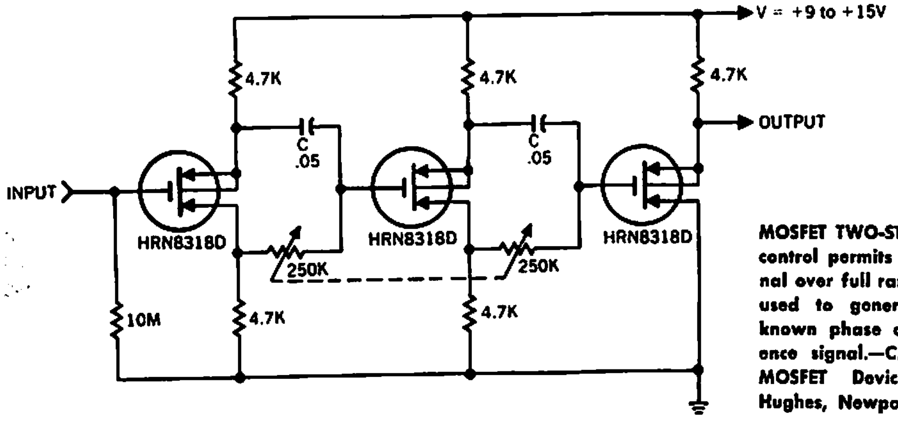
-20V
R1
3K
OUTPUT 1
2K
2N388
5K
2N652
R4
22K
OUTPUT 2
51
R3
13K
R2
3K
+20

PHASE SPLITTER WITH GAIN OF 150—Direct-coupled complementary pair with feedback provides voltage gain and equal outputs 180 deg out of phase. Values of R1 and R2 must be changed according to output impedance and R3 then adjusted to give circuit bias for desired operating level of output transistor.—R. E. Risely, DC Phase Splitter Adds Voltage Gain, *Electronic Design*, Feb. 3, 1964, p 46 and 48.



22v
R2
50k
-28v
47k
1k
100k
100k
OUTPUT
Q1
2N652A
INPUT
0.01µf
600hz
C1
0.01µf
D1
1N1602
C3
0.01µf
22k
R1
1k
C2
0.1µf

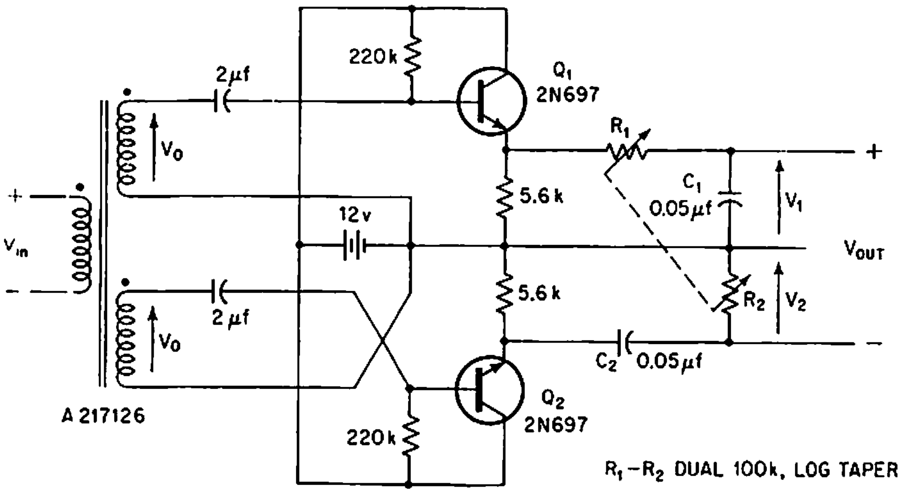
VOLTAGE-VARIABLE SHIFTER—Can be used as a-c motor speed control for mixers, blenders, and drills, where firing point of scr is changed. Can also serve as correction circuit in feedback loop of automatic phase control system. Phase angle of low-frequency input signal can be shifted up to 70 deg without distorting waveform. As adjustable phase reference, one circuit can control many servomechanisms. Reduction of 5:1 in output amplitude over phase-shifting range can be cut to 1.2:1 by adjusting R1.—T. T. Kalal, Zener Diode Controls Variable Phase Shifter, *Electronics*, Dec. 26, 1966, p 72–73.

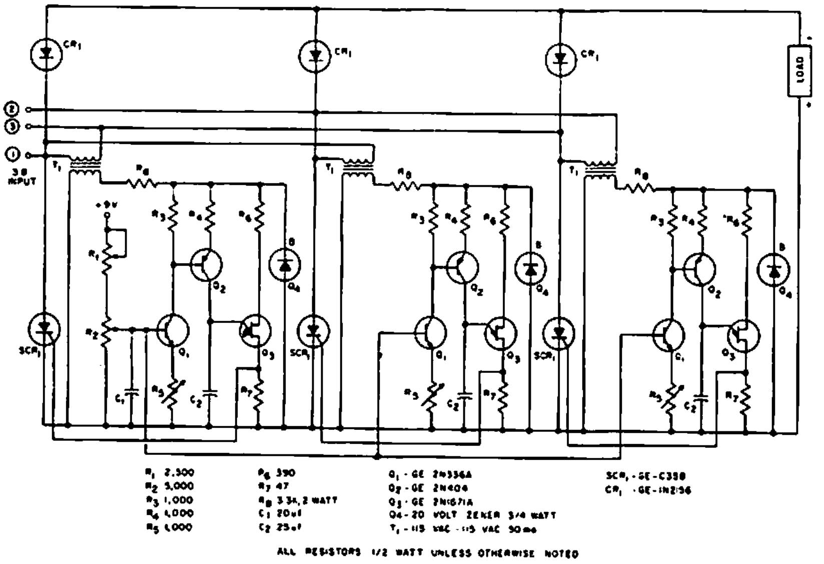


V = +9 to +15V
4.7K
4.7K
4.7K
OUTPUT
C
.05
C
.05
INPUT
HRN8318D
HRN8318D
HRN8318D
250K
250K
10M
4.7K
4.7K

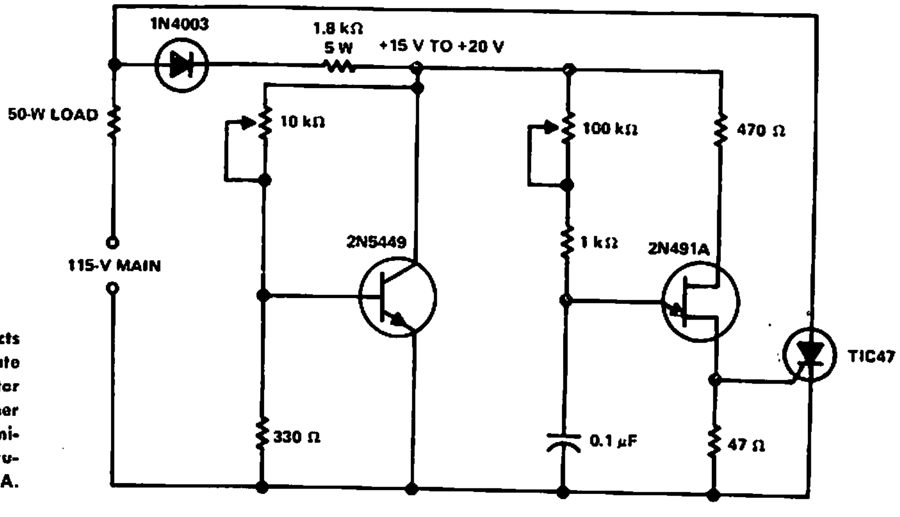
MOSFET TWO-STAGE PHASE SHIFTER—Ganged control permits shifting phase of 400-Hz signal over full range of 0 to 180 deg. Can be used to generate pulse or signal having known phase difference from that of reference signal.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 26.

CONSTANT-AMPLITUDE PHASE SHIFTER—Shifts sinusoidal signal over 180-deg range, and reversal of input leads provides additional 180-deg shift. Maintains constant output amplitude and low output impedance. Used for phase-locking amplifiers.—J. J. Shin, Signals Shifted 180 Deg as Amplitude Remains Constant, *Electronics*, May 12, 1969, p 110.

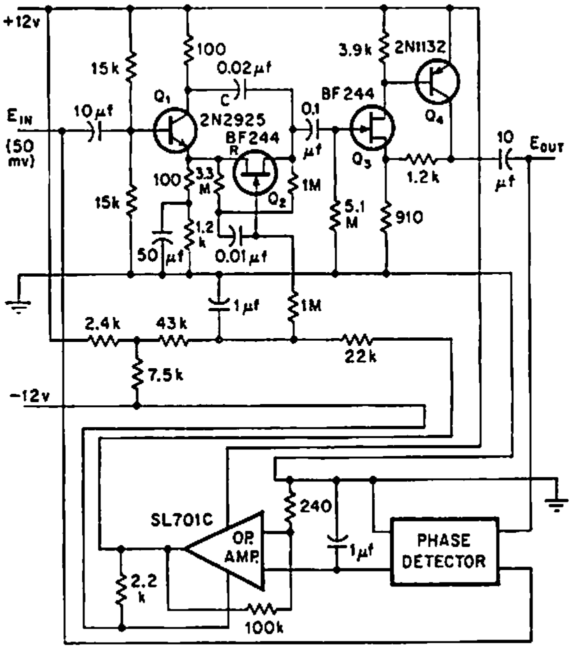

220k
2μf
Q1
2N697
R1
+
V0
Vin
+
−
12v
5.6 k
C1
0.05μf
V1
VOUT
5.6 k
R2
V2
−
2 μf
V0
C2 0.05μf
A 217126
Q2
2N697
220k
R1−R2 DUAL 100k, LOG TAPER


CR1
LOAD
②
③
①
3Ø INPUT
T1
R8
+9V
R1
R2
R3
R4
R6
Q1
Q2
Q3
Q4
8
SCR1
C1
R5
C2
R7
R1 2,300
R2 5,000
R3 1,000
R4 4,000
R5 4,000
R6 390
R7 47
R8 3.3k, 2 WATT
C1 20uf
C2 25uf
Q1 - GE 2N336A
Q2 - GE 2N404
Q3 - GE 2N1671A
Q4 - 20 VOLT ZENER 3/4 WATT
T1 - 115 VAC - 115 VAC 50 ma
SCR1 - GE - C35B
CR1 - GE - 1N2156
ALL RESISTORS 1/2 WATT UNLESS OTHERWISE NOTED

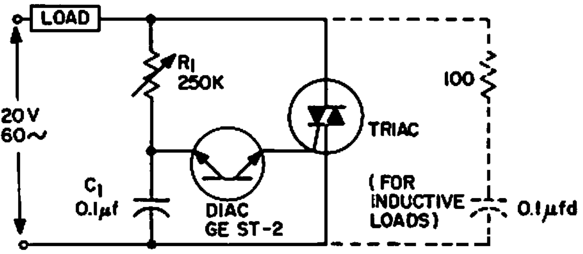
THREE-PHASE WITH STEPLESS 0–100% CONTROL—Uses separate triggering of each phase for varying d-c output voltage smoothly down to zero, for applications such as ring counters, flip-flops, and magnetic firing controls. Will not fall out of synchronism. Power output depends on scr's used. Tracking accuracy, controlled by pots R5, is accurate within 1 deg at 60 Hz.—J. D. Atherly, F. W. Gutzwiller, and F. Pastore, Three Phase SCR Firing Circuits for DC Power Supplies, General Electric, Syracuse, N.Y., No. 200.21, 1962.


1N4003
1.8 kΩ
5 W
+15 V TO +20 V
50-W LOAD
10 kΩ
100 kΩ
470 Ω
115-V MAIN
2N5449
1 kΩ
2N491A
TIC47
330 Ω
0.1 μF
47 Ω

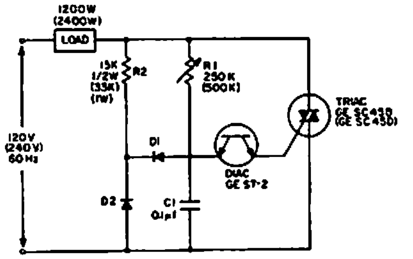
50-W HALF-WAVE A-C CONTROL—Conducts over range of 10 to 170 deg on alternate half-cycles. May be used for heater or motor control, as relay driver, or as lamp dimmer if flicker is not objectionable.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, CC101, 1968, p 7108A.


+12v
15k
100
0.02μf
C
3.9k
2N1132
Q₄
BF244
Q₁
2N2925
E_IN
(50 mv)
10μf
0.1 μf
BF244
R
Q₃
10 μf
E_OUT
100
3.3 M
Q₂
1M
1.2k
15k
1.2 k
5.1 M
910
50μf
0.01μf
1μf
1M
2.4k
43k
22k
7.5k
-12v
SL701C
OP. AMP.
240
1μf
PHASE DETECTOR
2.2 k
100k

FREQUENCY-INDEPENDENT 90-DEG SHIFTER—Will produce 90-deg shift independently of frequency in audio range, for producing circular sweeps on crt. Can also be used for phase measurements where calibrated 0–90 deg phase shifter is formed by adding signal to quadrature component. Fet is used as variable resistance in R-C phase shifter, with resistance controlled by feedback from phase detector and opamp.—J. Kalinski, Variable FET Resistance Gives 90 Deg Phase Shifts, *Electronics*, July 20, 1970, p 88.

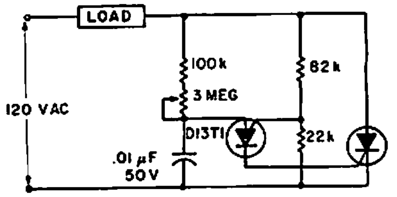

LOAD
R1 250K
100
120V 60~
TRIAC
C1 0.1μf
DIAC GE ST-2
(FOR INDUCTIVE LOADS)
0.1μfd

FULL-WAVE DIAC-TRIAC—Simplicity makes circuit ideal for many lamp, heater, and fan speed controls, despite limited control range and large hysteresis effect at low outputs. Choice of triac depends on load to be handled.—"SCR Manual," 4th Edition, General Electric, 1967, p 139–140.

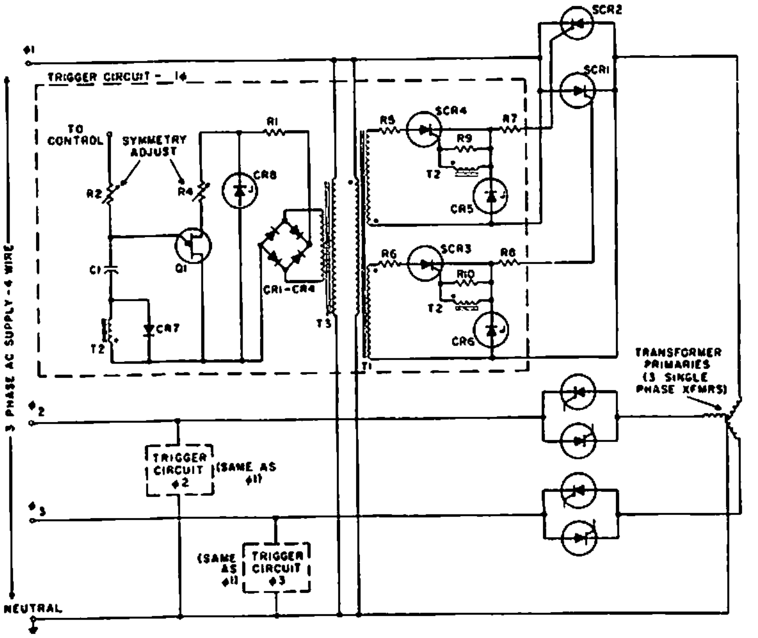

1200W (2400W)
LOAD
15K 1/2W (33K) (1W)
R2
R1 250K (500K)
TRIAC GE SC43B (GE SC45D)
120V (240V) 60Hz
D1
DIAC GE ST-2
D2
C1 0.1μf

D1,D2-200V DIODES (GE A14B)

FULL-WAVE WITH ALTERNATE RESET—Uses diode to reset capacitor at end of each positive half-cycle. Does not reset at end of negative half-cycle, but snap-on effect is negligible.—"SCR Manual," 4th Edition, General Electric, 1967, p 188.


LOAD
100k
82k
3 MEG
120 VAC
D13T1
22k
.01μF 50V

LINE-OPERATED SCR TRIGGER—Uses D13T1 triode thyristor as programmable ujt in phase control circuit that derives required interbase voltage directly from a-c line. Potentiometer in resistor divider controls point in each cycle at which scr (at right) is triggered.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 7.


SCR2
SCR1
ϕ1
TRIGGER CIRCUIT - ϕ1
TO CONTROL
SYMMETRY ADJUST
R1
R5
SCR4
R7
R9
T2
CR5
CR8
R2
R4
Q1
C1
CR1-CR4
R6
SCR3
R8
R10
T2
CR6
T3
T1
CR7
T2
3 PHASE AC SUPPLY-4 WIRE
TRANSFORMER PRIMARIES (3 SINGLE PHASE XFMRS)
ϕ2
TRIGGER CIRCUIT ϕ2
(SAME AS ϕ1)
ϕ3
(SAME AS ϕ1)
TRIGGER CIRCUIT ϕ3
NEUTRAL

R1 - 3.3K, 5 WATT
R2 - SEE FIG. 8
R4 - 10K, 1 WATT
R5, R6 - 22Ω, 2 WATT
R7, R8 - 33Ω, 2 WATT
R9, R10 - 47Ω, 1/2 WATT

C1 - 0.1 MFD
Q1 - G E 2N2646
SCR1, SCR2 - AS REQUIRED
SCR3, SCR4 - G E 2N1595
CR1 TO CR4 - G E 1N1693
CR5, CR6 - G E 1N1765
CR7 - G E 1N1692
CR8 - G E 1N1776

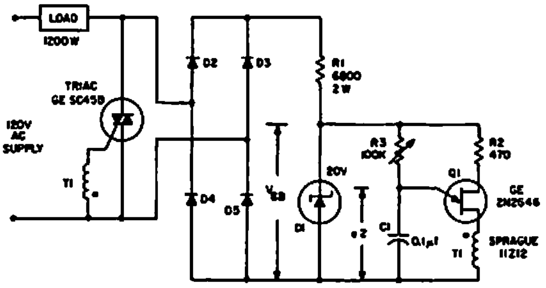
T1 - ISOLATION TRANSFORMER WITH 12.6 VOLT, 1/4 AMP, SECONDARIES, PRIMARY AS REQUIRED FOR SPECIFIC LINE VOLTAGE

T2 - PULSE TRANSFORMER PE 2229, UTC H51 OR EQUIVALENT

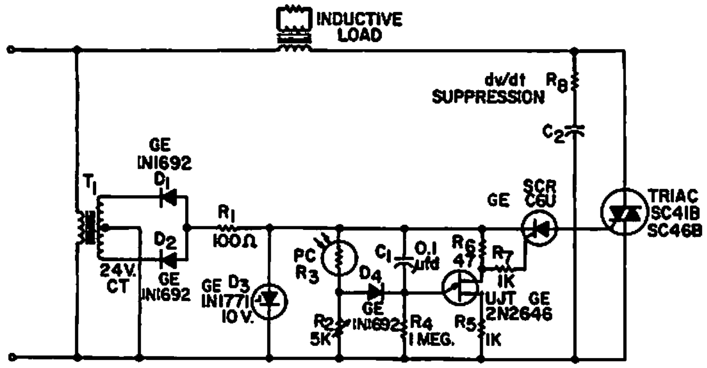
T3 - ISOLATION TRANSFORMER WITH 120 VOLT, 50 MA SECONDARY. PRIMARY AS REQUIRED FOR SPECIFIC LINE VOLTAGE (FOR 120 VOLT PRIMARY, TRIAD N-51X)

FULL-RANGE THREE-PHASE CONTROL—Used in four-wire a-c system feeding three wye-connected transformers. One pair of scr's is in series with each line, and transformer neutral is connected to system neutral. Trigger circuits are between line and neutral of each phase. Ujt triggers pilot scr's. Article has five circuit variations for controlling the three ujt's from single master signal.—"SCR Manual," 4th Edition, General Electric, 1967, p 205–207.

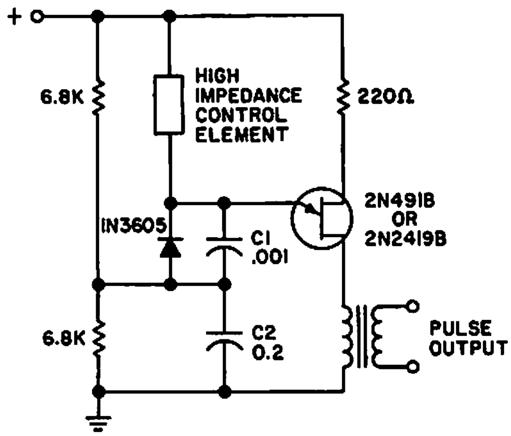
MANUAL SCR CONTROL—Basic manually controlled scr with ujt covers full range from minimum to maximum power. Zener clamps voltage of control circuit to fixed level.—"SCR Manual," 4th Edition, General Electric, 1967, p 189–190.


LOAD
1200W
TRIAC
GE SC45B
120V
AC
SUPPLY
T1
D2
D3
D4
D5
V_{SB}
R1
6800
2W
20V
D1
e2
R3
100K
C1
0.1μf
R2
470
Q1
GE
2N2646
T1
SPRAGUE
11Z12

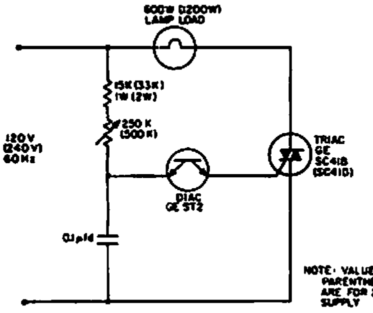
D_1 = GE-Z4XL20
$D_{2,3,4,5}$ = GE-A13B


INDUCTIVE
LOAD
dv/dt
SUPPRESSION
R8
C2
GE
IN1692
D1
T1
R1
100Ω
D2
24V.
CT
GE
IN1692
GE D3
IN1771
10V.
PC
R3
C1
0.1
μfd
D4
GE
IN1692
R2
5K
R4
1MEG.
R6
47
R7
1K
UJT GE
2N2646
R5
1K
GE
SCR
C6U
TRIAC
SC41B
SC46B

RAMP AND PEDESTAL CONTROL—Designed for inductive loads. Rectified supply voltage is used with small pilot scr to give continuous drive to triac gate after triggering, to hold triac on until load current is high enough for triac to latch.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 12.

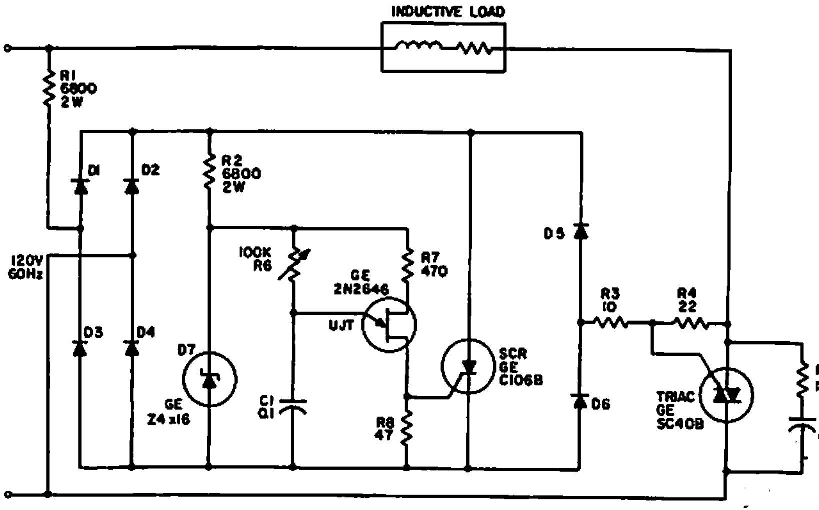

+
6.8K
HIGH
IMPEDANCE
CONTROL
ELEMENT
220Ω
IN3605
C1
.001
2N4918
OR
2N2419B
6.8K
C2
0.2
PULSE
OUTPUT

HIGH-GAIN UJT—Simple modification of conventional ujt-scr phase-control circuit increases effective gain up to 10,000 times, giving equivalent of several stages of transistor amplification. Article covers choice of capacitor values to give desired output pulse amplitude.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 2.


600W (1200W)
LAMP LOAD
15K (33K)
1W (2W)
250 K
(500 K)
120V
(240V)
60Hz
DIAC
GE ST2
TRIAC
GE
SC41B
(SC41D)
0.1μfd

NOTE: VALUES IN PARENTHESES ARE FOR 240 VAC SUPPLY

FULL-WAVE WITH REDUCED SNAP-ON—Control circuit is connected to supply to reduce snap-on effect wherein load current jumps suddenly to value from which it is smoothly controlled. This allows capacitor to recharge slightly between triggering point and end of half-cycle.—"SCR Manual," 4th Edition, General Electric, 1967, p 188.

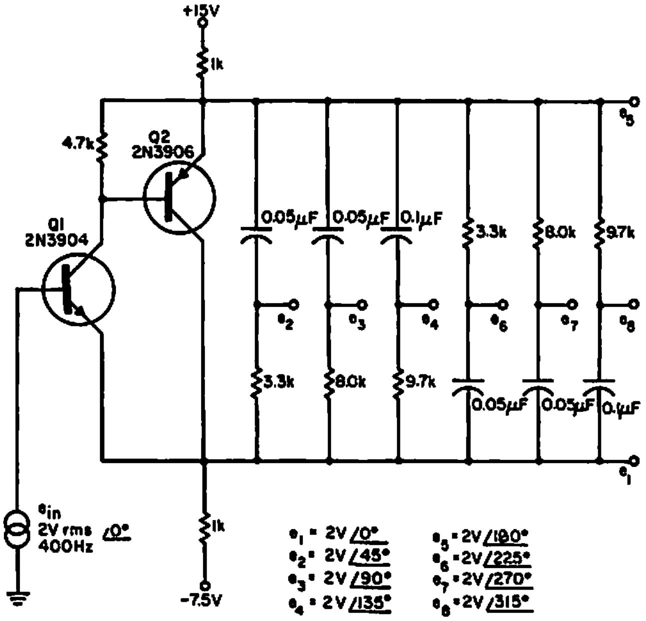

INDUCTIVE LOAD
R1
6800
2W
D1
D2
R2
6800
2W
120V
60Hz
100K
R6
GE
2N2646
R7
470
UJT
D3
D4
D7
GE
Z4 X16
C1
0.1
R8
47
SCR
GE
C106B
D5
D6
R3
10
R4
22
TRIAC
GE
SC40B
R5
100
C2
0.1

D1—D6 = GE A13B

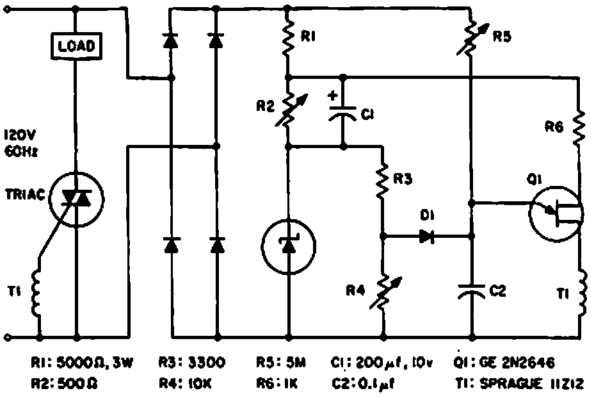
NOTE: FOR 240 VOLT OPERATION:
R1 = R2 = 15K, 4W
D1-D6 = GE A13D
SCR = GE C22D
TRIAC = GE SC40D

R5, C2: dv/dt SUPPRESSION

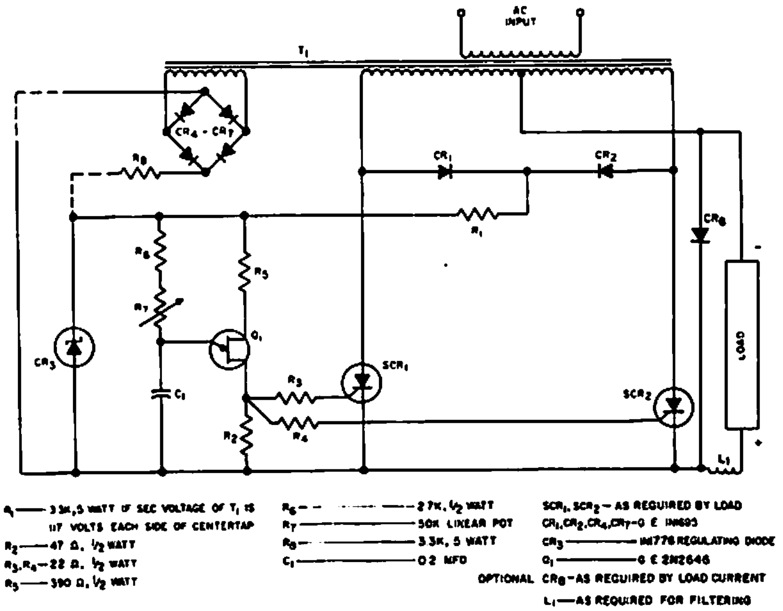
TRANSFORMERLESS TRIGGER—In smaller and lower-cost version of phase control for inductive a-c loads, bridge rectifier supplies power to ujt trigger and holding current to scr. If triggering occurs before turn-off of triac, scr will be turned on and held by current through R1.—"SCR Manual," 4th Edition, General Electric, 1967, p 197–198.


+15V
1k
4.7k
Q2
2N3906
Q1
2N3904
0.05μF
0.05μF
0.1μF
3.3k
8.0k
9.7k
e_5
e_2
e_3
e_4
e_6
e_7
e_8
3.3k
8.0k
9.7k
0.05μF
0.05μF
0.1μF
e_1
e_{in}
2V rms ∠0°
400Hz
1k
-7.5V
e_1 = 2V∠0°
e_2 = 2V∠45°
e_3 = 2V∠90°
e_4 = 2V∠135°
e_5 = 2V∠180°
e_6 = 2V∠225°
e_7 = 2V∠270°
e_8 = 2V∠315°

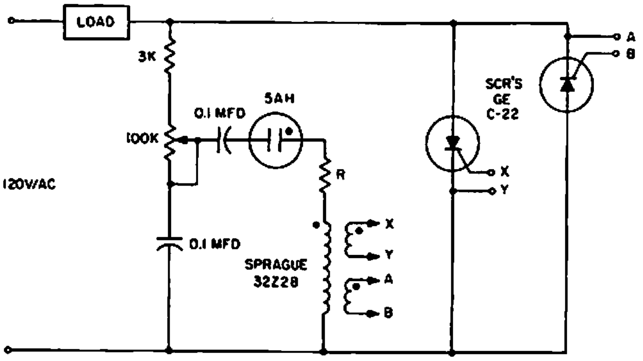
EIGHT-OUTPUT SHIFTER—Provides outputs 45 deg apart from 0 to 360 deg with constant amplitude and with phase nearly independent of load impedance. Output impedance is 2 ohms.—A. G. Lloyd, Multioutput Phase Shifter Uses One Transistor, *Electronic Design*, Oct. 25, 1967, p 130 and 132.


LOAD
120V
60Hz
TRIAC
T1
R1
R2
C1
R3
R4
R5
R6
D1
Q1
C2
T1
R1: 5000Ω, 3W
R2: 500Ω
R3: 3300
R4: 10K
R5: 5M
R6: 1K
C1: 200μf, 10v
C2: 0.1μf
Q1: GE 2N2646
T1: SPRAGUE 11Z12

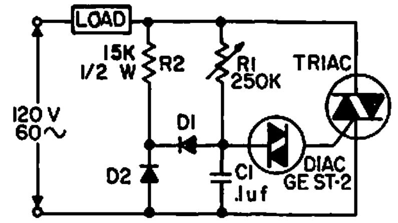
LINE-VOLTAGE COMPENSATION—R2 and C1 add to zener voltage a d-c voltage proportional to a-c supply voltage, to serve as ujt interbase voltage. Reducing supply voltage reduces interbase and peak-point voltages of ujt, to make triggering occur earlier on ramp and compensate for line voltage drop. Holds rms output voltage constant within 5% for 50% change in supply voltage.—"SCR Manual," 4th Edition, General Electric, 1967, p 195–196.


AC INPUT
T_1
CR_4 - CR_7
R_8
CR_1
CR_2
R_1
CR_8
R_6
R_5
R_7
Q_1
CR_3
C_1
R_3
SCR_1
SCR_2
R_2
R_4
LOAD
L_1
-
+
R_1 — 3.3K, 5 WATT IF SEC VOLTAGE OF T_1 IS 117 VOLTS EACH SIDE OF CENTERTAP
R_2 — 47 Ω, ½ WATT
R_3, R_4 — 22 Ω, ½ WATT
R_5 — 390 Ω, ½ WATT
R_6 — 2.7K, ½ WATT
R_7 — 50K LINEAR POT
R_8 — 3.3K, 5 WATT
C_1 — 0.2 MFD
SCR_1, SCR_2 — AS REQUIRED BY LOAD
CR_1, CR_2, CR_4, CR_7 — G E 1N693
CR_3 — 1N776 REGULATING DIODE
Q_1 — G E 2N2646
OPTIONAL CR_8 — AS REQUIRED BY LOAD CURRENT
L_1 — AS REQUIRED FOR FILTERING

PHASE-CONTROLLED D-C SUPPLY—D-c voltage across load can be steplessly adjusted by R7 from maximum to zero, with scr's in single-phase center-tapped phase-controlled rectifier. Single ujt Q1 develops gate signal to fire both scr's on alternate half-cycles. At 60 Hz, R7 varies firing angle from 10 deg for maximum load power to 180 deg for fully off. —"SCR Manual," 4th Edition, General Electric, 1967, p 199–200.

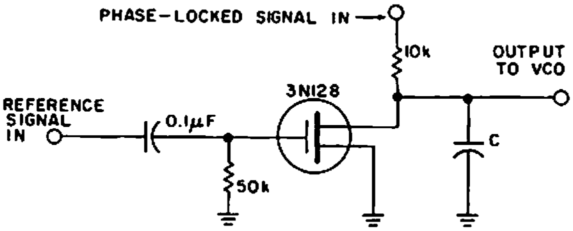

LOAD
3K
100K
0.1 MFD
5AH
R
120V/AC
0.1 MFD
SPRAGUE
32228
X
Y
A
B
SCR'S
GE
C-22
X
Y
A
B

FULL-WAVE NEON-SCR TRIGGER—Transformer-coupled full-wave a-c phase-controlled circuit uses 5AH neon as trigger for two-terminal system. Pulse transformer allows scr's to alternate in firing. Loss of load voltage is only about 5% of what it would be without control circuit.—"SCR Manual," 4th Edition, General Electric, 1967, p 199.

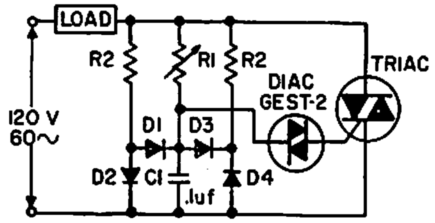

LOAD
15K
1/2 W
R2
R1
250K
TRIAC
120 V
60~
D1
D2
C1
.1uf
DIAC
GE ST-2

D1, D2 - 200V DIODES (GE A14B)

HYSTERESIS-FREE TRIAC CONTROL—Timing capacitor is reset to same level after each positive half-cycle, to provide uniform initial condition for phase-control operation. Arrangement is useful only for resistive loads such as lamps and heaters, because firing angle is not symmetrical throughout range from minimum to maximum load power. Choice of triac depends on load. For 220 V, change R1 to 500K, R2 to 22K, and D1-2 to A14D.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 8.

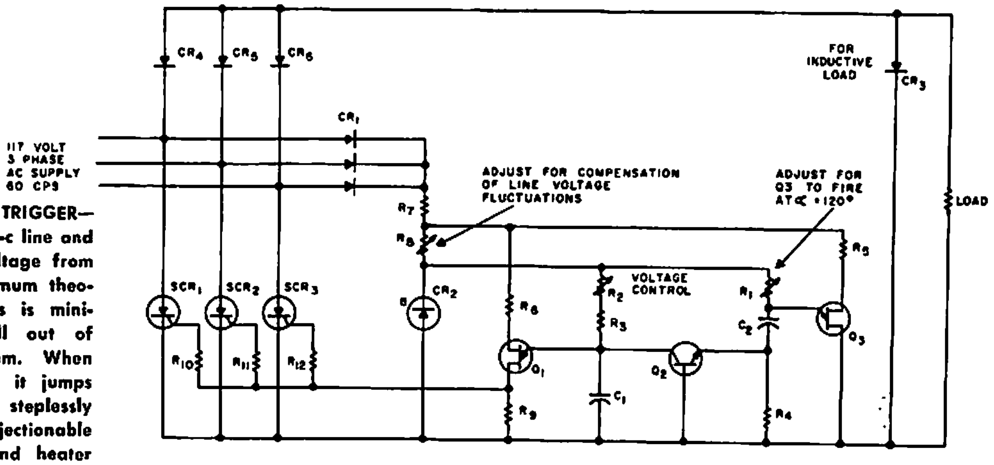

PHASE-LOCKED SIGNAL IN
10k
OUTPUT
TO VCO
3N128
REFERENCE
SIGNAL
IN
0.1μF
C
50k

PHASE-LOCK DETECTOR—Mosfet operating in variable-resistance region provides d-c output voltage proportional to phase difference between input signal and reference signal. Used to drive vco of function generator. Value of C is chosen so its reactance is very much less than 10,000 ohms at oscillator frequency.—G. Worstell, Phase-Lock Detector Requires No External Power Supply, *Electronic Design*, Oct. 25, 1969, p 107.


LOAD
R2
R1
R2
TRIAC
DIAC
GE ST-2
120 V
60~
D1
D3
D2
C1
.1uf
D4

R1 - 250K POT.
R2, R3 - 15K 1/2 W
D1, D2, D3, D4 - 200V DIODES (GE A14B)

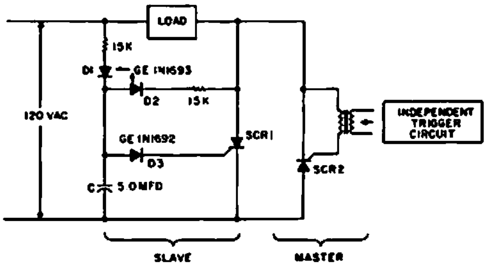
TRIAC CONTROL OF INDUCTIVE LOADS—Provides symmetrical firing for hysteresis-free operation of inductive loads. Choice of triac depends on load. For 220 V, change R1 to 500K, R2 and R3 to 22K, D1-D4 to A14D, and use 400-V triac.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 8.


CR4
CR5
CR6
FOR
INDUCTIVE
LOAD
CR3
CR1
117 VOLT
3 PHASE
AC SUPPLY
60 CPS
ADJUST FOR COMPENSATION
OF LINE VOLTAGE
FLUCTUATIONS
ADJUST FOR
Q3 TO FIRE
AT∝ = 120°
LOAD
R7
R8
R5
SCR1
SCR2
SCR3
CR2
VOLTAGE
CONTROL
R2
R1
R6
R3
C2
Q3
Q1
Q2
R10
R11
R12
C1
R9
R4

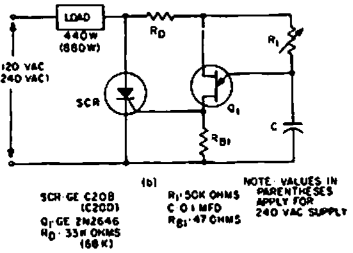
THREE-PHASE WITH COMMON TRIGGER—Operates from three-phase 117-V a-c line and provides control of d-c output voltage from zero to practically 100% of maximum theoretical value. Effect of transients is minimized. Firing circuit cannot fall out of synchronism with a-c power system. When d-c voltage is raised from zero, it jumps abruptly to 25% and then rises steplessly above that value; this is not objectionable for such applications as lamp and heater control. Similarly, when control voltage is reduced below 25%, output jumps abruptly to zero.—J. D. Atherly, F. W. Gutzwiller, and F. Pastore, Three Phase SCR Firing Circuits for DC Power Supplies, General Electric, Syracuse, N.Y., No. 200.21, 1962.

CR$_1$ - (3) GE 1N1695
CR$_2$ - 20 VOLT, 1 WATT ZENER DIODE, 1N1527
CR$_3$, CR$_4$, CR$_5$, CR$_6$, - AS REQUIRED FOR LOAD (GE 1N2156)
SCR$_1$, SCR$_2$, SCR$_3$ - AS REQUIRED FOR LOAD (GE C35B)
Q$_1$, Q$_3$, - GE 2N1671A Q$_2$ - GE 2N635
R$_1$ - 10K POT
R$_2$ - 20K POT
R$_3$ - 470 OHMS

R$_4$ - 100 OHMS
R$_5$, R$_6$ - 390 OHMS
R$_7$, - 3.3K, 2W
R$_8$ - 500 OHM POT, 2W
R$_9$ - 100 OHMS
R$_{10}$, R$_{11}$, R$_{12}$ - 25 OHMS
C$_1$ - 0.5 MFD
C$_2$ - 1.0 MFD

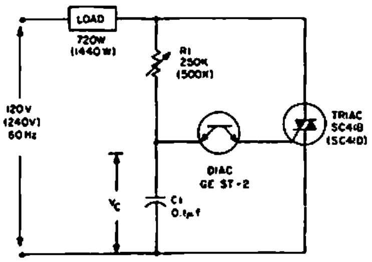

LOAD
15K
D1
GE 1N1693
D2
15K
120 VAC
GE 1N1692
D3
SCR1
C
5.0MFD
INDEPENDENT TRIGGER CIRCUIT
SCR2
SLAVE
MASTER

FULL-WAVE SLAVE CONTROL—Half-wave SCR2 circuit is triggered externally on one half-cycle at predetermined phase angle. On next half-cycle, slave circuit triggers SCR1 at same phase angle, to give full-wave phase control of load current. Both scr's are C11/C20.—"SCR Manual," 4th Edition, General Electric, 1967, p 69.


LOAD
440W
(880W)
R_D
R_1
120 VAC
(240 VAC)
SCR
Q_1
C
R_{B1}
(b)
SCR·GE C20B
(C20D)
Q_1·GE 2N2646
R_D· 33K OHMS
(68 K)
R_1·50K OHMS
C·0.1 MFD
R_{B1}·47 OHMS

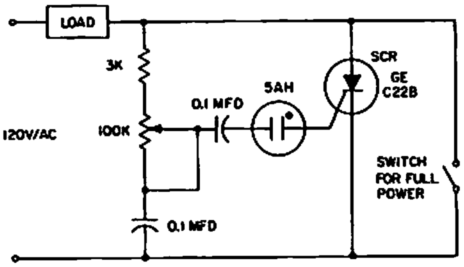
NOTE: VALUES IN PARENTHESES APPLY FOR 240 VAC SUPPLY

HALF-WAVE WITH UJT CAPACITOR RESET—Uses basic ujt relaxation oscillator to trigger scr during positive half-cycles of a-c line. Capacitor is reset at end of each positive half-cycle, by discharging through ujt, to prevent cycle-skipping caused by residual charge on half-cycles when scr is not triggered.—"SCR Manual," 4th Edition, General Electric, 1967, p 185–186.

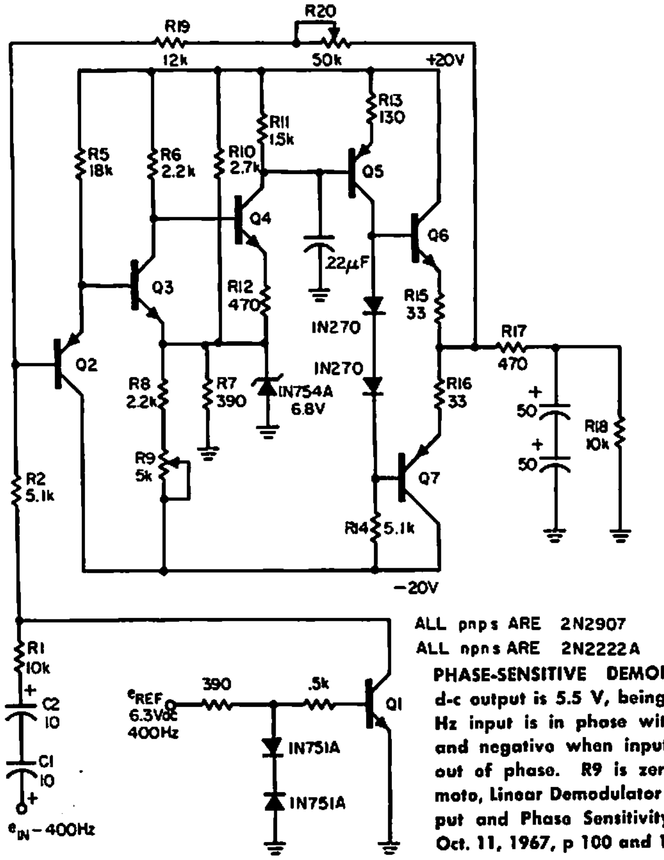

LOAD
720W
(1440W)
R1
250K
(500K)
120V
(240V)
60Hz
TRIAC
SC41B
(SC41D)
DIAC
GE ST-2
V_C
C1
0.1μf

NOTE:
VALUES IN PARENTHESES ARE FOR 240VAC SUPPLY.

DIAC-TRIAC FULL-WAVE—Circuit is simplest full-wave phase control. R1 determines load current. Chief drawback is snap-on effect, wherein load current jumps suddenly to value from which it is smoothly controlled.—"SCR Manual," 4th Edition, General Electric, 1967, p 187–188.

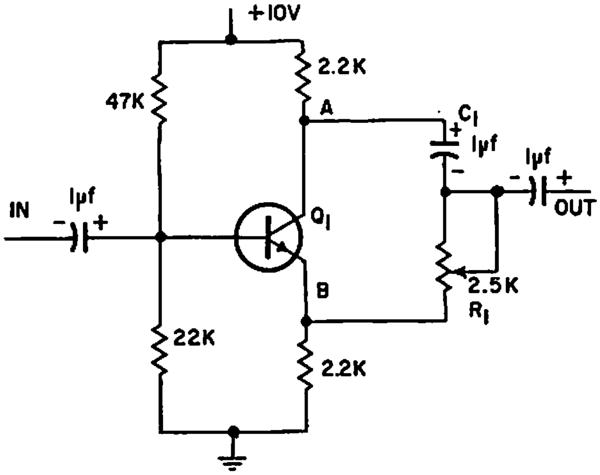

LOAD
3K
100K
120V/AC
0.1 MFD
5AH
SCR
GE
C22B
SWITCH FOR FULL POWER
0.1 MFD

HALF-WAVE NEON-SCR TRIGGER—Combines low cost of R-C diode phase control circuit with improved performance of 5AH neon that triggers when voltage across capacitors reaches breakdown level of neon. Control range is from full off to 95% of half-wave rms output voltage.—"SCR Manual," 4th Edition, General Electric, 1967, p 198–199.

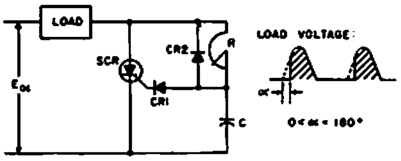

R19
12k
R20
50k
+20V
R5
18k
R6
2.2k
R10
2.7k
R11
1.5k
R13
130
Q5
Q4
Q6
22μF
Q3
R12
470
R15
33
1N270
1N270
R17
470
Q2
R8
2.2k
R7
390
1N754A
6.8V
R16
33
50
50
R18
10k
R9
5k
R2
5.1k
Q7
R14
5.1k
-20V
R1
10k
C2
10
C1
10
e_{REF}
6.3Vac
400Hz
390
.5k
Q1
1N751A
1N751A
e_{IN}-400Hz

ALL pnps ARE 2N2907
ALL npns ARE 2N2222A

PHASE-SENSITIVE DEMODULATOR—Maximum d-c output is 5.5 V, being positive when 400-Hz input is in phase with 400-Hz reference, and negative when input and reference are out of phase. R9 is zero adjust.—N. Nekomoto, Linear Demodulator Combines High Output and Phase Sensitivity, *Electronic Design*, Oct. 11, 1967, p 100 and 102.

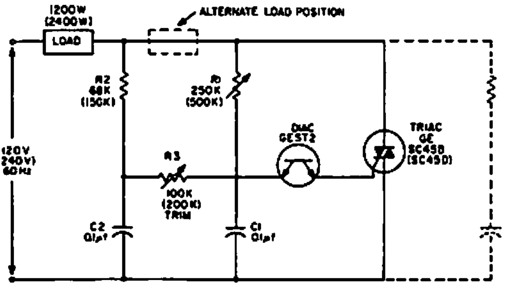

+10V
47K
2.2K
A
C_1
1μf
1μf
IN
1μf
Q_1
OUT
B
2.5K
R_1
22K
2.2K

170-DEG PHASE SHIFTER—Used in servos and other phase-sensitive systems to buck out residual phase shift. Transistor acts only as phase splitter, to provide complementary outputs from which desired value can be obtained by adjusting R1. Operates from 600 to 4,000 Hz, using 2N1306 transistor.—Transistorized Phase Shifter, "Electronic Circuit Design Handbook," Tab Books, Blue Ridge Summit, Pa., p 20.

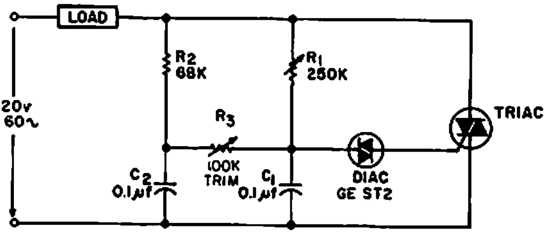

LOAD
LOAD VOLTAGE:
CR2
R
SCR
E_{ac}
CR1
C
α
0 < α < 180°

TYPICAL CIRCUIT VALUES FOR E_{ac} = 120 V
SCR: GE C11 (2N1770 SERIES)
R = 40K OHMS
C = .25 MFD
SCR: GE C11/C20 TYPES
R = 10 K OHMS
C = 1.0 MFD
CR1: GE 1N1693
CR2: GE 1N1692

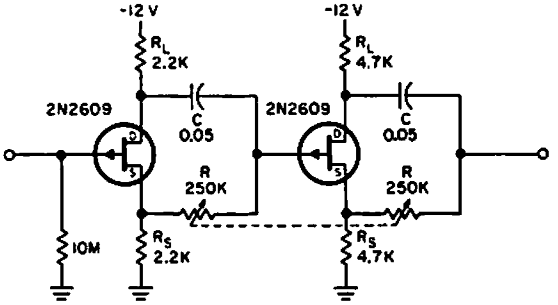
HALF-WAVE SCR—Gives full 180-degree phase control of half-wave load current.—"SCR Manual," 4th Edition, General Electric, 1967, p 69.


1200W
(2400W)
LOAD
ALTERNATE LOAD POSITION
R2
68K
(150K)
R1
250K
(500K)
120V
(240V)
60Hz
R3
100K
(200K)
TRIM
DIAC
GEST2
TRIAC
GE
SC45B
(SC45D)
C2
0.1μf
C1
0.1μf
dv/dt SUPPRESSOR
AS REQUIRED

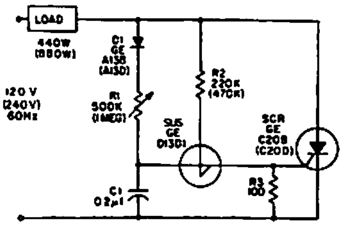
EXTENDED-RANGE FULL-WAVE—Has very little snap-on effect. C2 recharges C1 after triggering. R3 is adjusted to compensate for use of wide-tolerance components. Values in parentheses are for 240-V a-c line.—"SCR Manual," 4th Edition, General Electric, 1967, p 189.


LOAD
R2
68K
R1
250K
120v
60∿
R3
100K
TRIM
C2
0.1μf
C1
0.1μf
DIAC
GE ST2
TRIAC

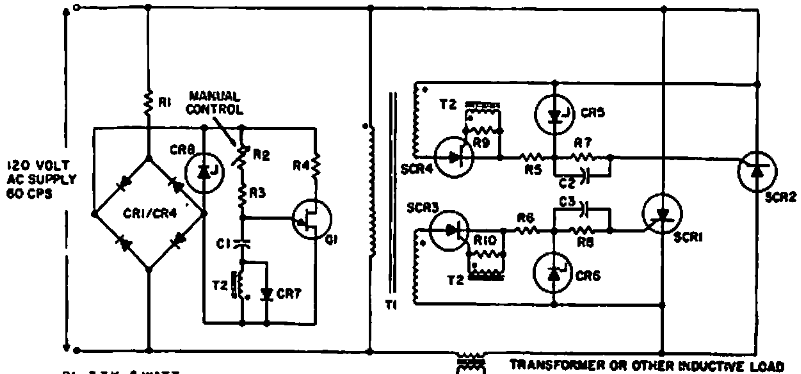
FULL-WAVE TRIAC CONTROL—Provides smooth phase-shift control with R1 over range of from 5 to 95% of full load power, although subject somewhat to line voltage variations. R3 is adjusted so triac just drops out of conduction when R1 is brought to maximum resistance (minimum load power). Circuit has some hysteresis. Choice of triac depends on load. For 220 V, change R1 to 500K, R2 to 120K, and R3 to 200K.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 8.


-12 V
R_L
2.2K
2N2609
C
0.05
R
250K
10M
R_S
2.2K
-12 V
R_L
4.7K
2N2609
C
0.05
R
250K
R_S
4.7K

360-DEG FET SHIFTER—Each stage provides adjustable shift of 0 to 180 deg, depending on setting of ganged controls R.—"FET Circuit Ideas," Siliconix, Sunnyvale, Cal., 1966.


LOAD
440W
(880W)
120 V
(240V)
60Hz
D1
GE
A13B
(A13D)
R1
500K
(1MEG)
R2
220K
(470K)
SUS
GE
D13D1
SCR
GE
C20B
(C20D)
C1
0.2μf
R3
100

HALF-WAVE WITH SUS CAPACITOR RESET—Uses basic silicon unilateral switch (sus) relaxation oscillator to trigger scr at controlled triggering angle during positive half-cycles of a-c line. If switching voltage is not reached during one positive half-cycle, sus trigger does not switch and high residual voltage is left on C1, causing cycle-skipping. This is avoided by forcing sus to switch at end of each positive half-cycle with R2 current when line voltage goes negative. Values in parentheses are for 240 V a-c.—"SCR Manual," 4th Edition, General Electric, 1967, p 185–186.


120 VOLT
AC SUPPLY
60 CPS
R1
MANUAL
CONTROL
CR8
R2
R3
R4
CR1/CR4
C1
Q1
T2
CR7
T1
T2
CR5
R9
R7
SCR4
R5
C2
SCR3
R6
C3
R10
R8
T2
CR6
SCR1
SCR2
TRANSFORMER OR OTHER INDUCTIVE LOAD
TO LOAD

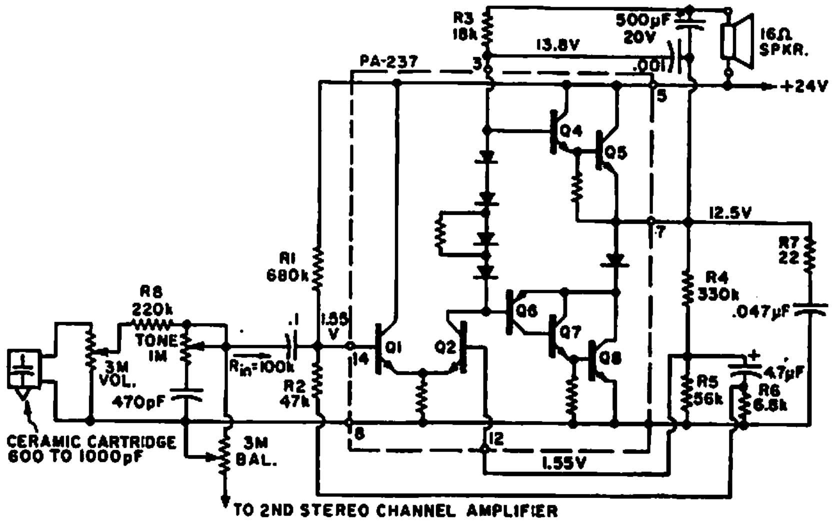
R1 - 3.3K, 5 WATT
R2 - 250K, 2 WATT
R3 - 3.3K, 1 WATT
R4 - 330, 1/2 WATT
R5, R6 - 22Ω, 2 WATT
R7, R8 - 33Ω, 2 WATT
R9, R10 - 47Ω, 1/2 WATT
C1, C2, C3 - 0.1 MFD
Q1 - GE 2N2646
SCR1, SCR2 — CONTROLLED RECTIFIERS, AS REQUIRED
SCR3, SCR4 - GE 2N1595

CR1 TO CR4 - GE 1N1693
CR5, CR6 - GE 1N1765
CR7 - GE 1N1692
CR8 - GE 1N1776
T1 - ISOLATION TRANSFORMER 120/12.6/12.6 VAC; PRIMARY VOLTAGE DEPENDS ON LINE VOLTAGE (UTC FT-10 FOR 120V.)
T2 - PULSE TRANSFORMER PE 2229, UTC H51 OR SPRAGUE 93Z20 EQUIVALENT

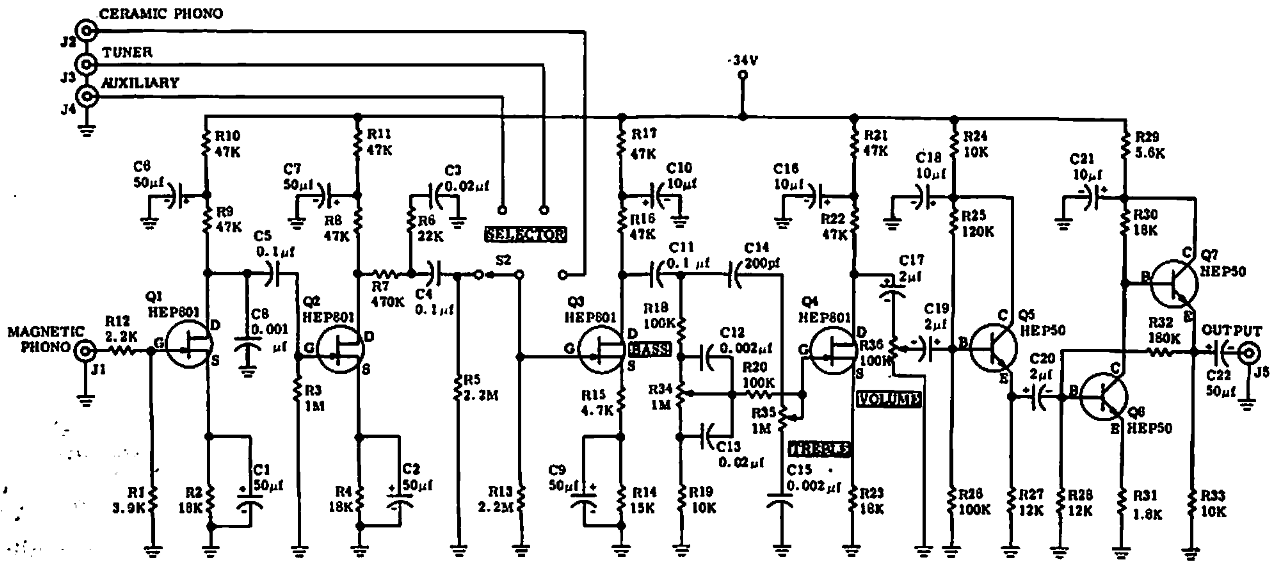
TRIGGER FOR INDUCTIVE LOADS—Designed for phase-controlled scr's feeding inductive a-c load. Obtains synchronization from a-c supply voltage rather than from scr voltage. Trigger signal is continuous for most of desired conduction period. Ujt Q1 is connected across a-c line by bridge rectifier, for triggering on both halves of a-c cycle.—"SCR Manual," 4th Edition, General Electric, 1967, p 196–197.

CHAPTER 61

Phonograph Circuits

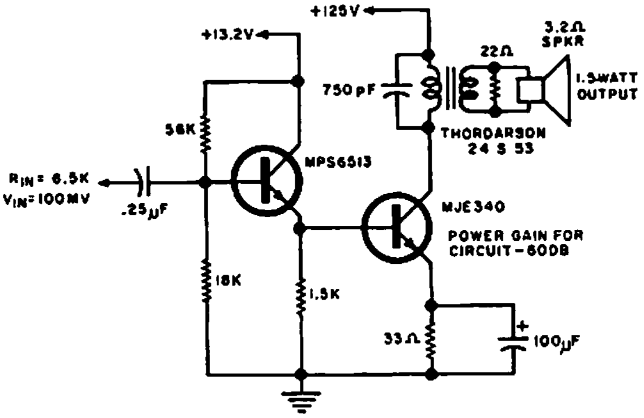

R3
18k
500μF
20V
16Ω
SPKR.
13.8V
PA-237
3
.001
5
+24V
Q4
Q5
12.5V
7
R7
22
R1
680k
R4
330k
.047μF
R8
220k
TONE
1M
.1
1.55
V
14
Q1
Q2
Q6
Q7
Q8
3M
VOL.
R_{in}=100k
R2
47k
470pF
R5
56k
4.7μF
R6
6.8k
CERAMIC CARTRIDGE
600 TO 1000pF
8
12
3M
BAL.
1.55V
TO 2ND STEREO CHANNEL AMPLIFIER

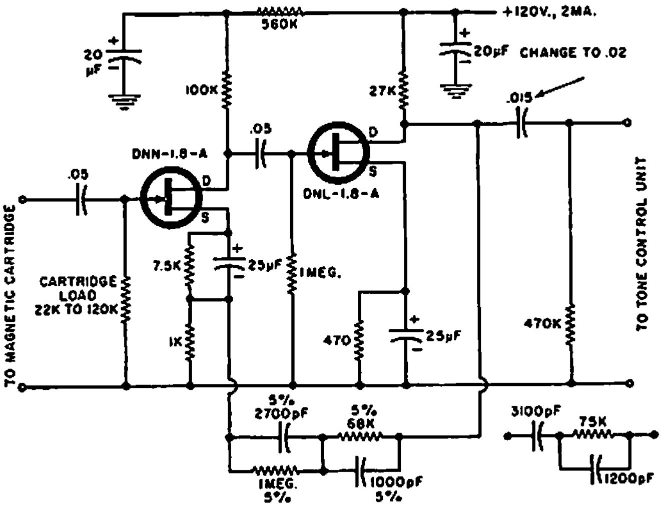
4-W IC PHONO AMPLIFIER—Bootstrapping of R2 to increase input impedance is possible because input and output of G-E integrated circuit are in phase. Article analyzes circuit performance at different volume control settings.—D. V. Jones, Audio-Frequency Integrated Circuits, *Electronics World*, July 1968, p 54–56.


CERAMIC PHONO
J2
TUNER
J3
AUXILIARY
J4
-34V
R10
47K
R11
47K
R17
47K
R21
47K
R24
10K
R29
5.6K
C6
50μf
C7
50μf
C3
0.02μf
C10
10μf
C16
10μf
C18
10μf
C21
10μf
R9
47K
R8
47K
R6
22K
SELECTOR
R16
47K
R22
47K
R25
120K
R30
18K
C5
0.1μf
R7
470K
C4
0.1μf
S2
C11
0.1 μf
C14
200pf
C17
2μf
Q7
HEP50
Q1
HEP801
Q2
HEP801
Q3
HEP801
R18
100K
Q4
HEP801
C19
2μf
Q5
HEP50
R32
180K
OUTPUT
MAGNETIC
PHONO
J1
R12
2.2K
G
D
S
C8
0.001
μf
BASS
C12
0.002μf
R20
100K
R36
100K
VOLUME
C20
2μf
C22
50μf
J5
R3
1M
R5
2.2M
R15
4.7K
R34
1M
R35
1M
TREBLE
C13
0.02μf
Q8
HEP50
C
B
E
C1
50μf
C2
50μf
C9
50μf
C15
0.002μf
R1
3.9K
R2
18K
R4
18K
R13
2.2M
R14
15K
R19
10K
R23
18K
R26
100K
R27
12K
R28
12K
R31
1.8K
R33
10K

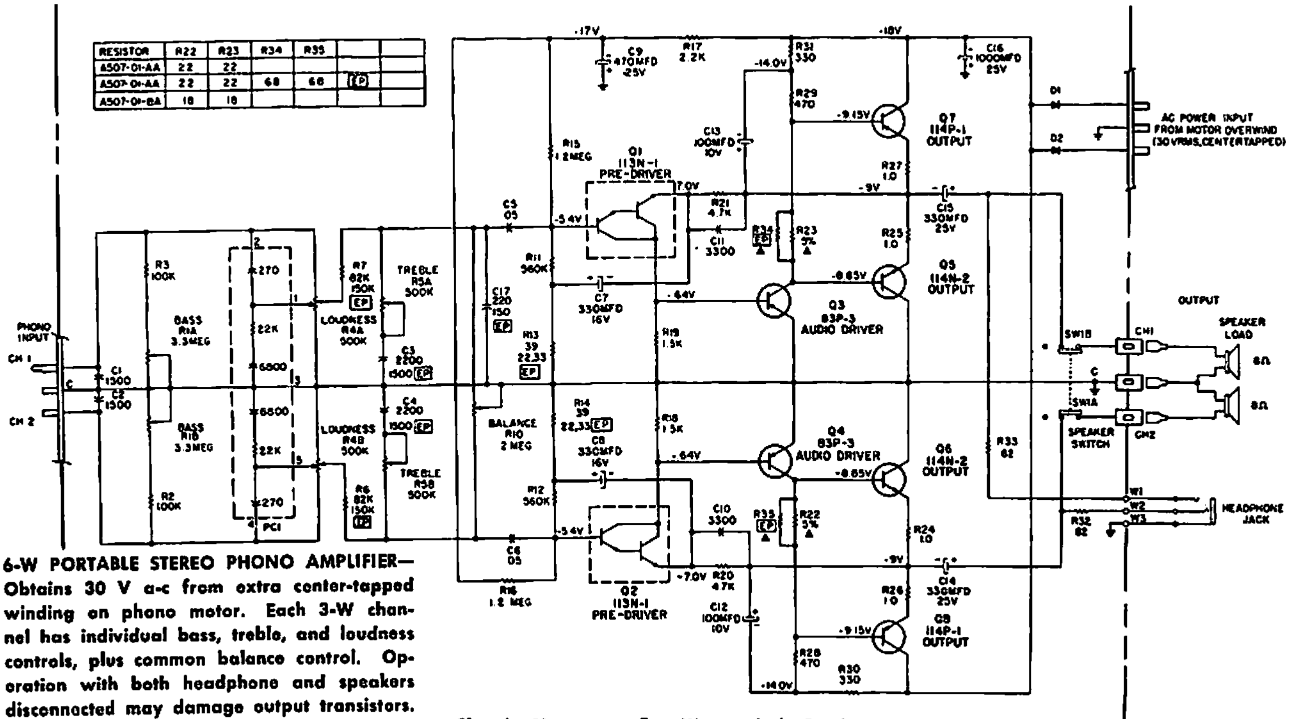
FET MONO AUDIO—Serves as complete control center for high- and low-impedance audio sources, including tone controls and necessary equalization for each source. Article gives construction details, including circuit of 34-V power supply using 117/25 V Stancor P6469 transformer, HEP177 full-wave bridge rectifier, and single 2,000-μF filter capacitor.—"Field Effect Transistor Projects," Motorola, Phoenix, Ariz., 1966, p 57–74.

1.5-W LINE-OPERATED AMPLIFIER—Output stage is powered directly from rectified a-c line, while driver transistor gets its voltage from extra winding on phonograph motor after rectification.—D. E. Lancaster, Plastic Power Transistors—Advantages and Applications, *Electronics World*, Feb. 1968, p 50–52.


+125V
+13.2V
3.2Ω SPKR
22Ω
1.5WATT OUTPUT
750 pF
THORDARSON 24 S 53
56K
MPS6513
R_IN = 6.5K
V_IN = 100MV
.25μF
MJE340
POWER GAIN FOR CIRCUIT-60DB
18K
1.5K
33Ω
100μF


+120V., 2MA.
560K
20 μF
20μF CHANGE TO .02
100K
27K
.015
.05
D
DNN-1.8-A
.05
D
S
S
DNL-1.8-A
TO MAGNETIC CARTRIDGE
TO TONE CONTROL UNIT
CARTRIDGE LOAD 22K TO 120K
7.5K
25μF
1MEG.
470
25μF
470K
1K
5% 2700pF
5% 68K
3100pF
75K
1MEG. 5%
1000pF 5%
1200pF

FET PHONO EQUALIZER-PREAMP—High-quality performance is obtained with this voltage amplifier design, which provides proper biasing for field-effect transistors. Feedback network at bottom center gives exact RIAA equalization. Alternative network at lower right (with 0.015 capacitor changed to 0.02) is preferable for organ music having pronounced low frequencies. Gain is 40 dB, and overload-to-noise ratio is 104 dB. Noise level is 7 dB lower than best tube circuit, overload level is 5 dB higher, and dynamic range is much greater than with conventional transistors.—W. A. Rheinfelder, Phono Equalizer Uses FET's, *Electronics World*, April 1966, p 32–33 and 93.

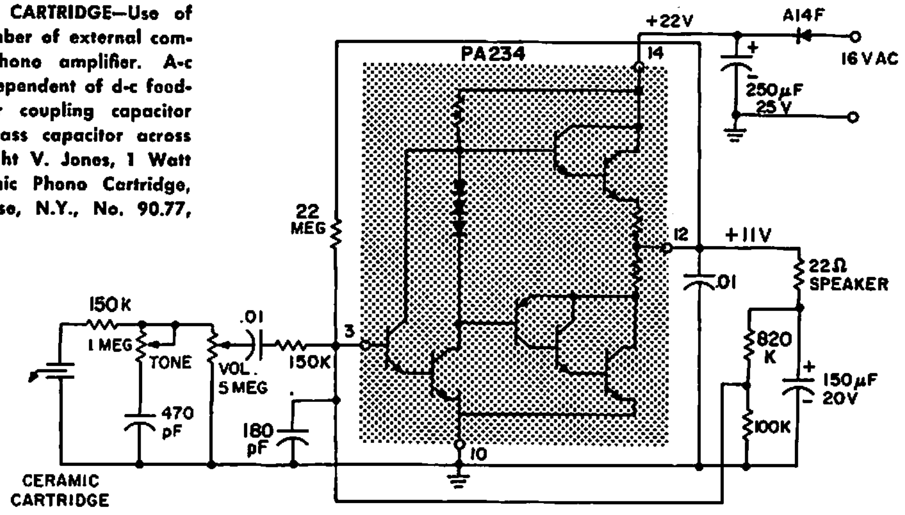


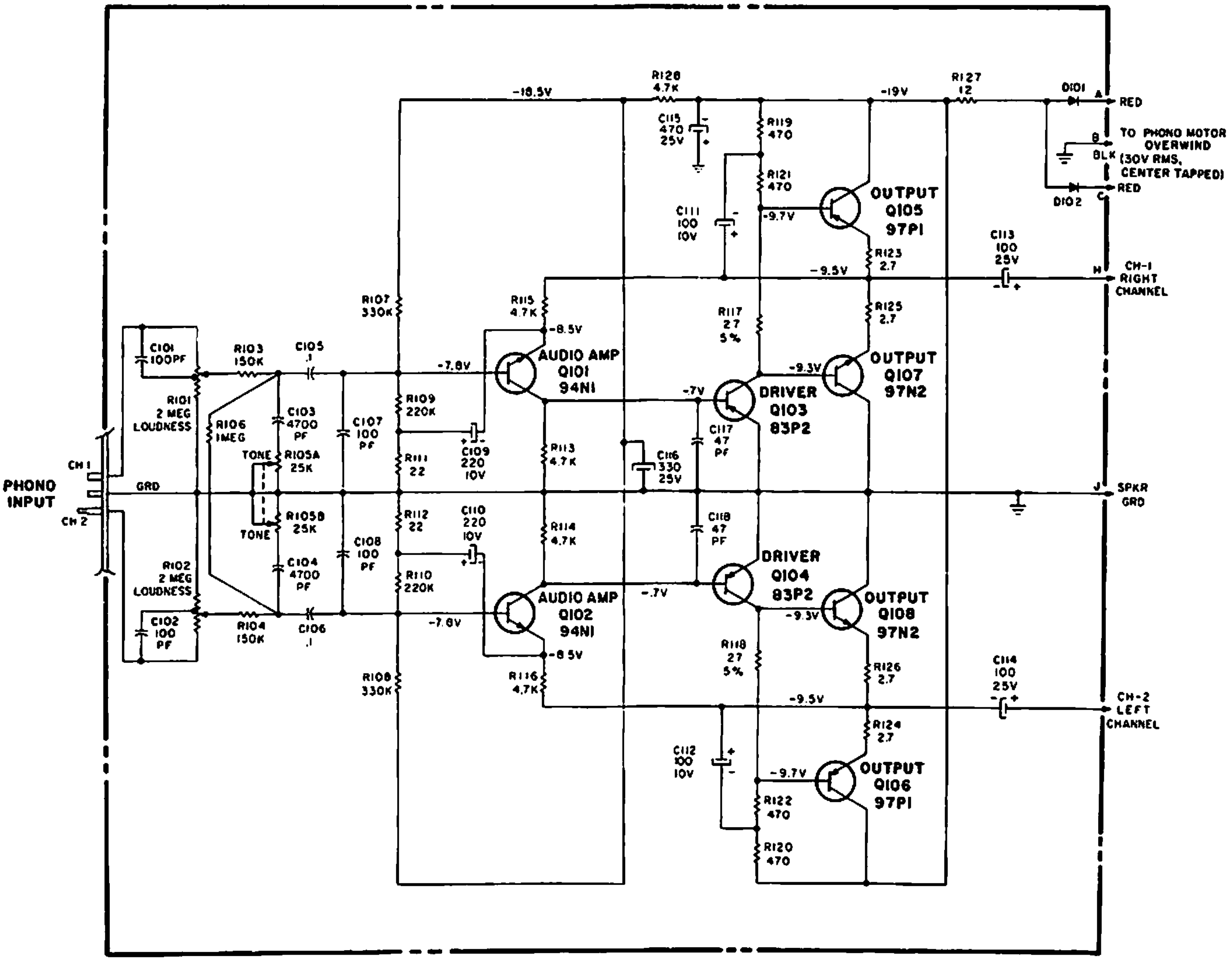
RESISTOR	R22	R23	R34	R35		
A507-01-AA	22	22				
A507-01-AA	22	22	68	68	EP	
A507-01-BA	18	18				

PHONO INPUT
CH 1
C
CH 2
C1 1300
C2 1300
R3 100K
BASS R1A 3.3MEG
BASS R1B 3.3MEG
R2 100K
2
270
1
22K
6800
3
6800
22K
5
270
4
PC1
R7 82K 150K EP
LOUDNESS R4A 500K
TREBLE R5A 500K
C3 2200 1500 EP
C4 2200 1500 EP
LOUDNESS R4B 500K
TREBLE R5B 500K
R6 82K 150K EP
-17V
C9 470MFD 25V
R17 2.2K
-14.0V
R31 330
-18V
C16 1000MFD 25V
R29 470
R15 1.2MEG
Q1 113N-1 PRE-DRIVER
C13 100MFD 10V
-9.15V
Q7 114P-1 OUTPUT
D1
D2
AC POWER INPUT FROM MOTOR OVERWIND (30VRMS,CENTERTAPPED)
R27 1.0
C5 .05
-5.4V
7.0V
R21 4.7K
-9V
C15 330MFD 25V
C11 3300
R34 EP
R23 5%
R25 1.0
R11 560K
-8.65V
Q5 114N-2 OUTPUT
C17 220 150 EP
C7 330MFD 16V
-.64V
Q3 83P-3 AUDIO DRIVER
R19 1.5K
R13 39 22.33 EP
OUTPUT
SPEAKER LOAD
SW1B
CH1
8Ω
C
8Ω
SW1A
SPEAKER SWITCH
CH2
BALANCE R10 2 MEG
R14 39 22.33 EP
C8 330MFD 16V
R18 1.5K
-.64V
Q4 83P-3 AUDIO DRIVER
-8.65V
Q6 114N-2 OUTPUT
R33 62
R12 560K
C10 3300
R35 EP
R22 5%
W1
W2
W3
HEADPHONE JACK
R32 62
-5.4V
R24 1.0
-9V
C6 .05
-7.0V
R20 4.7K
C14 330MFD 25V
R16 1.2 MEG
Q2 113N-1 PRE-DRIVER
C12 100MFD 10V
R26 1.0
-9.15V
Q8 114P-1 OUTPUT
R28 470
R30 330
-14.0V

6-W PORTABLE STEREO PHONO AMPLIFIER—Obtains 30 V a-c from extra center-tapped winding on phono motor. Each 3-W channel has individual bass, treble, and loudness controls, plus common balance control. Operation with both headphone and speakers disconnected may damage output transistors. Capacitance values above 1 are pF unless otherwise indicated.—A507 Series Amplifier Chassis, Magnavox, Fort Wayne, Ind., Service Manual 4340, 1969.

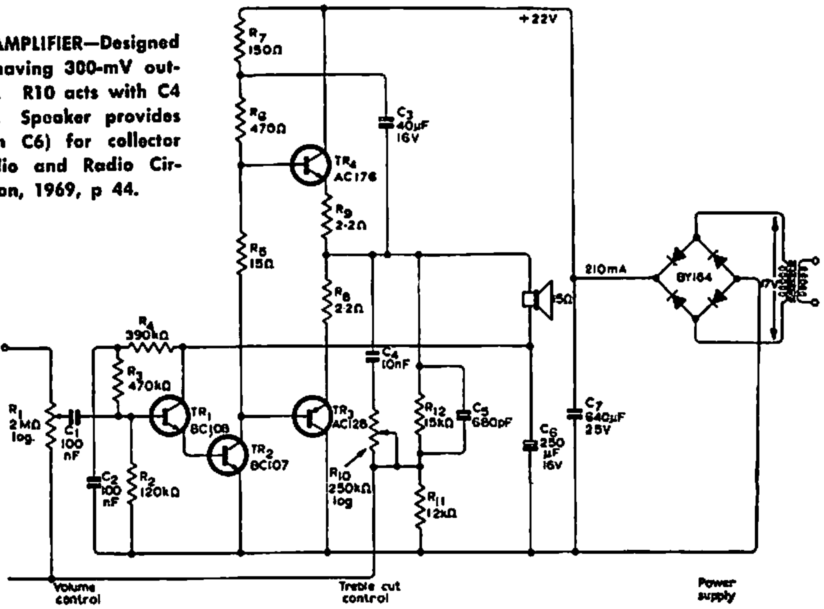
1-W IC FOR CERAMIC CARTRIDGE—Use of PA234 IC minimizes number of external components needed for phono amplifier. A-c feedback network is independent of d-c feedback network. Speaker coupling capacitor serves also as a-c bypass capacitor across d-c bias resistors.—Dwight V. Jones, 1 Watt IC Amplifier for Ceramic Phono Cartridge, General Electric, Syracuse, N.Y., No. 90.77, 1969.

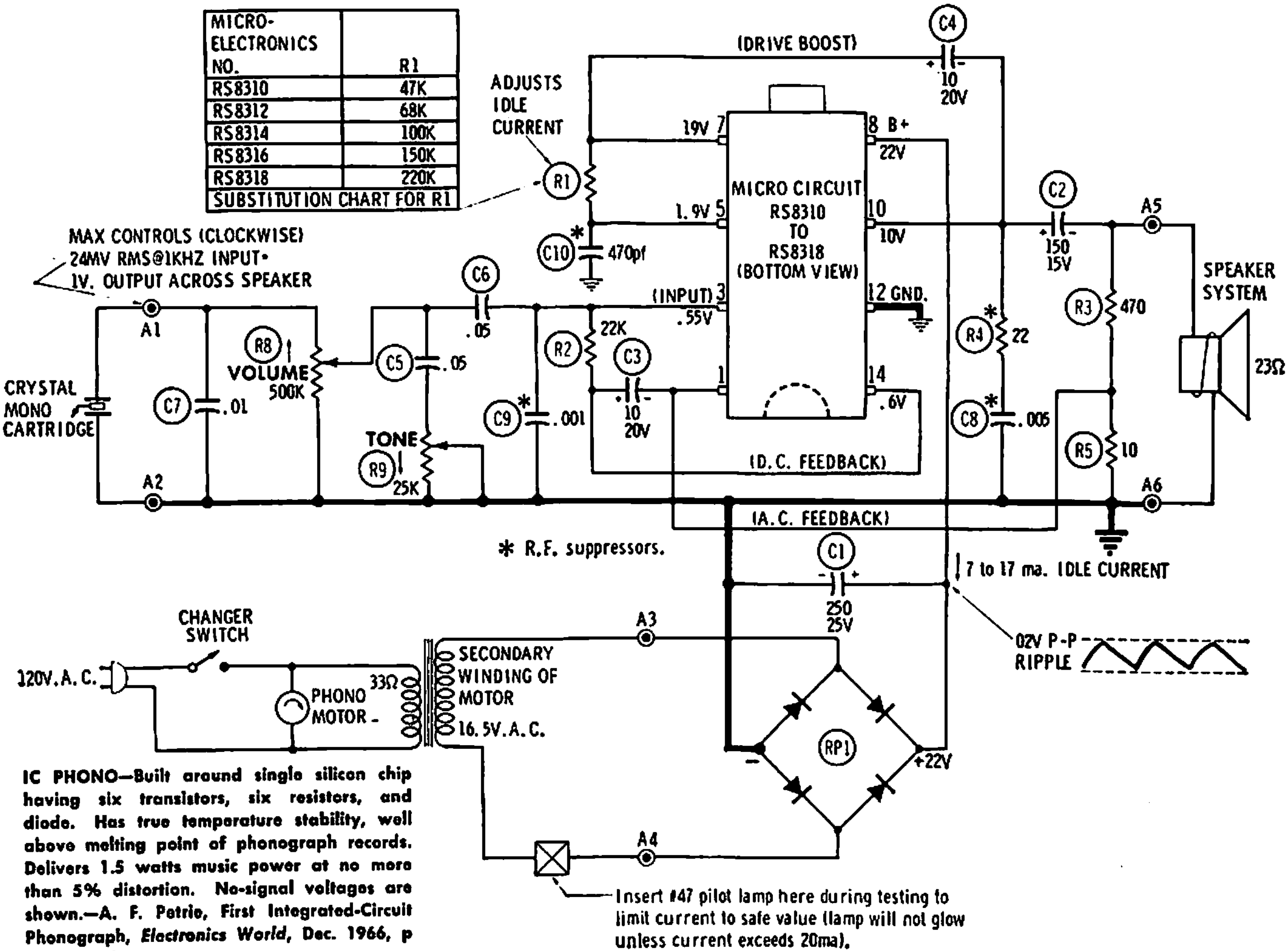

+22V
A14F
PA234
14
16VAC
250μF
25V
22
MEG
12
+11V
.01
22Ω
SPEAKER
150K
1 MEG
TONE
.01
VOL.
5MEG
150K
3
820
K
150μF
20V
470
pF
180
pF
100K
10
CERAMIC
CARTRIDGE


R128
4.7K
-18.5V
-19V
R127
12
D101
A
RED
C115
470
25V
R119
470
B
TO PHONO MOTOR
OVERWIND
BLK
(30V RMS,
CENTER TAPPED)
D102
C
RED
R121
470
C111
100
10V
-9.7V
OUTPUT
Q105
97P1
C113
100
25V
R123
2.7
-9.5V
H
CH-1
RIGHT
CHANNEL
R107
330K
R115
4.7K
-8.5V
R125
2.7
R117
27
5%
C101
100PF
R103
150K
C105
.1
-7.8V
AUDIO AMP
Q101
94N1
-9.3V
OUTPUT
Q107
97N2
-7V
DRIVER
Q103
83P2
R101
2 MEG
LOUDNESS
R106
1MEG
C103
4700
PF
C107
100
PF
R109
220K
C109
220
10V
C117
47
PF
TONE
R105A
25K
R111
22
R113
4.7K
C116
330
25V
CH 1
PHONO
INPUT
GRD
J
SPKR
GRD
CH 2
TONE
R105B
25K
R112
22
C110
220
10V
C118
47
PF
R114
4.7K
C108
100
PF
DRIVER
Q104
83P2
R102
2 MEG
LOUDNESS
C104
4700
PF
R110
220K
AUDIO AMP
Q102
94N1
-7V
-9.3V
OUTPUT
Q108
97N2
C102
100
PF
R104
150K
C106
.1
-7.8V
-8.5V
R118
27
5%
R108
330K
R116
4.7K
R126
2.7
C114
100
25V
-9.5V
CH-2
LEFT
CHANNEL
R124
2.7
C112
100
10V
-9.7V
OUTPUT
Q106
97P1
R122
470
R120
470

3 W WITH EIGHT TRANSISTORS—Provides 1.5 W per channel of music power output, for use in portable stereo phonograph having extra winding on motor for supplying 30 V a-c to rectifiers for amplifier. Complementary-symmetry output stage drives speaker directly for each channel. Transistors have special Magnavox type numbers.—A509 Series Amplifier Chassis, Magnavox, Fort Wayne, Ind., Service Manual 4341, 1970.

3-W RECORD-PLAYER AMPLIFIER—Designed for use with cartridges having 300-mV output, such as crystal units. R10 acts with C4 as simple treble control. Speaker provides low-voltage supply (with C6) for collector of TR1.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 44.


+22V
R7 150Ω
R9 470Ω
C3 40μF 16V
TR4 AC176
R9 2·2Ω
R5 15Ω
R6 2·2Ω
15Ω
210mA
BY164
17V
R4 390kΩ
R3 470kΩ
R1 2MΩ log.
C1 100 nF
TR1 BC108
TR2 BC107
TR3 AC128
C4 10nF
R12 15kΩ
C5 680pF
C6 250 μF 16V
C7 640μF 25V
C2 100 nF
R2 120kΩ
R10 250kΩ log
R11 12kΩ
Volume control
Treble cut control
Power supply



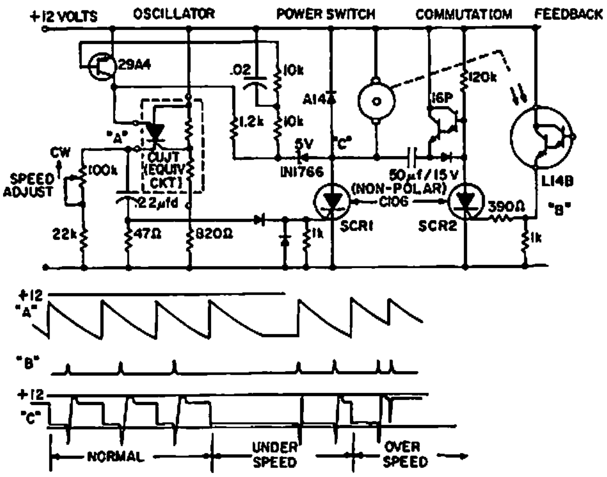
MICRO-ELECTRONICS NO.	R1
RS8310	47K
RS8312	68K
RS8314	100K
RS8316	150K
RS8318	220K

SUBSTITUTION CHART FOR R1

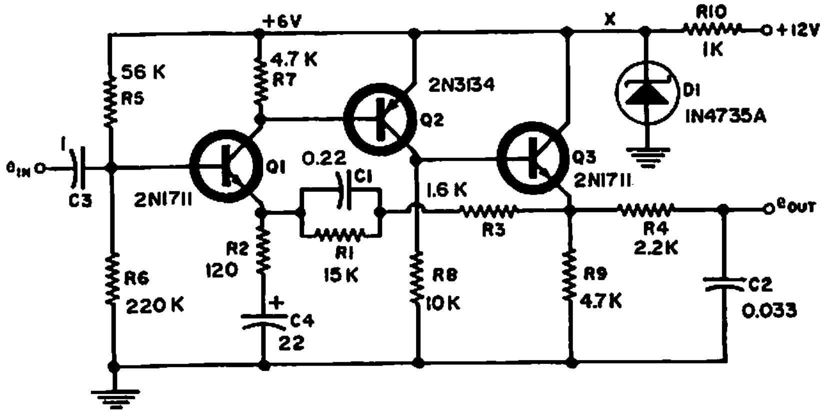
ADJUSTS IDLE CURRENT
(DRIVE BOOST)
C4 10 20V
19V 7
8 B+ 22V
MICRO CIRCUIT RS8310 TO RS8318 (BOTTOM VIEW)
R1
1.9V 5
10 10V
C10 470pf
C2 150 15V
A5
SPEAKER SYSTEM
MAX CONTROLS (CLOCKWISE) 24MV RMS@1KHZ INPUT• 1V. OUTPUT ACROSS SPEAKER
C6 .05
(INPUT) 3 .55V
12 GND.
R3 470
A1
R8 VOLUME 500K
C5 .05
R2 22K
C3 10 20V
1
14 .6V
R4 22
23Ω
CRYSTAL MONO CARTRIDGE
C7 .01
C9 .001
C8 .005
R5 10
TONE R9 25K
(D.C. FEEDBACK)
A2
A6
(A.C. FEEDBACK)
* R.F. suppressors.
C1 250 25V
7 to 17 ma. IDLE CURRENT
.02V P-P RIPPLE
CHANGER SWITCH
120V.A.C.
PHONO MOTOR
33Ω
SECONDARY WINDING OF MOTOR 16.5V.A.C.
A3
RP1
+22V
A4

Insert #47 pilot lamp here during testing to limit current to safe value (lamp will not glow unless current exceeds 20ma).

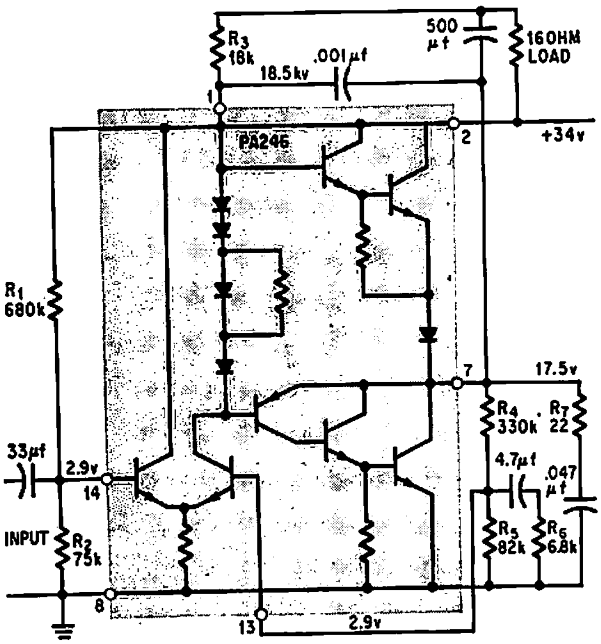
IC PHONO—Built around single silicon chip having six transistors, six resistors, and diode. Has true temperature stability, well above melting point of phonograph records. Delivers 1.5 watts music power at no more than 5% distortion. No-signal voltages are shown.—A. F. Petrie, First Integrated-Circuit Phonograph, *Electronics World*, Dec. 1966, p 28–29 and 70.


+12 VOLTS
OSCILLATOR
POWER SWITCH
COMMUTATION
FEEDBACK
29A4
.02
10k
1.2k
10k
A14
16P
120k
"A"
CW
SPEED ADJUST
100k
UJT (EQUIV CKT)
22μfd
5V
"C"
1N1766
50μf/15V (NON-POLAR)
C106
SCR1
SCR2
390Ω
L14B
"B"
1k
22k
47Ω
820Ω
1k
+12
"A"
"B"
+12
"C"
NORMAL
UNDER SPEED
OVER SPEED

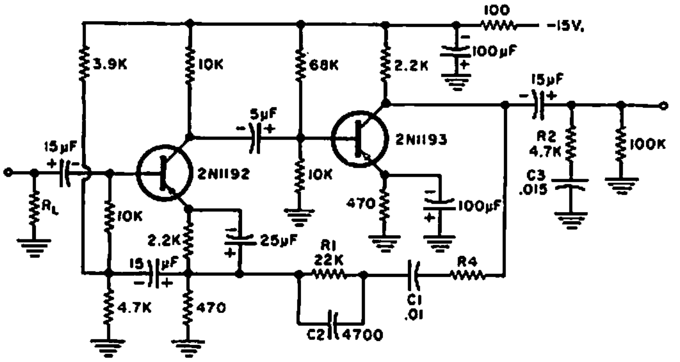
PHONO MOTOR SPEED CONTROL—Complementary ujt 3N81 (dashed box) is used in free-running relaxation oscillator to stabilize speed of d-c motor drive for portable phonographs and tape recorders. Light reflected off disc on motor is sensed by phototransistor L14B, turning SCR2 on and turning off SCR1. When 0.22-μF capacitor charges to peak point and fires, SCR1 comes on again and process repeats itself to make motor synchronous with oscillator. Article describes operation in detail.—W. R. Spofford, Jr., Complementary Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.72, 1968, p 15.


+6V
X
R10
1K
+12V
56 K
R5
4.7 K
R7
2N3134
Q2
D1
1N4735A
1
e_IN
C3
Q1
2N1711
0.22
C1
1.6 K
R3
Q3
2N1711
R4
2.2K
e_OUT
R2
120
R1
15 K
R6
220 K
R8
10 K
R9
4.7K
C2
0.033
+
C4
22

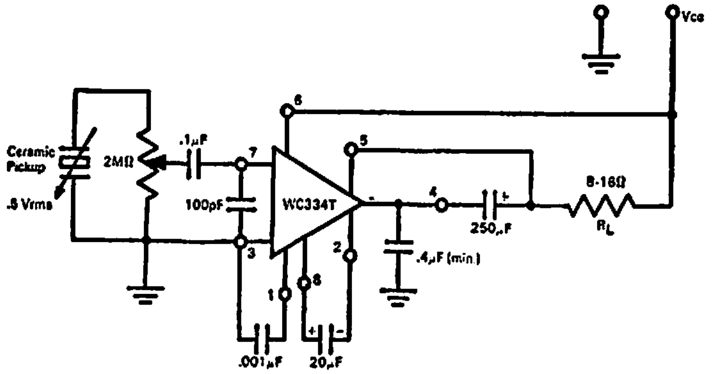
STEREO PHONO PREAMP—Has 50,000-ohm input impedance for magnetic cartridges and delivers up to 10 mV for audio power amplifier. Both channels are identical, each with its own RIAA feedback network. Article gives design procedure. If gain control is used between preamp and amplifier, it should be 25,000 to 100,000 ohms, without blocking capacitor.—J. G. Holbrook, The Engineer's Stereo Preamp, *Electronics World*, May 1968, p 44–45.


R3
16k
18.5kv
.001μf
500 μf
16OHM LOAD
1
PA246
2
+34v
R1
680k
7
17.5v
R4
330k
R7
22
33μf
2.9v
14
4.7μf
.047 μf
INPUT
R2
75k
R5
82k
R6
6.8k
8
13
2.9v

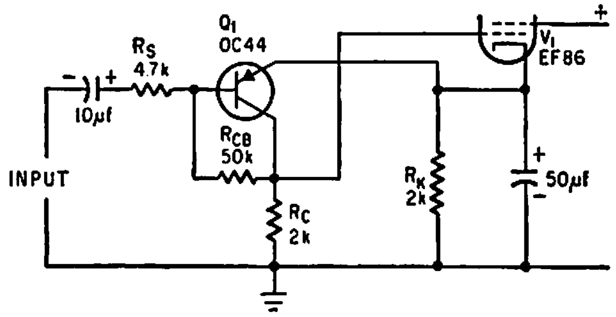
5-W AUDIO IC—Complete phonograph amplifier is obtained simply by adding resistors and capacitors to General Electric PA246 IC audio amplifier. Frequency response is 30 Hz to 100 kHz. Designed for 0.5-V signal from phono pickup and 16-ohm speaker load. Can also be used in radios and tape recorders. Requires 34-V supply.—IC Audio Amplifier Puts Out 5 Watts, *Electronics*, Nov. 25, 1968, p 111–112.


100
-15V.
100μF
3.9K
10K
68K
2.2K
15μF
5μF
2N1193
15μF
R2
4.7K
100K
2N1192
10K
C3
.015
470
100μF
RL
10K
2.2K
25μF
R1
22K
15μF
C1
.01
R4
4.7K
470
C2
4700

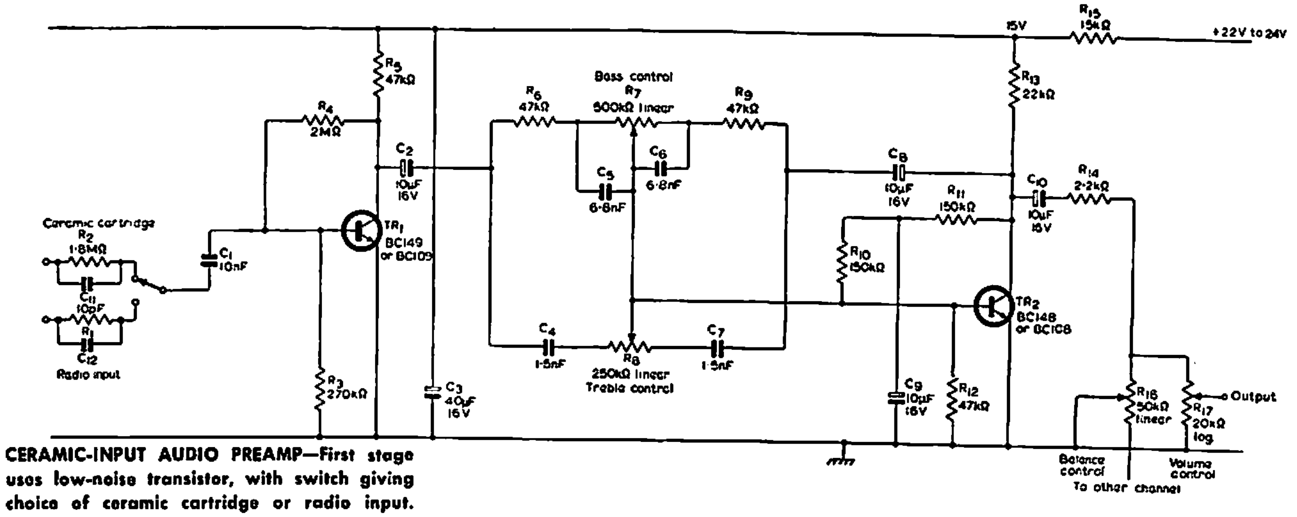
GERMANIUM-TRANSISTOR PHONO PREAMP—Feedback gives RIAA equalization and offsets inherent base-emitter nonlinearity, to give high fidelity along with required high input impedance and low output impedance. Gain is 40 dB. Current drain is 5 mA, and overload-to-noise ratio is 85 dB.—W. A. Rheinfelder, Phono Equalizer Uses FET's, *Electronics World*, April 1966, p 32–33 and 93.


Vcc
Ceramic Pickup
.5 Vrms
2MΩ
.1μF
100pF
7
6
5
WC334T
3
1
8
2
4
250μF
8-16Ω
RL
.4μF (min)
.001μF
20μF

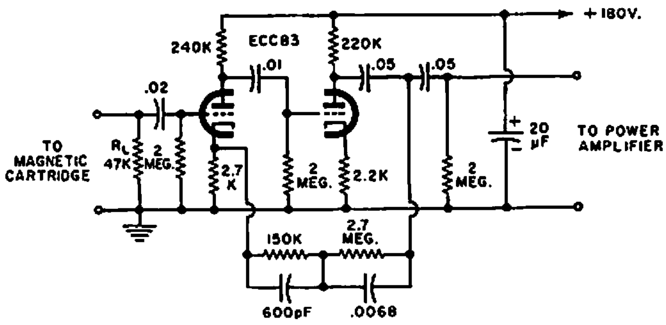
SINGLE-IC PHONO AMPLIFIER—Provides 25 dB gain for 0.5 V rms output of ceramic pickup and delivers 1 W to 8-ohm speaker at 5% harmonic distortion.—Westinghouse To Unveil IC Device, *Electronic News*, Aug. 21, 1967, p 84.


Q1
OC44
RS
4.7k
10μf
INPUT
RCB
50k
RC
2k
RK
2k
V1
EF86
50μf
+

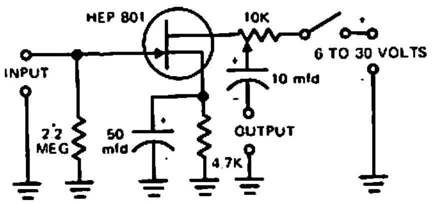
GAIN BOOSTER FOR MAGNETIC CARTRIDGE—Single transistor boosts gain of tube preamp for crystal cartridge by 10, to permit use of magnetic cartridge without adding step-up transformer or extra separately powered tube stage. Cathode bias of tube is supply voltage for transistor.—Y. L. Li, Cathode Voltage Boosts Amplifier Gain Tenfold, *Electronics*, May 15, 1967, p 95.


Ceramic cartridge
R2
1·8MΩ
C11
10pF
R1
C12
Radio input
C1
10nF
R4
2MΩ
R5
47kΩ
C2
10μF
16V
TR1
BC149
or BC109
R3
270kΩ
C3
40μF
16V
Bass control
R6
47kΩ
R7
500kΩ linear
R9
47kΩ
C5
6·8nF
C6
6·8nF
C4
1·5nF
R8
250kΩ linear
Treble control
C7
1·5nF
15V
R15
15kΩ
+22V to 24V
R13
22kΩ
C8
10μF
16V
R11
150kΩ
R10
150kΩ
C10
10μF
16V
R14
2·2kΩ
TR2
BC148
or BC108
C9
10μF
16V
R12
47kΩ
R16
50kΩ
linear
R17
20kΩ
log
Output
Balance control
Volume control
To other channel

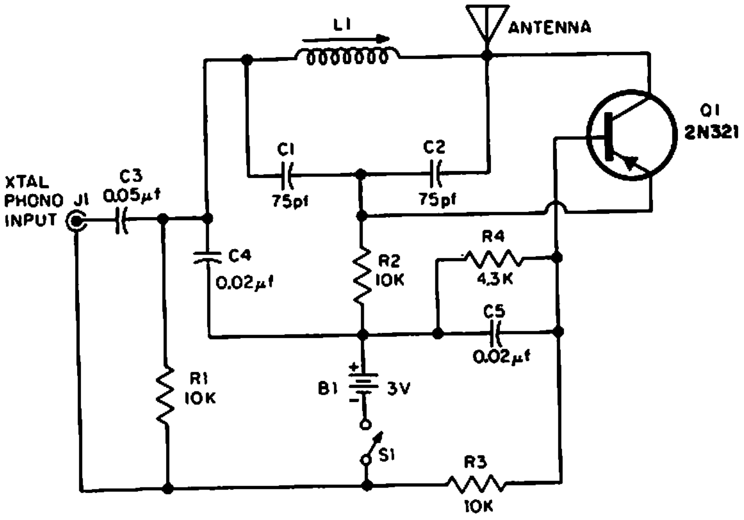
CERAMIC-INPUT AUDIO PREAMP—First stage uses low-noise transistor, with switch giving choice of ceramic cartridge or radio input. Choose R1 experimentally to give required sensitivity with radio used, then choose C12 to give with R1 an 18-μs time constant. Balance control is provided for stereo use.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 42.


+180V.
240K
ECC83
220K
.01
.05
.05
.02
TO MAGNETIC CARTRIDGE
R_L 47K
2 MEG.
2.7 K
2 MEG.
2.2K
2 MEG.
+ 20 μF
TO POWER AMPLIFIER
150K
2.7 MEG.
600pF
.0068

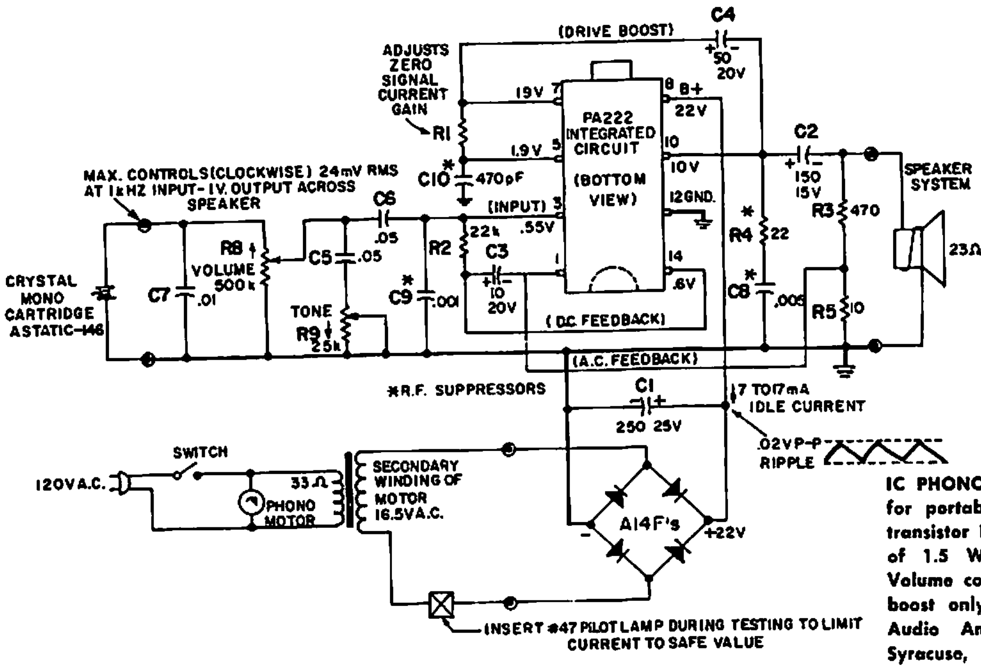
LOW-NOISE PHONO PREAMP—Feedback from last anode into first cathode uses network trimmed to give exact RIAA equalization. Gain is 40 dB.—W. A. Rheinfelder, Phono Equalizer Uses FET's, *Electronics World*, April 1966, p 32–33 and 93.


HEP 801
10K
6 TO 30 VOLTS
INPUT
10 mfd
2.2 MEG
50 mfd
OUTPUT
4.7K

FET MICROPHONE OR PHONO—Gives excellent frequency response over wide range of supply voltages for ceramic or crystal microphone or phono cartridge.—"Tips on Using FET's," Motorola, Phoenix, Ariz., HMA-33, 1969.

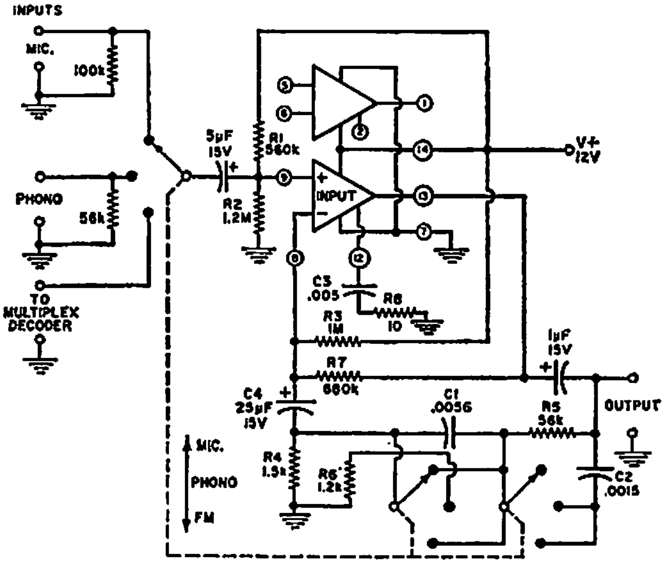

L1
ANTENNA
Q1 2N321
C1 75pf
C2 75pf
XTAL PHONO INPUT
J1
C3 0.05μf
C4 0.02μf
R2 10K
R4 4.3K
C5 0.02μf
R1 10K
B1 3V
S1
R3 10K

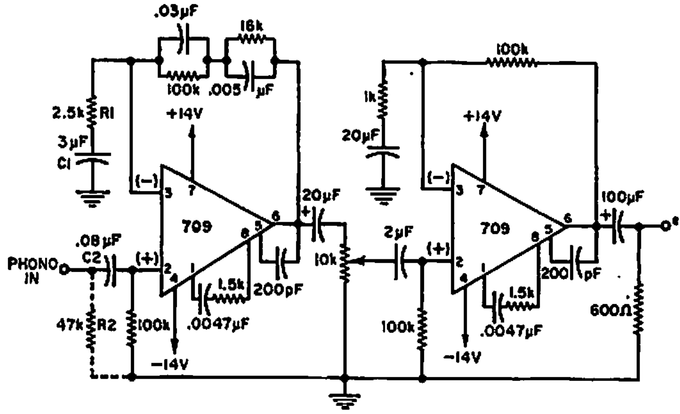
WIRELESS PHONO OSCILLATOR—Developed to broadcast phono pickup signal of inexpensive phonograph to high-quality a-m receiver nearby, for better audio reproduction. Antenna is limited to 10 feet by law. L1 is ferrite vari-loopstick, used for tuning to dead-spot at low end of broadcast band on receiver.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 15.


(DRIVE BOOST)
C4 50 20V
ADJUSTS ZERO SIGNAL CURRENT GAIN
R1
19V 7
8 B+ 22V
PA222 INTEGRATED CIRCUIT
(BOTTOM VIEW)
1.9V 5
10
10V
C2 150 15V
SPEAKER SYSTEM
MAX. CONTROLS (CLOCKWISE) 24mV RMS AT 1kHZ INPUT- 1V. OUTPUT ACROSS SPEAKER
C10 470pF
(INPUT) 3
12 GND.
C6 .05
R3 470
R8 VOLUME 500k
C5 .05
R2 22k
.55V
C3 10 20V
14
R4 22
23Ω
CRYSTAL MONO CARTRIDGE ASTATIC-146
C7 .01
TONE R9 25k
C9 .001
1
.6V
C8 .005
R5 10
(DC FEEDBACK)
(A.C. FEEDBACK)
*R.F. SUPPRESSORS
C1 250 25V
17 TO 17mA IDLE CURRENT
.02VP-P RIPPLE
SWITCH
120V A.C.
33Ω
PHONO MOTOR
SECONDARY WINDING OF MOTOR 16.5V A.C.
A14F's
-
+22V
INSERT #47 PILOT LAMP DURING TESTING TO LIMIT CURRENT TO SAFE VALUE

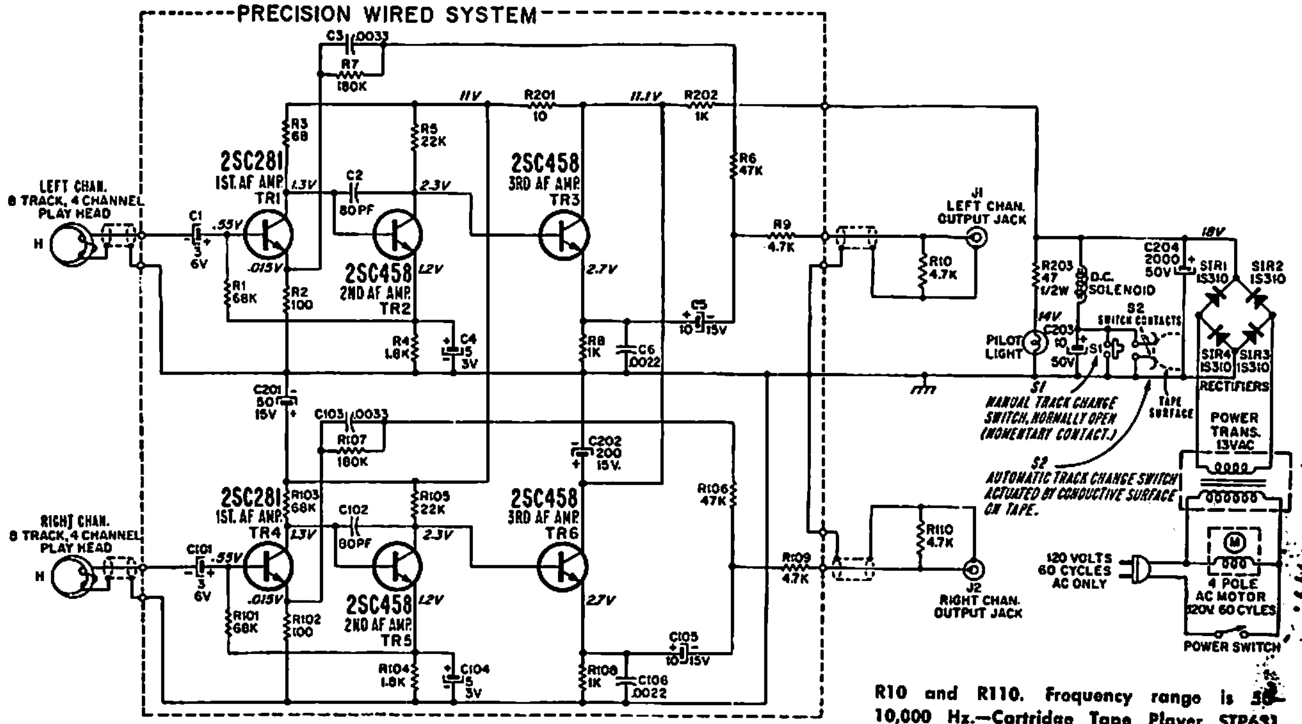
IC PHONO—Complete audio amplifier circuit for portable phonograph, built around six-transistor IC audio amplifier, provides output of 1.5 W with less than 5% distortion. Volume control is connected to provide bass boost only at low level.—Integrated Circuit Audio Amplifier PA222, General Electric, Syracuse, N.Y., No. 85.20, 1967.

DUAL-CHANNEL IC PREAMP—Uses two operational amplifiers on single chip, similar to Motorola MC1302P IC. External connections are shown for only one channel; other channel is wired identically to terminals 1, 2, 5, and 6. Used in H. H. Scott Series 2500 a-m/f-m compact stereo radio-phonos. Maximum output is 3 V.—D. R. von Recklinghausen, IC Op-Amp Hi-Fi Preamplifier, *Electronics World,* June 1968, p 44–45.

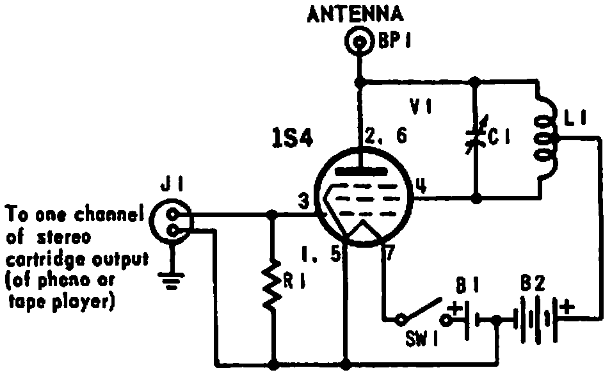

INPUTS
MIC.
100k
PHONO
56k
TO MULTIPLEX DECODER
5µF 15V
R1 560k
R2 1.2M
INPUT
V+ 12V
C3 .005
R8 10
R3 1M
R7 680k
C4 25µF 15V
1µF 15V
C1 .0056
R5 56k
OUTPUT
C2 .0015
R4 1.5k
R6 1.2k
MIC.
PHONO
FM


.03µF
18k
100k
.005
µF
2.5k
R1
3µF
C1
+14V
(–)
3
7
709
6
8
5
20µF
PHONO IN
.08µF
C2
(+)
2
4
1
1.5k
200pF
47k
R2
100k
.0047µF
–14V
1k
20µF
10k
2µF
100k
100k
+14V
709
100µF
200
pF
1.5k
.0047µF
–14V
600Ω
e_o

RIAA PHONO PREAMP—Designed for magnetic phono cartridge. Uses either Fairchild µA709 or National LM709 IC opamp with compensating R-C networks in feedback loop of first amplifier. Requires 6-mV input at 1 kHz to give 4-dBm reference output level. Circuit rejects signals below 20 Hz to minimize transients.—S. L. Silver, IC Op Amps Boost Audio Circuit Performance, *Electronics World,* Sept. 1968, p 30–32.

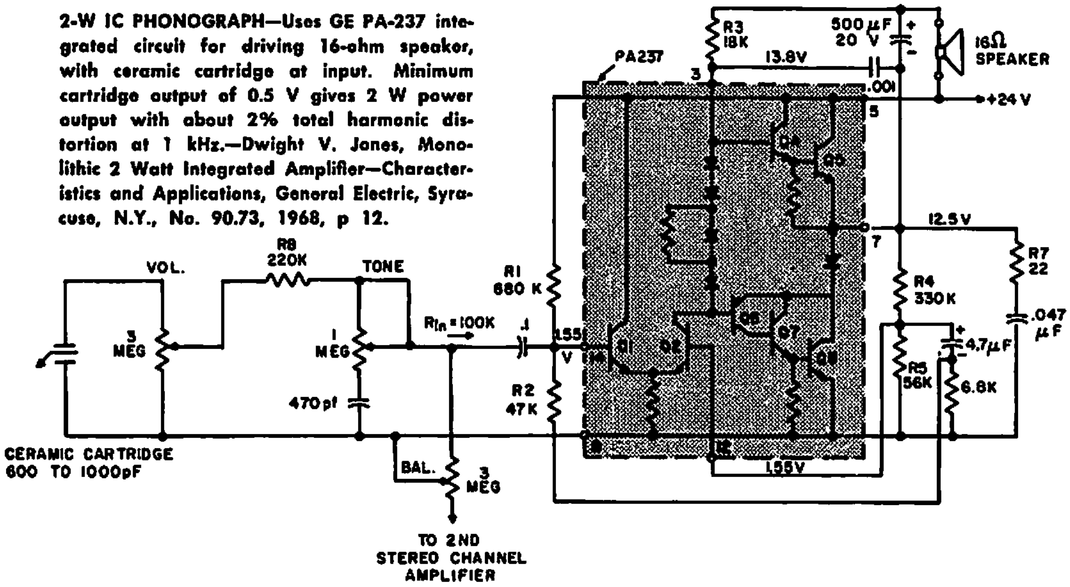

PRECISION WIRED SYSTEM
C3 .0033
R7 180K
R3 68
R5 22K
11V
R201 10
11.1V
R202 1K
R6 47K
2SC281 1ST. AF AMP TR1
2SC458 3RD AF AMP TR3
2SC458 2ND AF AMP TR2
LEFT CHAN. 8 TRACK, 4 CHANNEL PLAY HEAD
C1 5 6V
.55V
1.3V
C2 80PF
2.3V
.015V
12V
2.7V
R1 68K
R2 100
R4 1.8K
C4 5 3V
R8 1K
C6 .0022
C5 10 15V
R9 4.7K
J1 LEFT CHAN. OUTPUT JACK
R10 4.7K
C201 50 15V
C103 .0033
R107 180K
C202 200 15V
R103 68K
R105 22K
R106 47K
2SC281 1ST. AF AMP TR4
2SC458 3RD AF AMP TR6
2SC458 2ND AF AMP TR5
RIGHT CHAN. 8 TRACK, 4 CHANNEL PLAY HEAD
C101 5 6V
C102 80PF
R101 68K
R102 100
R104 1.8K
C104 5 3V
R108 1K
C106 .0022
C105 10 15V
R109 4.7K
R110 4.7K
J2 RIGHT CHAN. OUTPUT JACK
18V
R203 47 1/2W
D.C. SOLENOID
C204 2000 50V
SIR1 IS310
SIR2 IS310
SIR4 IS310
SIR3 IS310
RECTIFIERS
14V
PILOT LIGHT
C203 10 50V
S1
S2 SWITCH CONTACTS
TAPE SURFACE
S1 MANUAL TRACK CHANGE SWITCH, NORMALLY OPEN (MOMENTARY CONTACT)
S2 AUTOMATIC TRACK CHANGE SWITCH ACTUATED BY CONDUCTIVE SURFACE ON TAPE.
POWER TRANS. 13VAC
120 VOLTS 60 CYCLES AC ONLY
4 POLE AC MOTOR 120V. 60 CYCLES
POWER SWITCH

STEREO CARTRIDGE PLAYER—Delivers 0.1 V per channel into 200K impedance, for driving transistor amplifiers. To obtain 0.2-V output for tube amplifiers, clip 4.7K resistors R10 and R110. Frequency range is 50–10,000 Hz.—Cartridge Tape Player STP631, Admiral, Bloomington, Ill., Service Manual S1213, 1969.


ANTENNA
BP1
V1
1S4
2, 6
C1
L1
J1
3
4
To one channel of stereo cartridge output (of phono or tape player)
R1
1, 5
7
B1
B2
SW1

STEREO PHONO OSCILLATOR—Can be used with a-m radio to convert monaural phonograph for stereo records. Change to stereo cartridge, feed one channel to regular phono amplifier, and connect other to J1 for broadcasting to radio used for second channel. For good stereo effect, place radio about 7 ft from phonograph. Tune radio to dead spot, and adjust C1 until music is heard while playing stereo record. Antenna can be few feet of wire (legal limit is 10 ft). Values are: B1 1.5 V; B2 30 V; C1 365 pF; R1 510K; L1 182 turns No. 30 enamel center-tapped on ⅝" form.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 166.

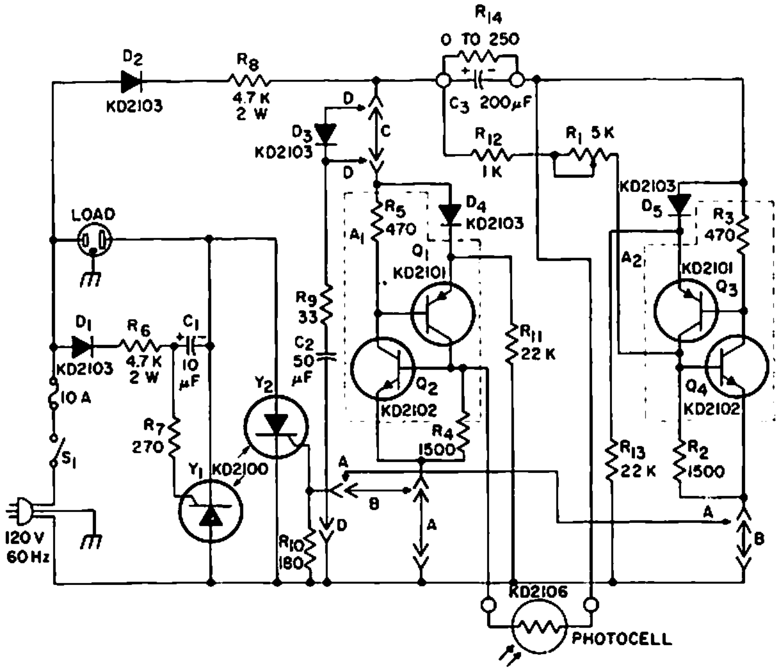
2-W IC PHONOGRAPH—Uses GE PA-237 integrated circuit for driving 16-ohm speaker, with ceramic cartridge at input. Minimum cartridge output of 0.5 V gives 2 W power output with about 2% total harmonic distortion at 1 kHz.—Dwight V. Jones, Monolithic 2 Watt Integrated Amplifier—Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.73, 1968, p 12.


R3
18K
500 μF
20 V
16Ω
SPEAKER
PA237
13.8V
3
.001
+24 V
5
12.5V
7
R7
22
VOL.
R8
220K
TONE
R1
680 K
R4
330K
.047
μF
3
MEG
1
MEG
R_{in} = 100K
.1
1.55
V
Q1
Q2
Q4
Q5
Q6
Q7
Q8
14
4.7μF
R5
56K
6.8K
470pf
R2
47K
12
1.55V
CERAMIC CARTRIDGE
600 TO 1000pF
BAL.
3
MEG
TO 2ND
STEREO CHANNEL
AMPLIFIER

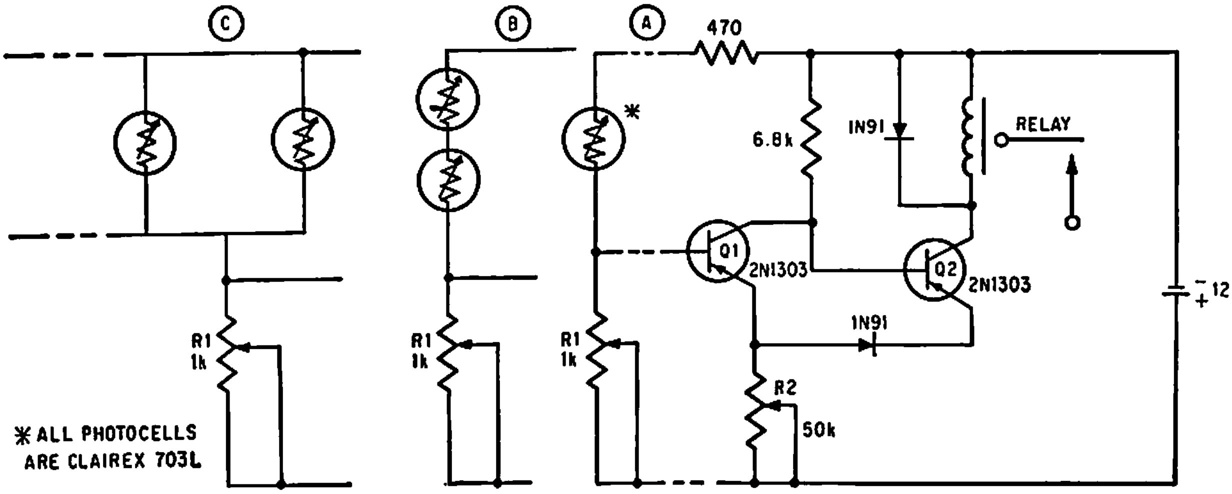
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 62

Photoelectric Circuits


R14
0 TO 250
D2
KD2103
R8
4.7 K
2 W
D
C
D3
KD2103
D
C3 200μF
R12
1 K
R1 5 K
KD2103
D5
R3
470
R5
470
A1
D4
KD2103
Q1
KD2101
A2
KD2101
Q3
LOAD
R9
33
C2
50
μF
R11
22 K
Q2
KD2102
Q4
KD2102
D1
R6
4.7 K
2 W
C1
10
μF
KD2103
10 A
Y2
R7
270
R4
1500
R13
22 K
R2
1500
S1
Y1
KD2100
A
B
A
A
B
D
120 V
60 Hz
R10
180
KD2106
PHOTOCELL

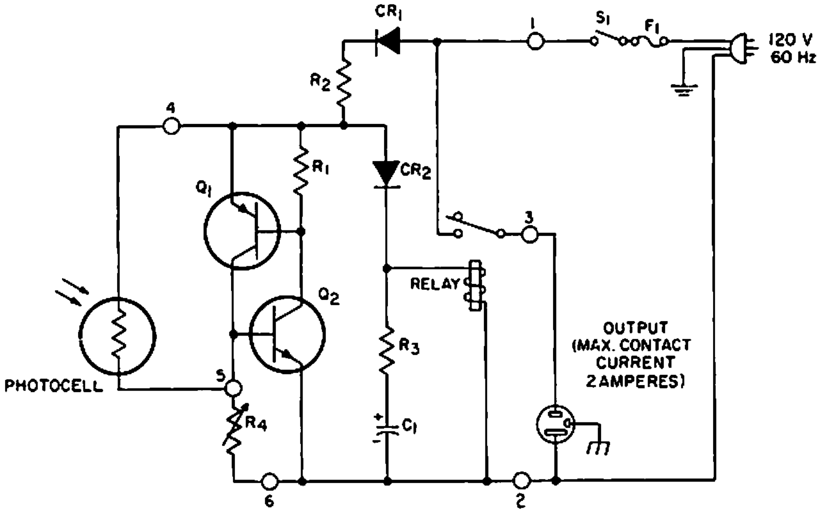
LIGHT-OPERATED ON-OFF SWITCH—Different combinations of wiring give choice of operating methods. With wiring A, increase in light turns off load. With wiring B, increase in light turns on load. With wiring combination of A and C, increase in light turns off load but it is turned back on again when light level increases to level determined by setting of R1, as required for automatic night lamp in vacant homes or for street lamp control. Connection D, for R9 and C2, is optional latching circuit. Maximum load is 600 W.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., p 106.

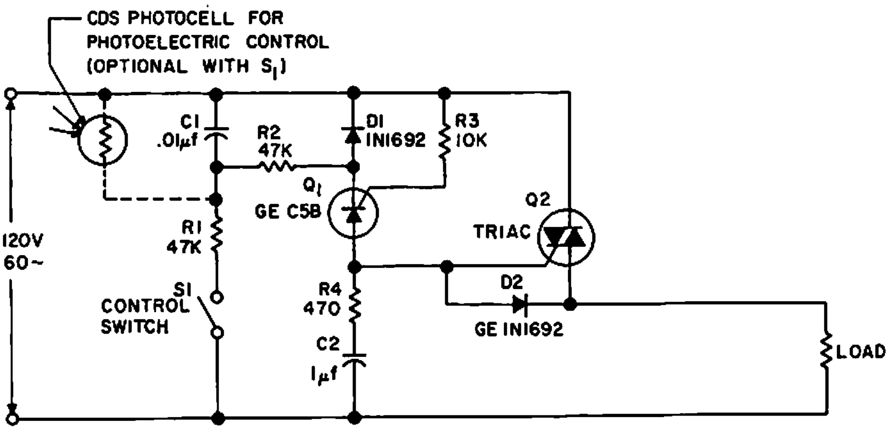

C
B
A
470
*
6.8k
1N91
RELAY
Q1
2N1303
Q2
2N1303
12V
1N91
R1
1k
R1
1k
R1
1k
R2
50k

✱ALL PHOTOCELLS ARE CLAIREX 703L

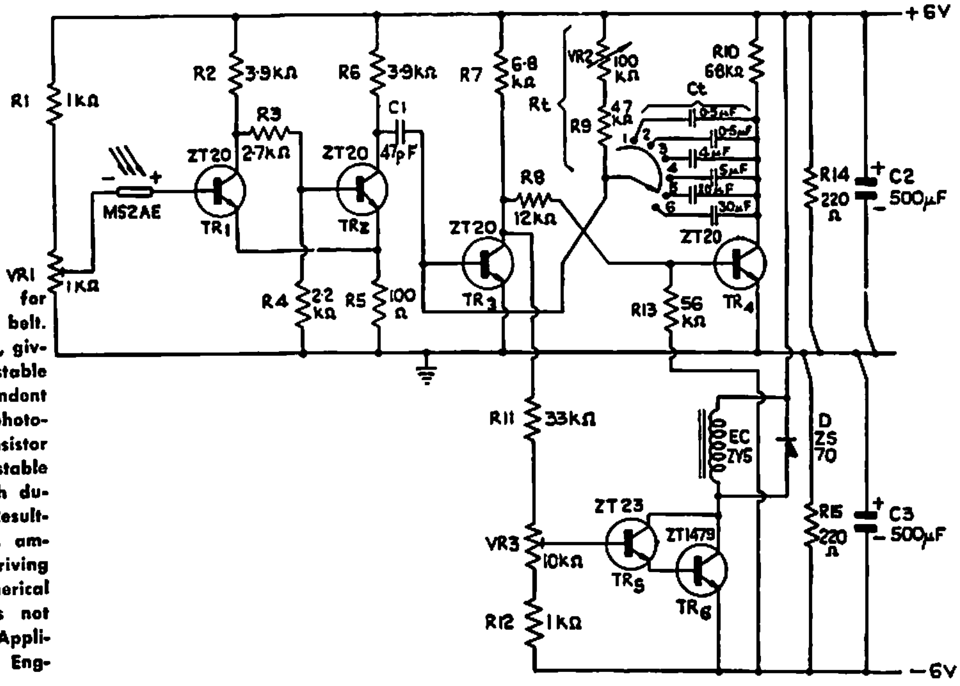
SCHMITT TRIGGER DRIVES RELAY FASTER—Ordinary photoelectric control relay is tripped directly at high speed in response to small changes in light intensity on photoconductive cell connected into basic Schmitt trigger. With circuit configuration A, relay pulls in when light drops. With B, both cells must be illuminated for relay dropout, thus giving AND logic function. With C, illumination on either cell makes relay drop out, to give OR logic function. Reversing locations of R1 and cells gives relay pull-in with increasing light; R1 should then be increased to 50K.—R. A. Farrall, Light-activated Schmitt Triggers Control Relay, *Electronics*, May 15, 1967, p 98.

2-A PHOTOSWITCH—Provides on-off action. When light on photocell exceeds predetermined level set by R4, relay releases and turns off lamp or other load. When light drops below same level, relay pulls in and turns on lamp load again. Values: R1 150; R2 5.6; R3 470; R4 250; C1 5 μF; F1 3 A; CR1 SK3031; CR2 SK3030; Q1 SK3005; Q2 SK3020; photocell KD2016; relay 1.35K 12 V. —"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 87.

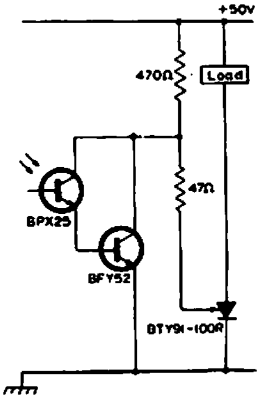

CR1
1
S1
F1
120 V
60 Hz
R2
4
R1
CR2
Q1
3
Q2
RELAY
R3
OUTPUT
(MAX. CONTACT
CURRENT
2 AMPERES)
PHOTOCELL
5
R4
C1
6
2


CDS PHOTOCELL FOR
PHOTOELECTRIC CONTROL
(OPTIONAL WITH S1)
C1
.01μf
R2
47K
D1
IN1692
R3
10K
Q1
GE C5B
Q2
TRIAC
120V
60~
R1
47K
S1
CONTROL
SWITCH
R4
470
D2
GE IN1692
C2
1μf
LOAD

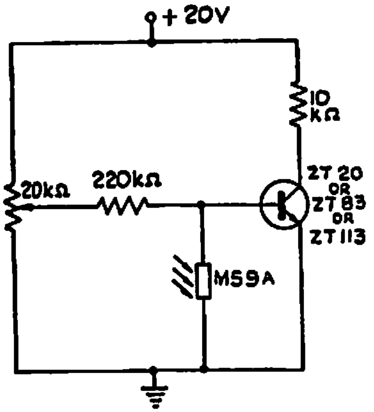
SYNCHRONOUS SWITCHING—When photocell resistance increases or control switch is closed, scr-triac combination turns on load current only at next instant when a-c supply voltage passes through zero. Similarly, light on photocell or opening of switch does not turn off load until current next passes through zero. This gives minimum disturbance to power supply when switching, with conduction only for integral number of whole cycles. Eliminates rfi and audio filtering problems. With transformers or other inductive loads, eliminates fuse-blowing nuisance caused by surge of magnetizing current.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 15.


+6V
R1
1kΩ
R2
3·9kΩ
R3
2·7kΩ
R6
3·9kΩ
C1
47pF
R7
6·8
kΩ
VR2
100
kΩ
Rt
R9
47
kΩ
R10
68kΩ
Ct
0·5μF
0·5μF
1μF
5μF
10μF
30μF
1
2
3
4
5
6
MS2AE
ZT20
TR1
ZT20
TR2
R8
12kΩ
ZT20
TR3
ZT20
TR4
R14
220
Ω
C2
500μF
VR1
1kΩ
R4
2·2
kΩ
R5
100
Ω
R13
56
kΩ
R11
33kΩ
EC
ZYS
D
ZS
70
ZT23
TR5
ZT1479
TR6
VR3
10kΩ
R15
220
Ω
C3
500μF
R12
1kΩ
−6V

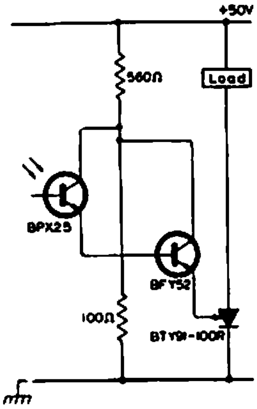
LIGHT-ACTUATED COUNTER—Designed for counting objects moving on conveyor belt. Operates only on leading edge of object, giving output power pulse that is adjustable between 15 ms and 5 s and is independent of length or shape of object. Silicon photocell feeds directly into base of first transistor of Schmitt trigger used to switch monostable TR3 from stable to unstable state, with duration of delay determined by Rt-Ct. Resulting pulse, of predetermined length, is amplified by d-c amplifier TR5-TR6 for driving electromagnetic counter or other numerical display device. Jitter of object does not cause false count.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 14.


+50V
470Ω
Load
47Ω
BPX25
BFY52
BTY91-100R

DARKNESS-ON D-C SWITCH—When light on phototransistor drops below 1,000 lux, transistor generates trigger that turns on thyristor handling up to 16 A load current.—Applications of Silicon Planar Phototransistor, BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.

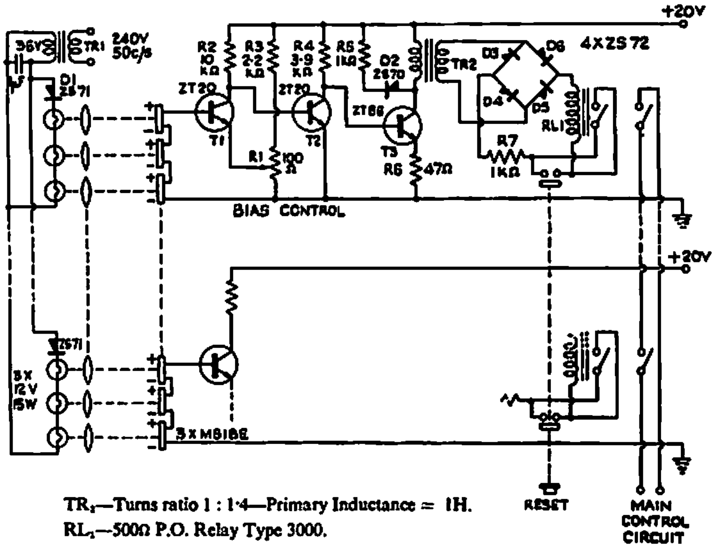

+20V
10 KΩ
20kΩ
220kΩ
ZT 20 OR ZT 83 OR ZT 113
M59A

SILICON PHOTOCELL TURNS OFF TRANSISTOR—Illumination on cell generates signal that turns off transistor. Can be used in punched tape readers.—"Silicon Photocell Applications," Ferranti, Oldham, Lancs., England, No. 9, 1967, p 6.

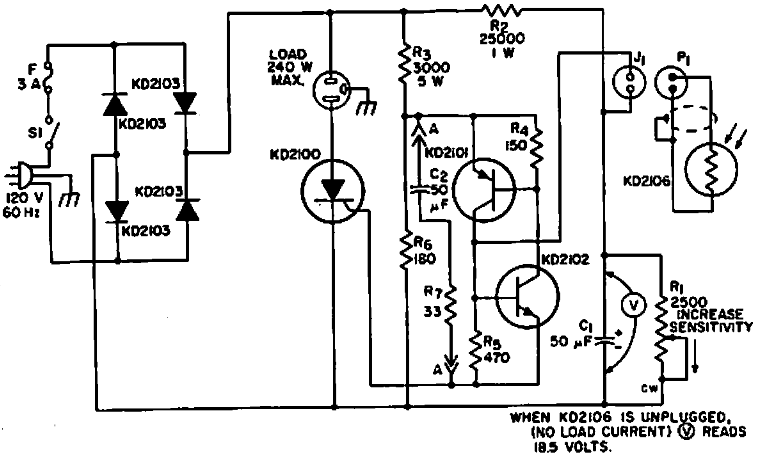

+50V
560Ω
Load
BPX25
BFY52
100Ω
BTY91-100R

DARKNESS-OFF D-C SWITCH—With phototransistor dark, transistor has no base current and no collector current, so thyristor is held off. Light produces trigger that turns on thyristor to apply power to load. Requires 1,000 lux to turn on 16-A load.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.

LIGHT-CURTAIN GUARD FOR MACHINES—Fail-safe a-c system uses light source that is modulated by operating small-filament lamp in series with rectifier from a-c line, to give high 50-Hz (or 60-Hz) flicker content. With modulated light, system will fail safe either if normally conducting transistor becomes short-circuited or normally nonconductive transistor becomes open circuit. Curtain of light is projected across throat of punch press, power shears, or other dangerous machines, so operator cannot insert hand through curtain without interrupting at least one beam of light and pulling in machine-stopping relay.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 18.

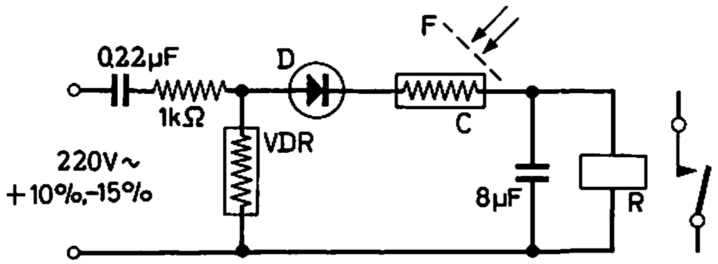

+20V
36V
TR1
240V 50c/s
1μF
D1 ZS71
R2 10 KΩ
R3 2·2 KΩ
R4 3·9 KΩ
R5 1KΩ
D2 ZS70
TR2
D3
D6
4XZS72
D4
D5
RL1
ZT20
T1
ZT20
T2
ZT86
T3
R1 100 Ω
R6 47Ω
R7 1KΩ
BIAS CONTROL
+20V
ZS71
3X 12V 15W
3XMS186
RESET
MAIN CONTROL CIRCUIT

TR₁—Turns ratio 1 : 1·4—Primary Inductance = 1H.
RL₁—500Ω P.O. Relay Type 3000.


F 3 A
S1
120 V 60 Hz
KD2103
KD2103
KD2103
KD2103
LOAD 240 W MAX.
KD2100
R2 25000 1 W
R3 3000 5 W
A
KD2101
C2 50 μF
R4 150
R6 180
R7 33
A
R5 470
KD2102
J1
P1
KD2106
V
C1 50 μF
R1 2500 INCREASE SENSITIVITY
CW

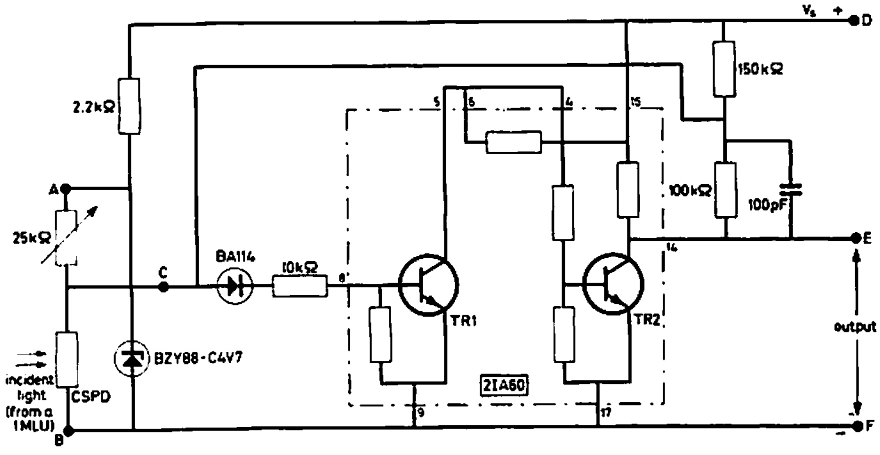
WHEN KD2106 IS UNPLUGGED, (NO LOAD CURRENT) Ⓥ READS 18.5 VOLTS.

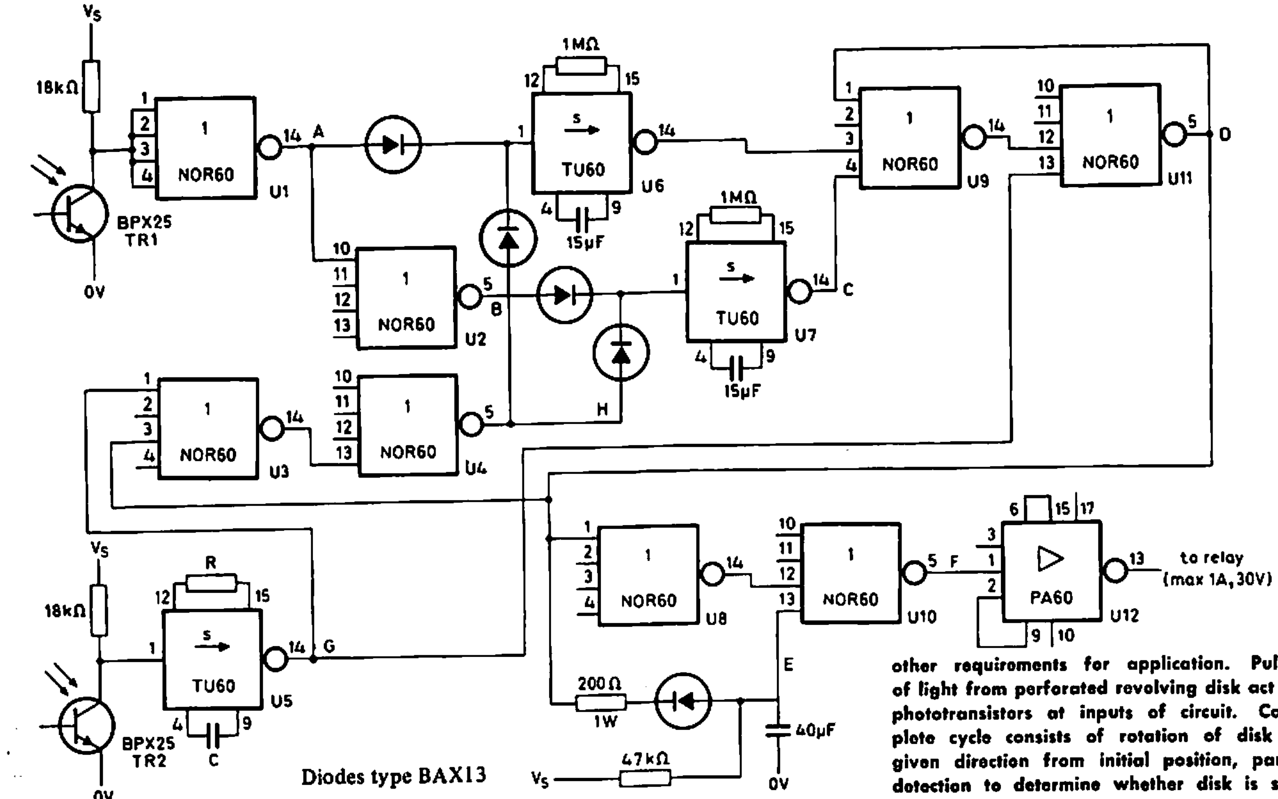
LIGHT-OPERATED TURN-ON SWITCH—Will switch on lamp, heater, or universal motor up to 240 W at predetermined light level determined by setting of R1. C2 and R7 form optional latching circuit that keeps load on until line switch S1 is opened. Applications include turning on advertising signs when illuminated by auto headlights, turning on dock lights with spotlight or flashlight when boat is returning after dark, and turning on lights at darkness.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 100.


0.22μF
1kΩ
D
F
C
VDR
220V~
+10%,-15%
8μF
R

220-V A-C TWILIGHT SWITCH—Relay releases at darkness, turning on lamp load. Cell is cadmium sulfide RPY20; diode is BYX10; VDR is voltage-dependent resistor E 299 DG/P248; R is 1K; C1 0.22 μF; C2 8 μF; relay is 20K with make at 45 V and break at about 20 V. Capacitor across relay prevents pull-in by flashes of light.—M. Donkers and E. B. G. Nijhof, The Application of Cadmium-Sulphide Photo-Conductive Cell RPY20 In Automatic Twilight Switches, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 424, 1964.

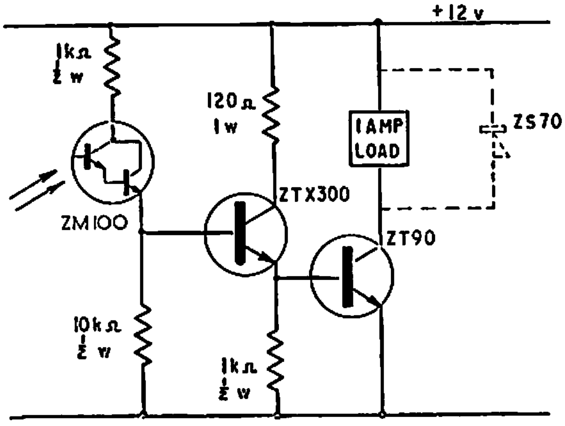
LOW-COST IC PHOTORELAY—Uses Philips 21-A60 two-transistor IC as amplifier for photocell. Intended for use in industrial control installations where distance between light source and photocell is under 8 ft. Pulse-shaping action of IC improves usefulness of output signal for driving up to 20 counting or logic units. Interruption of light on cell makes voltage across unloaded output terminals approach supply voltage.—Photoelectric Detecting System Using Light Sensor CSPD and Lamp Unit 1MLU, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 12, 1968.

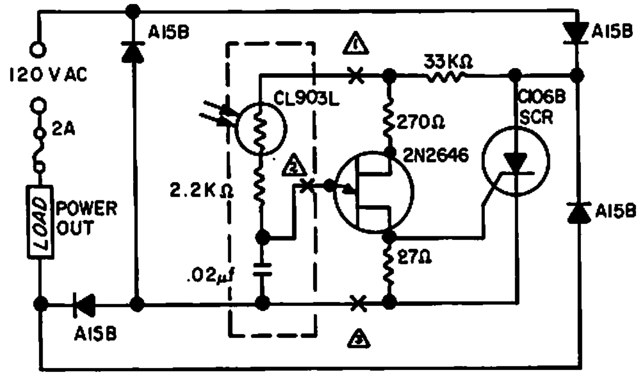

Vs +
D
2.2kΩ
150kΩ
5
6
4
15
A
100kΩ
100pF
25kΩ
E
14
BA114
10kΩ
C
8
TR1
TR2
output
BZY88-C4V7
incident light (from a 1MLU)
CSPD
2IA60
9
17
B
F


Vs
18kΩ
1
2
3
4
NOR60
U1
14
A
BPX25
TR1
0V
1MΩ
12
15
TU60
U6
15μF
10
11
12
13
NOR60
U2
5
B
U7
C
H
U3
U4
U9
U11
D
R
U5
G
BPX25
TR2
C
U8
U10
F
E
PA60
U12
to relay (max 1A,30V)
6
17
9
10
200Ω
1W
40μF
47kΩ
Vs
0V
Diodes type BAX13

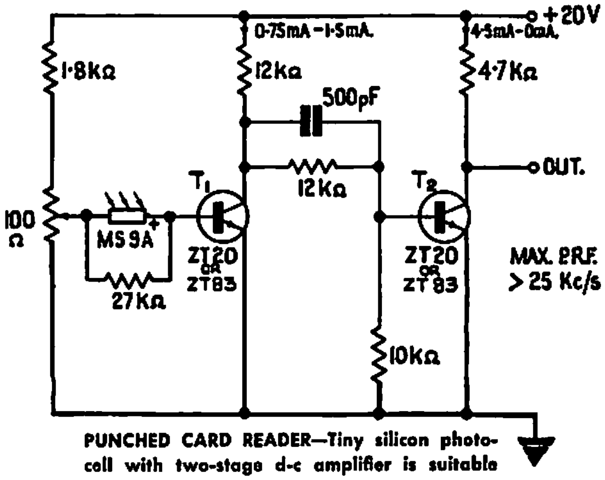
FURNACE-EMPTYING DETECTOR—Basic circuit detects long absences of action in industrial process where action can be converted into pulses of light. Originally developed to control slow emptying of furnace into hopper suspended on scales, so weight and time are registered and hopper emptied automatically if nothing dribbles out for 15 s. Uses combination of Philips IC gates connected as shown to provide required time delay and other requirements for application. Pulses of light from perforated revolving disk act on phototransistors at inputs of circuit. Complete cycle consists of rotation of disk in given direction from initial position, pause detection to determine whether disk is stationary for longer than 15 s, and return of disk to initial position. Cycle-terminating relay cannot operate again until disk is back home for start of new cycle.—H. Magro, Detection of Long-Duration Pauses in Machine Operations, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 67.

HIGH-SENSITIVITY PHOTO-DARLINGTON RELAY—Addition of two transistor amplifier stages to Ferranti ZM100 photo-Darlington permits turning on 1-A load with light level of only 2 lumens per sq ft.—A Photo Darlington Pair, Ferranti, Oldham, Lancs., England, No. 36, 1968.

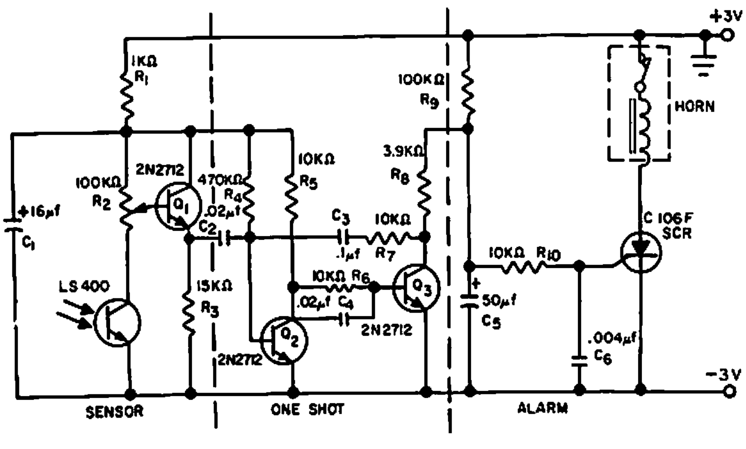

+12 v
1kΩ ½ w
120Ω 1 w
1 AMP LOAD
ZS70
ZM100
ZTX300
ZT90
10kΩ ½ w
1kΩ ½ w


A15B
120 VAC
2A
LOAD
POWER OUT
CL903L
33KΩ
270Ω
2N2646
C106B SCR
2.2KΩ
.02μf
27Ω
A15B
A15B
A15B

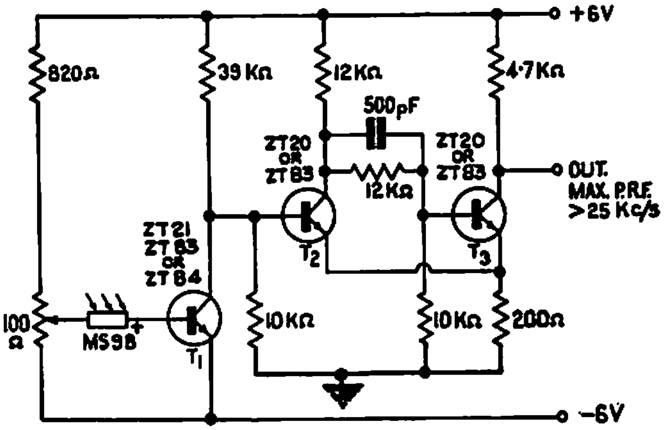
2-A PHOTORELAY—Load current varies with intensity of light reaching photoconductive cell. Ujt relaxation oscillator frequency varies with resistance of photocell, to change firing angle of scr and thereby change average current to load.—L. M. Hertz, "Solid State Lamps—Part II," General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 21.


+20V
0·75mA-1·5mA.
4·5mA-0mA.
1·8kΩ
12kΩ
500pF
4·7kΩ
12kΩ
OUT.
100 Ω
MS9A
T1
T2
ZT20 OR ZT83
ZT20 OR ZT83
27kΩ
10kΩ
MAX. P.R.F. >25 Kc/s

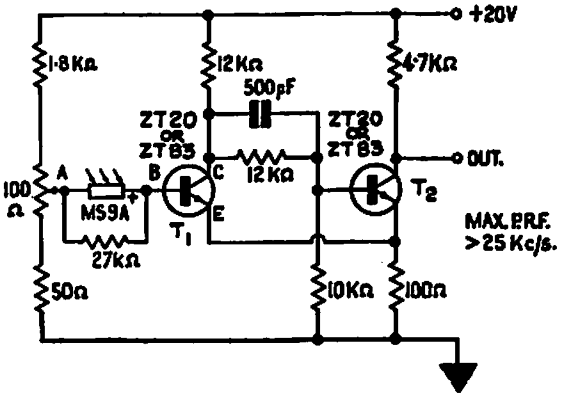
PUNCHED CARD READER—Tiny silicon photocell with two-stage d-c amplifier is suitable for light intensities of 1,000 to 3,000 lumens per square foot, as commonly used in punched card or tape readers in which reading is done while card is stationary.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 7.


+3V
1KΩ R1
100KΩ R9
HORN
2N2712
470KΩ R4
.02μf C2
10KΩ R5
3.9KΩ R8
100KΩ R2
+16μf C1
C3 .1μf
10KΩ R7
10KΩ R10
C 106F SCR
10KΩ R6
.02μf C4
Q1
Q2
Q3
LS 400
15KΩ R3
2N2712
2N2712
50μf C5
.004μf C6
-3V
SENSOR
ONE SHOT
ALARM

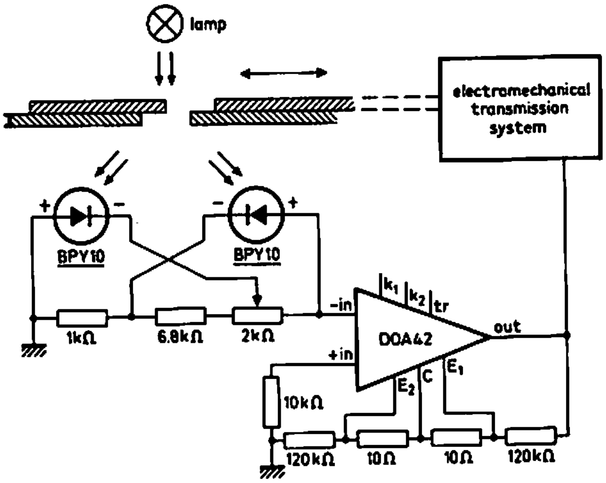
SMOKE DETECTOR RECEIVER—Responds to 10-pps pulsed light beam from transmitter. Optical path through area being monitored is 8 inches long, with four mirrors each ¼ inch square. One-shot triggers scr to turn on 1.5-V bicycle-horn alarm if smoke interrupts pulsed beam. Draws only 3 mA from pair of D flashlight cells when horn is off.—L. M. Hertz, "Solid State Lamps—Part II," General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 31.


+6V
820Ω
39 KΩ
12 KΩ
4·7KΩ
500pF
ZT20 OR ZT83
12 KΩ
ZT20 OR ZT83
OUT.
MAX. P.R.F. >25 Kc/s
ZT21 ZT83 OR ZT84
T2
T3
100 Ω
MS9B
T1
10KΩ
10KΩ
200Ω
−6V

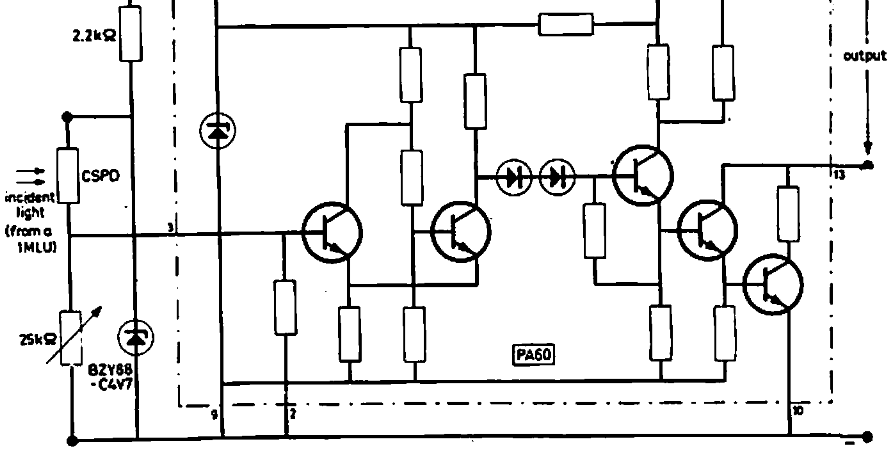
HOT-STRIP DETECTOR—Use of single-transistor d-c coupled amplifier stage between silicon photocell and input to Schmitt trigger T2-T3 gives operation down to light levels of 10 foot-candles, as required for detection of hot strip in rolling mills.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 11.


+20V
1·8KΩ
12KΩ
4·7KΩ
500pF
ZT20 OR ZT83
12KΩ
ZT20 OR ZT83
OUT.
100 Ω
A
B
C
E
MS9A
T1
T2
27KΩ
MAX. P.R.F. >25 Kc/s.
50Ω
10KΩ
100Ω

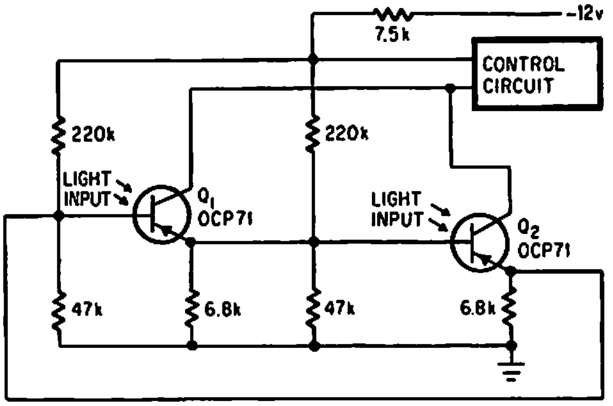
MOVING TAPE READER—Silicon-photocell circuit uses Schmitt trigger instead of straight d-c amplifier, for applications involving reading of holes in slow-moving punched cards or tape. Since circuit switches rapidly from one state to the other, operation is independent of card or tape speed.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 7.


lamp
electromechanical transmission system
BPY10
BPY10
1kΩ
6.8kΩ
2kΩ
-in
+in
k1
k2
tr
DOA42
out
C
E1
E2
10kΩ
120kΩ
10Ω
10Ω
120kΩ

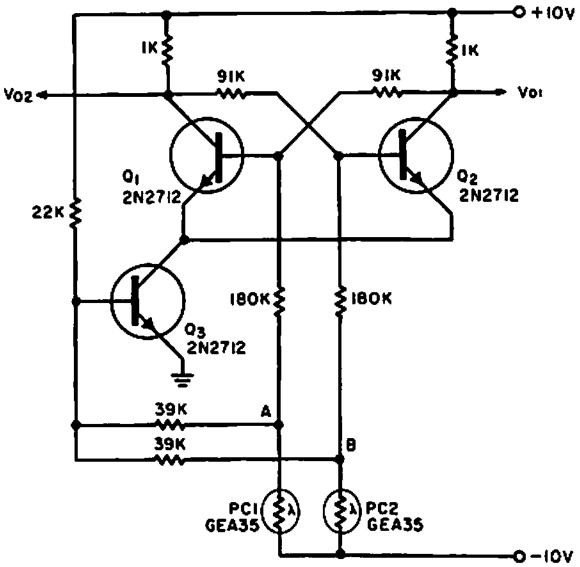
DISPLACEMENT DETECTION—Circuit minimizes effect of spread in parameters and changes in parameters with time and temperature. Purpose of circuit is to maintain two plates in predetermined position with respect to each other, with both photocells then receiving equal illumination. Uses Philips DOA42 opamp having voltage gain of 12,000 to drive electromechanical positioning system in correct direction for rebalancing photocells.—J. van Stam, Accurate Positioning With Photocells, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 81.


+
8
6
15
2.2kΩ
output
CSPD
incident light (from a 1MLU)
3
13
25kΩ
BZY88 -C4V7
PA60
9
2
10
−

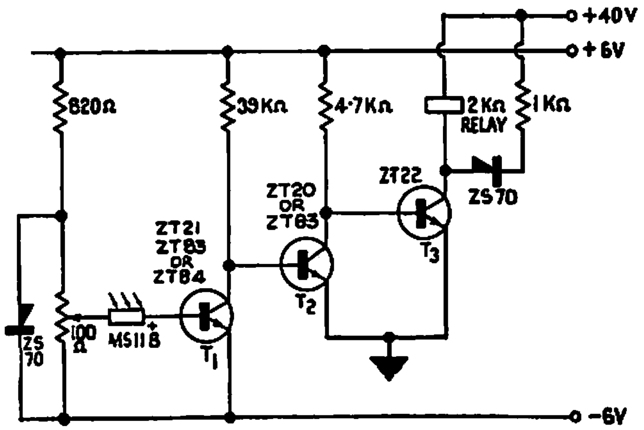
POWER-SWITCHING IC—Philips PA60 five-transistor IC, including Schmitt trigger, provides sufficient output power for energizing power relay when photocell is illuminated by 1MLU lamp from distance under about 8 feet.—Photoelectric Detecting System Using Light Sensor CSPD and Lamp Unit 1MLU, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 12, 1968.


-12v
7.5k
CONTROL CIRCUIT
220k
220k
LIGHT INPUT
Q_1 OCP71
LIGHT INPUT
Q_2 OCP71
47k
6.8k
47k
6.8k

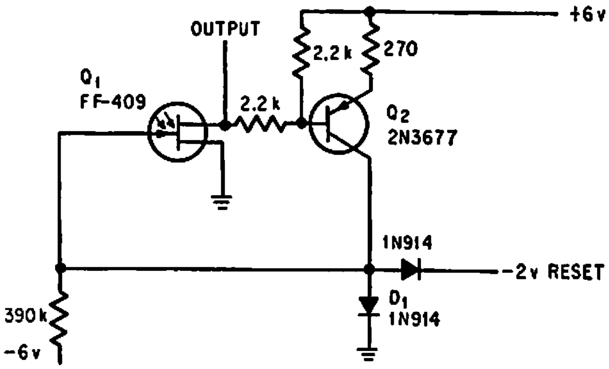
REGENERATIVE FEEDBACK FOR TWO PHOTOTRANSISTORS—Cascade connection with feedback gives current gain of 20 for typical illumination, as compared to gain of 4 without feedback.—R. Sivaswamy, Current Feedback Enhances Phototransistor Sensitivity, *Electronics*, June 12, 1967, p 103.


+10V
1K
1K
91K
91K
VO2
VO1
Q_1 2N2712
Q_2 2N2712
22K
180K
180K
Q_3 2N2712
39K
39K
A
B
PC1 GEA35
PC2 GEA35
-10V

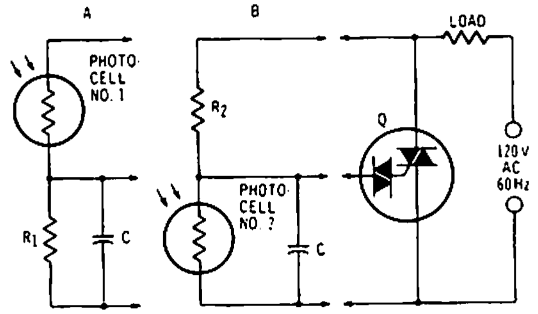
DIRECTION INDICATOR—Low-cost circuit actuates flip-flop to indicate direction of interruption of light beam by moving object. Output is negative-going at VO1 if object blocks light to PC1 before PC2. For object moving in opposite direction, output is negative-going at VO2.—H. J. Hildebrandt, Photocell Control Indicates Direction of Motion, *Electronic Design*, Oct. 12, 1964, p 80–81.


+40V
+6V
820Ω
39KΩ
4·7KΩ
2KΩ RELAY
1KΩ
ZT22
ZS70
ZT20 OR ZT83
T_3
ZT21 ZT83 OR ZT84
T_2
ZS 70
100 Ω
MS11B
T_1
-6V

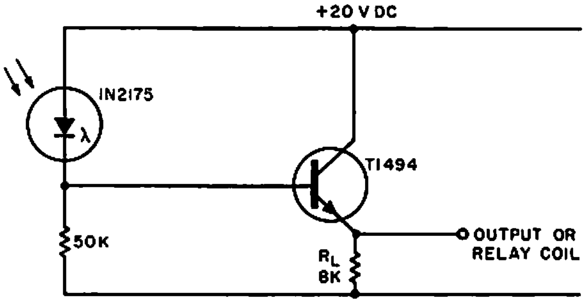
HIGH-GAIN PHOTORELAY—Three-stage direct-coupled amplifier with current gain of 10,000 gives reliable operation of telephone relay with light intensities as low as 1 lumen per sq ft on silicon photocell.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 11.


+6v
OUTPUT
Q_1 FF-409
2.2k
2.2k
270
Q_2 2N3677
1N914
-2v RESET
D_1 1N914
390k
-6v

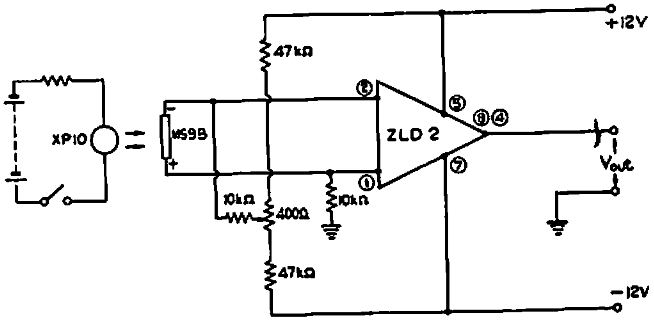
LOW-DRAIN FET LIGHT CONTROL—No power is dissipated by circuit in darkness, thus conserving battery life. Chief drawback is poor noise immunity, even though light-sensitive fet arrangement gives high voltage gain and high sensitivity.—B. R. Smith, Light-Sensitive FET, *Electronics*, Nov. 14, 1966, p 124–125.


A
B
PHOTO CELL NO. 1
R1
C
R2
PHOTO CELL NO. 2
C
Q
LOAD
120 V AC 60 Hz

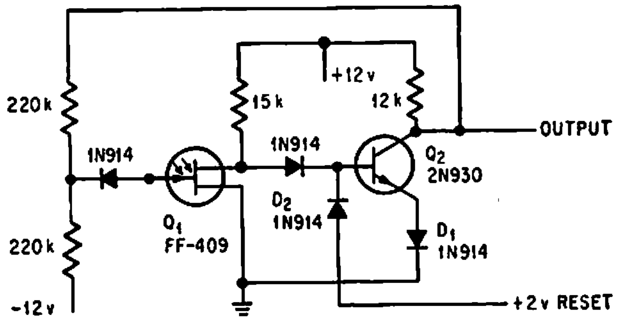
INTERNAL-TRIGGER TRIAC—Will control 720 W at up to 6 A. With connection A, load is energized when photocell is illuminated. With B, drop in light energizes load. Photocells are RCA 4453, triac is RCA-40431 silicon with internal trigger, R1 is 6.8K, and R2 is 13K.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 22.


+20 V DC
1N2175
λ
T1494
50K
RL 8K
OUTPUT OR RELAY COIL

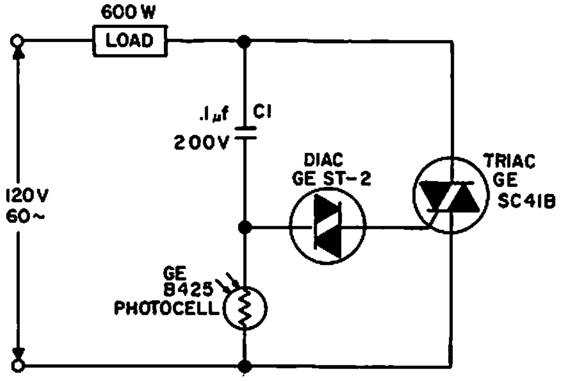
SENSOR, TRANSISTOR, AND RELAY—Emitter-follower is used between 1N2175 and 8,000-ohm relay for impedance transformation. Emitter voltage can also be used to drive amplifier, flip-flop, trigger, counter, or scr. Relay pull-in current is 1.2 mA.—D. Abel, Light Sensors—Bright Future for an Expanding Technology, *Electronic Design*, Feb. 17, 1964, p 76–79.


+12V
47kΩ
XP10
MS9B
⑫
①
ZLD 2
⑤
⑨④
⑦
10kΩ
400Ω
10kΩ
47kΩ
Vout
−12V

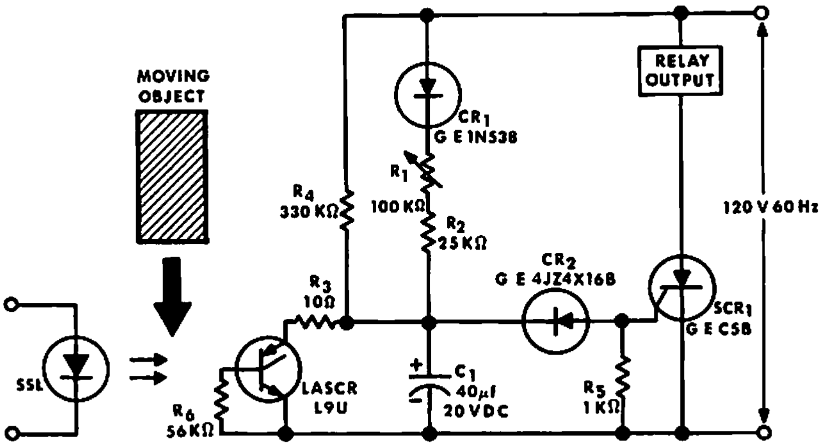
PUSH-PULL IC PHOTORELAY—Uses Ferranti ZLD2 differential d-c amplifier with silicon photocell at input, illuminated by Ferranti XP10 gallium phosphide light-emitting diode 0.05 inch from active face of photocell. Full output swing of 10 V is obtained with 100% interruption of light beam by punched paper tape or shutter.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 13.


220k
+12v
15k
12k
OUTPUT
1N914
1N914
Q2 2N930
D2 1N914
Q1 FF-409
D1 1N914
220k
−12v
+2v RESET

FET DOOR-OPENER—Light saturates fet Q1 and turns off npn transistor Q2 to provide positive output voltage, as required for garage-door openers, smoke detectors, and paper-break detectors. High voltage gain (above 100,000) and sensitivity of 0.1 foot-candle make circuit useful also in star trackers. Has good noise immunity.—B. R. Smith, Light-Sensitive FET, *Electronics*, Nov. 14, 1966, p 124–125.

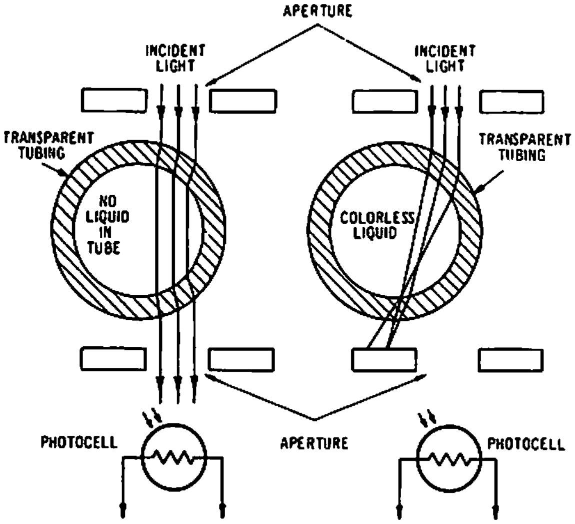

600 W
LOAD
.1μf 200V
C1
DIAC GE ST-2
TRIAC GE SC41B
120V 60~
GE B425 PHOTOCELL

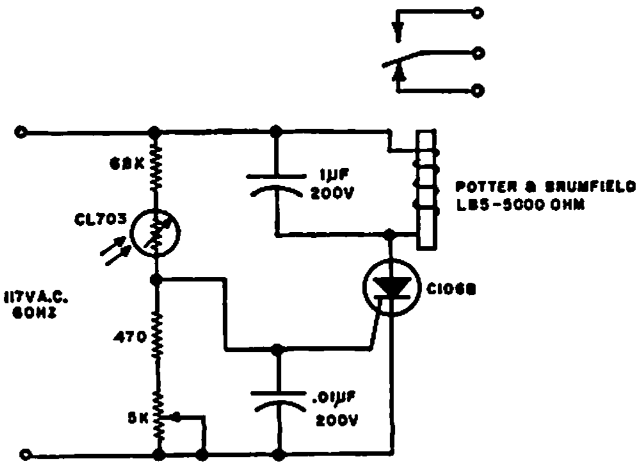
DIAC-TRIAC CONTROL—When photocell is dark, voltage across diac rises rapidly with a-c line voltage during each half-cycle, triggering diac early in cycle. When illumination makes photocell resistance drop below 2K, diac is not triggered and load power is shut off. For 240 V, change C1 to 0.1 μF.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 15.


MOVING OBJECT
RELAY OUTPUT
CR1
G E 1N538
R1
100 KΩ
R2
25 KΩ
R4
330 KΩ
R3
10Ω
CR2
G E 4JZ4X16B
SCR1
G E C5B
120 V 60 Hz
SSL
LASCR
L9U
R6
56 KΩ
C1
40µf
20 VDC
R5
1 KΩ

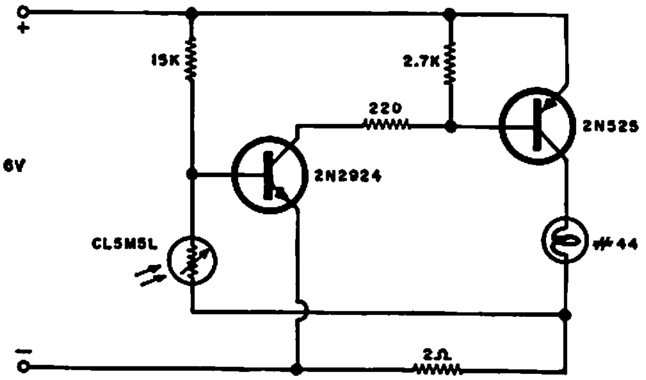
FLOW MONITOR—Used to detect impending catastrophic jams of small components moving down conveyor chute at high speed and shutting down line, while ignoring small self-clearing pile-ups. R1 controls amount of beam interruption permitted before relay is energized.—L. M. Hertz, "Solid State Lamps—Part II," General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 18.

COLORLESS-LIQUID DETECTOR—Photocell is initially positioned so light passes through empty glass tube to photocell. Apertures should be positioned so light goes through near inner edge of tubing, as shown. When liquid is present, it refracts light away from photocell. Any simple photoelectric relay circuit can be used to convert change in photocell impedance to relay or indicator operation.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 27.

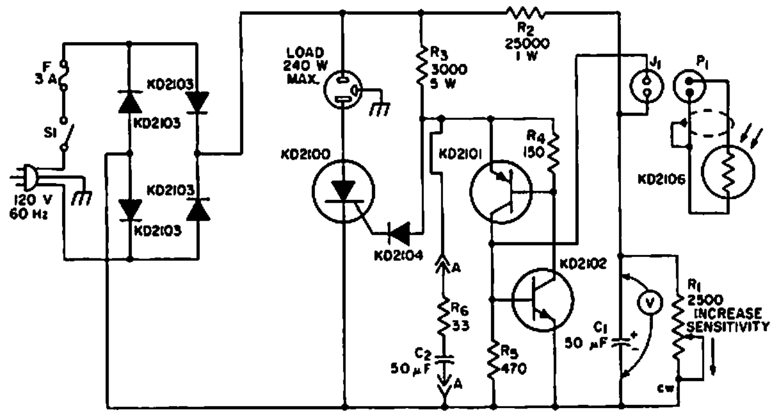

APERTURE
INCIDENT LIGHT
INCIDENT LIGHT
TRANSPARENT TUBING
TRANSPARENT TUBING
NO LIQUID IN TUBE
COLORLESS LIQUID
PHOTOCELL
APERTURE
PHOTOCELL


68K
CL703
117V A.C. 60HZ
470
5K
1µF 200V
.01µF 200V
POTTER & BRUMFIELD LB5-5000 OHM
C106B

SCR CONTROL—Simple line-operated modern control uses scr to pull in relay when illumination on photocell increases to predetermined level set by potentiometer.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.

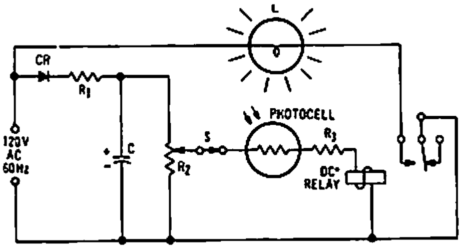

+
6V
−
15K
2.7K
220
2N525
2N2924
CL5M5L
#44
2Ω

SUNSET LAMP—Turns on night light or masthead lamp on boat when twilight falls. Uses modified complementary Schmitt trigger in which transistors conduct heavily when dark resistance of photocell goes above 1,500 ohms. In daylight, photocell drops below 500 ohms, transistors turn off, and battery drain drops to 400 µA.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.


F
3 A
S1
120 V
60 Hz
KD2103
KD2103
KD2103
KD2103
LOAD
240 W
MAX.
KD2100
KD2104
R3
3000
5 W
R2
25000
1 W
KD2101
R4
150
J1
P1
KD2106
KD2102
A
R6
33
C2
50 µF
A
R5
470
C1
50 µF
V
R1
2500
INCREASE
SENSITIVITY
CW

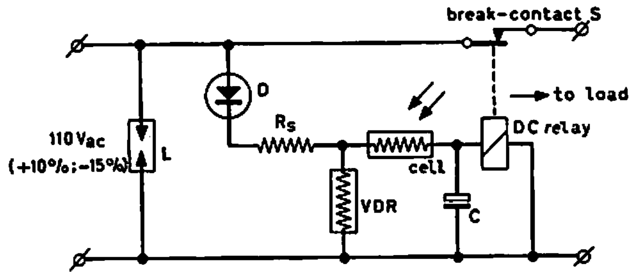
WHEN KD2106 IS UNPLUGGED.
(LOAD CURRENT FLOWS)
Ⓥ READS 18.5 VOLTS.

LIGHT-OPERATED TURN-OFF SWITCH—R1 determines level at which circuit interrupts power to lamp, heater, or universal motor up to 240 W. R6 and C2 provide optional latching to hold load off until line switch S1 is opened.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 103.

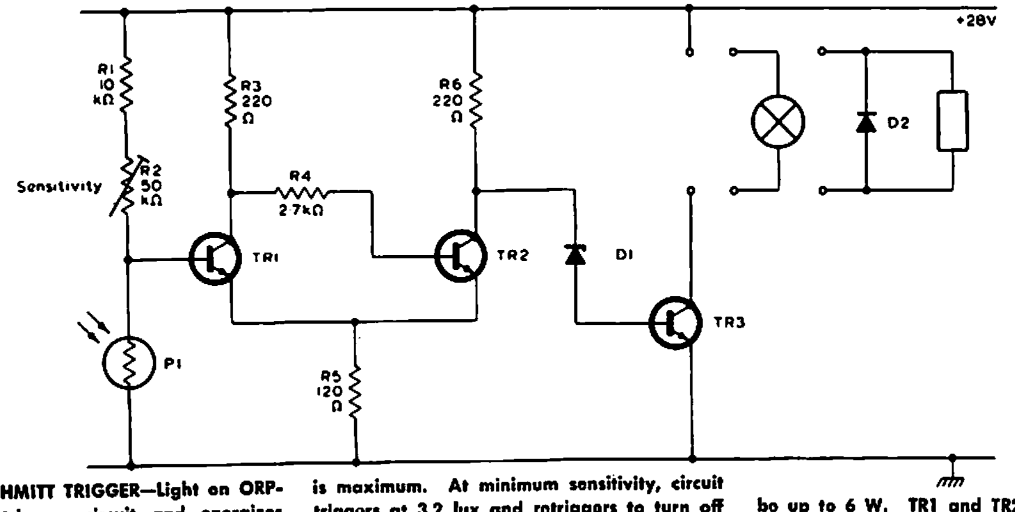

L
CR
R1
120V
AC
60Hz
C
R2
S
PHOTOCELL
R3
DC*
RELAY

*THE RELAY FRAME IS AT ARMATURE POTENTIAL AND SHOULD BE INSULATED FROM A COMMON CHASSIS FOR SAFETY REASONS.

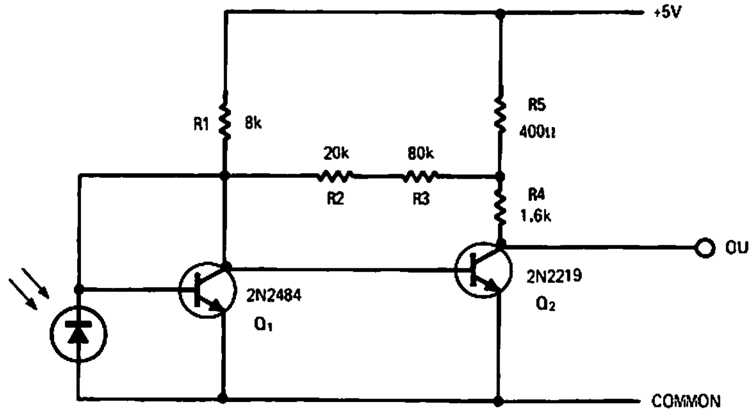
LIGHT-RESPONSIVE ALARM—Illumination on photocell, by burglar turning on room lights or flashlight, energizes relay to turn on outdoor lights, alarm, or hi-fi stereo recording of vicious barking dog. Values: R1 5.6; R2 25K; R3 2K; C 8 µF; CR 1N1763A; photocell 7163; relay 10K at 2 mA.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 24.


break-contact S
D
Rs
to load
DC relay
110 Vac
(+10%;-15%)
L
cell
VDR
C

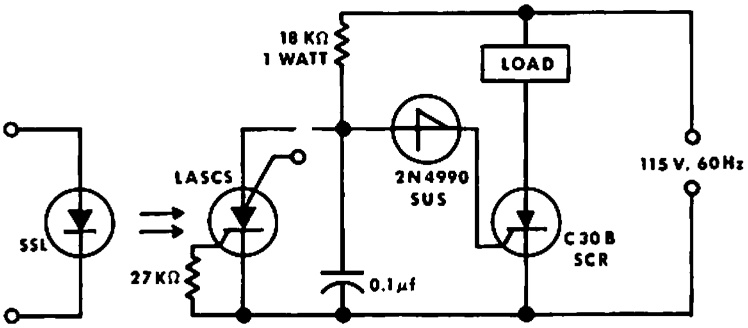
TWILIGHT SWITCH—Electrolytic capacitor across relay makes circuit insensitive to short light flashes and prevents relay from chattering as twilight falls and decreasing illumination on photocell increases impedance of cell to make relay release and apply power to lamp load. Lightning arrestor (Sigma Instruments A112) protects photocell from transients above 2 kV produced by lightning in power line. Diode is BYX10; Rs 3.3K; C 8 µF; photocell RPY20; VDR voltage-dependent resistor E 298 GD/A262; relay is 21.8K, with make at 45 V d-c and break at 18 V d-c.—M. Donkers and E. B. G. Nijhof, The Application of Cadmium-Sulphide Photo-Conductive Cell RPY20 In Automatic Twilight Switches, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 424, 1964.


+28V
R1
10
kΩ
R3
220
Ω
R6
220
Ω
R2
50
kΩ
Sensitivity
R4
2·7kΩ
TR1
TR2
D1
TR3
D2
P1
R5
120
Ω

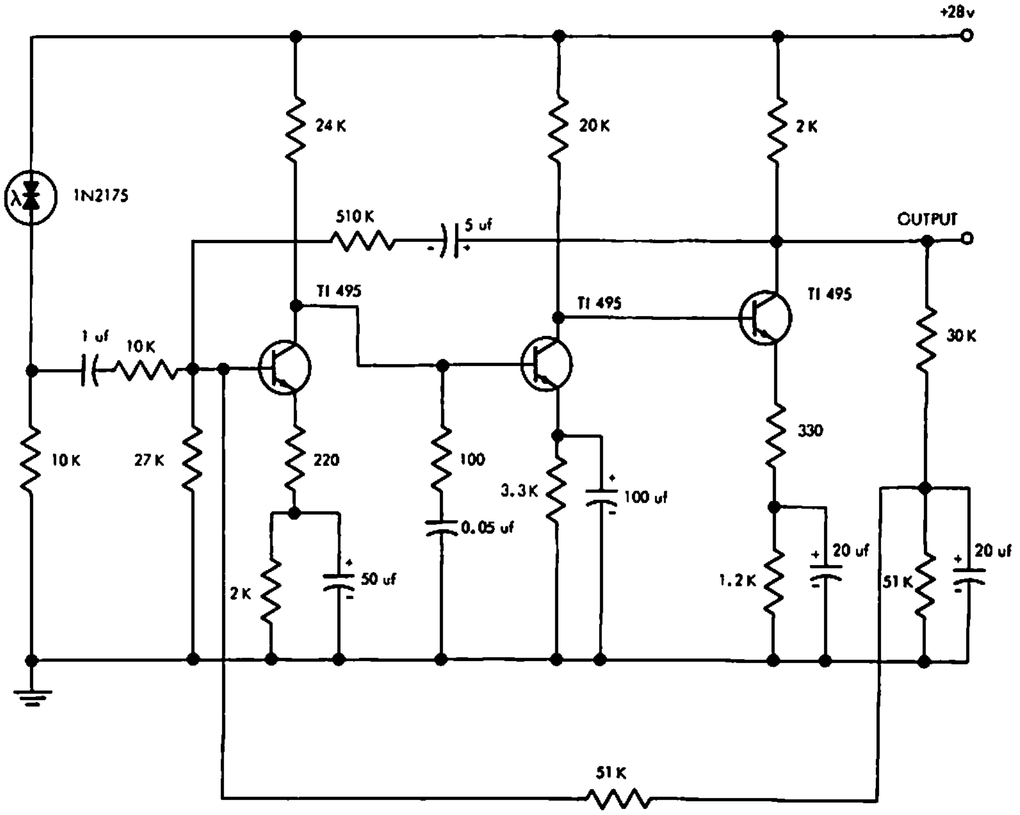
DRIVE FOR SCHMITT TRIGGER—Light on ORP-12 photocell triggers circuit and energizes lamp or relay load at level determined by R2. If set to trigger at 0.1 lux, circuit will be triggered again and lamp turned off when illumination rises to 0.11 lux and sensitivity is maximum. At minimum sensitivity, circuit triggers at 3.2 lux and retriggers to turn off lamp at 6.5 lux. Chief advantage of using Schmitt trigger is that output is switched very rapidly and does not remain in condition of high dissipation for long. Lamp load can be up to 6 W. TR1 and TR2 are BFY52, TR3 is BFY51, and D1 is OAZ215.—Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


+5V
R1
8k
R5
400Ω
20k
80k
R2
R3
R4
1.6k
OUT
2N2484
Q₁
2N2219
Q₂
COMMON

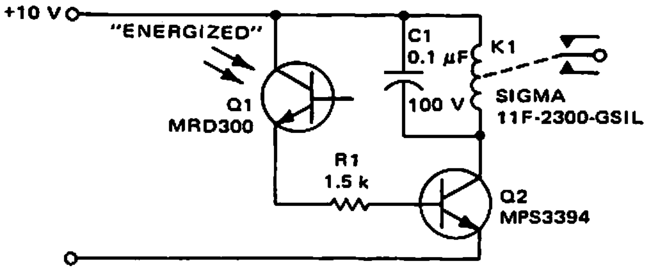
CARD READER—Schmitt trigger controlled by photovoltaic cell operating in diode mode provides consistent output from punched card or punched paper tape reader head assembly for light levels ranging from 100 to 1,000 foot-candles. Output is compatible with TTL or DTL logic and independent of erratic movement of cards or tape.—T. B. Stephenson, One Hole, One Pulse From Flutterless Card Reader, *EDN*, Feb. 15, 1970, p 59.


18 KΩ
1 WATT
LOAD
LASCS
2N4990
SUS
115 V, 60Hz
SSL
27 KΩ
0.1 µf
C30B
SCR

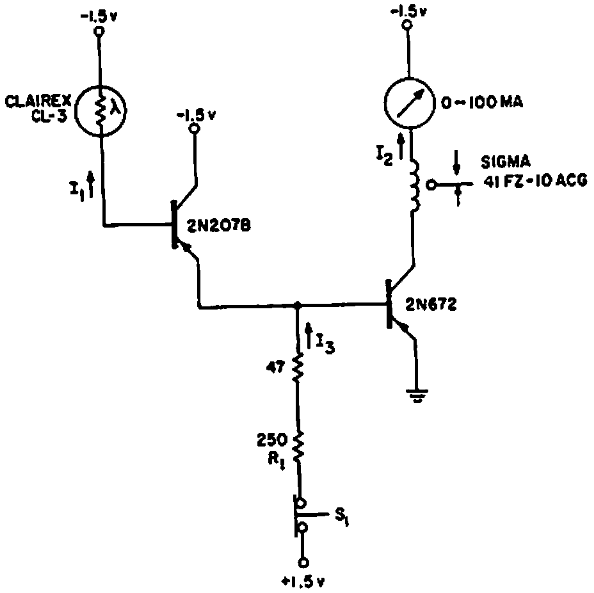
LIGHT-INTERRUPTION CONTROL—When beam between solid-state lamp and light-activated scs is interrupted, anode of silicon unilateral switch goes positive on next positive cycle of a-c line, triggering sus and scr to energize load for as long as light beam is interrupted.—L. M. Hertz, "Solid State Lamps—Part II," General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 16.

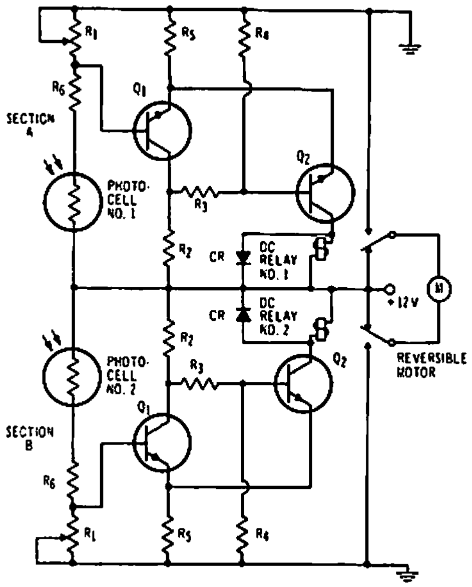

+28v
24 K
20 K
2 K
1N2175
510 K
5 uf
OUTPUT
TI 495
TI 495
TI 495
1 uf
10 K
30 K
10 K
27 K
220
100
3.3 K
100 uf
330
0.05 uf
2 K
50 uf
1.2 K
20 uf
51 K
20 uf
51 K

PHOTODUODIODE PREAMP—Provides voltage amplification of 30 dB, flat within 1 dB from 10 Hz to 20,000 Hz, for signal output of 1N2175 npn, diffused silicon photoduodiode. Applications include high-speed reading of punched cards and punched tape, light measurement, conveyor-line counting, and military light-detection systems. Output obtained across 1K load resistor is 4 V p-p.—"Preferred Semiconductors and Components," Texas Instruments, Dallas, Texas, CC101, 1968, p 27804.


+10 V
"ENERGIZED"
Q1
MRD300
C1
0.1 μF
100 V
K1
SIGMA
11F-2300-GSIL
R1
1.5 k
Q2
MPS3394

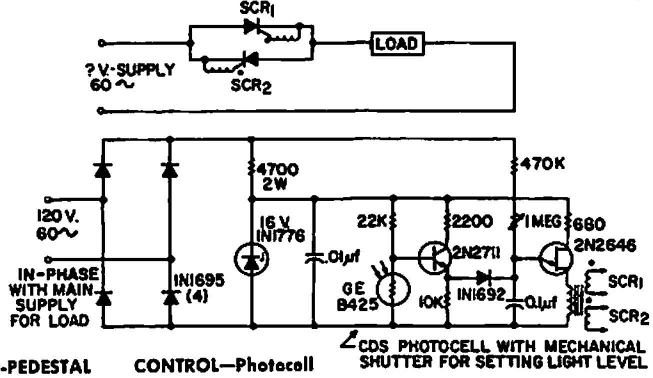
SIMPLE LIGHT-OPERATED RELAY—200 footcandles on phototransistor Q1 saturates Q2 and pulls in d-c relay. C1 protects Q2 from inductive voltage spike of relay coil.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–38.


-1.5v
CLAIREX
CL-3
-1.5v
I_1
2N2078
-1.5v
0–100MA
I_2
SIGMA
41FZ-10ACG
2N672
I_3
47
250
R_1
S_1
+1.5v

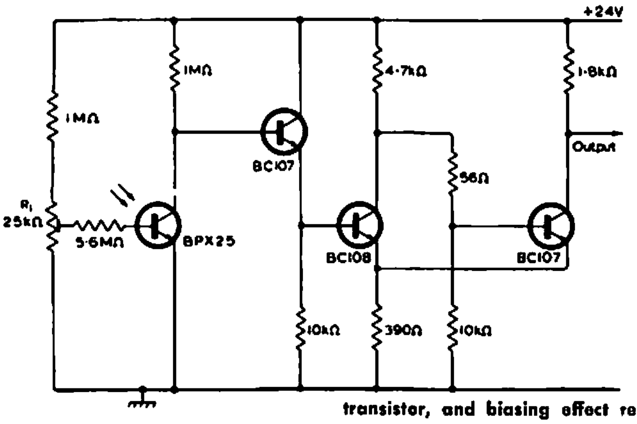

R1
R5
R4
R6
Q1
SECTION A
Q2
PHOTO-CELL NO. 1
R3
R2
CR
DC RELAY NO. 1
DC RELAY NO. 2
+12V
M
PHOTO-CELL NO. 2
REVERSIBLE MOTOR
SECTION B

HIGH-SENSITIVITY DETECTOR—Differential amplifier circuit gives relay operation for very small percentage change in light on photocell. Can be used in light-beam burglar alarm systems and machine-tool safety systems. R1 is decreased until current I2 is just sufficient to hold relay in when photocell illumination is normal. Decrease of fraction of foot-candle in light then makes I2 drop about 20 mA, releasing relay and tripping alarm. S1 must then be open momentarily to energize relay and reset system.—E. S. Gordon, Photoelectric Circuit Operates With High Light Resolution, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 107.

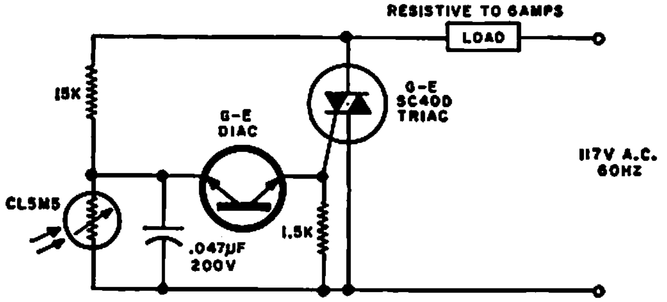
LIGHT-CONTROLLED SERVO—Two 12-V photocell-Schmitt triggers connected back-to-back apply no voltage to motor when both photocells are illuminated. When either photocell is dark, its relay pulls in and energizes motor for rotation in corresponding direction. Values: R1 5K; R2 820; R3 270; R4 820; R5 10; R6 1K; CR RCA-40266; Q1 40234; Q2 40084; photocells SQ2508; relays 96 ohms 12 V (shown de-energized).—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 27.


SCR1
LOAD
? V-SUPPLY
60 ~
SCR2
4700
2W
470K
120V.
60~
IN-PHASE WITH MAIN SUPPLY FOR LOAD
IN1695
(4)
16 V
IN1776
.01μf
22K
2200
1MEG
680
2N2646
2N2711
GE
B425
10K
IN1692
0.1μf
SCR1
SCR2
CDS PHOTOCELL WITH MECHANICAL SHUTTER FOR SETTING LIGHT LEVEL

RAMP-AND-PEDESTAL CONTROL—Photocell determines pedestal voltage to which capacitor is charged through transistor at beginning of each half-cycle. Capacitor then continues to charge along adjustable ramp until ujt triggers and fires load scr's through transformer. With lamp load for illumination control, rms voltage across load can be regulated by exposing photocell to small pilot lamp connected across load. For regulation of load current, low-voltage high-current lamp is connected in series with load and placed near photocell. For proportional control of load in response to mechanical position, sensing element should drive shutter between lamp and photocell.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 12.

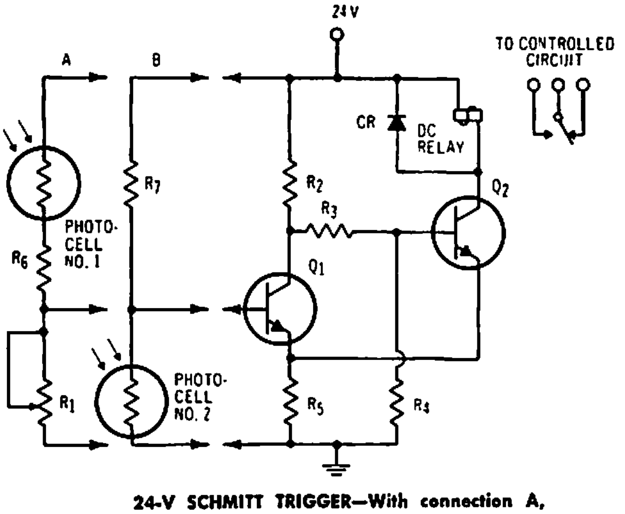

+24V
1MΩ
1MΩ
4·7kΩ
1·8kΩ
Output
BC107
56Ω
R1
25kΩ
5·6MΩ
BPX25
BC108
BC107
10kΩ
390Ω
10kΩ

REDUCING DARK CURRENT—Illumination of only 10 lux produces output voltage change of about 20 V in high-sensitivity circuit having backlash of only about 0.5 lux. Dark current is reduced by connecting high resistance between base and emitter of phototransistor, and biasing effect resulting therefrom is overcome with connection shown. Adjust R1 until phototransistor in dark is just cut off.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.

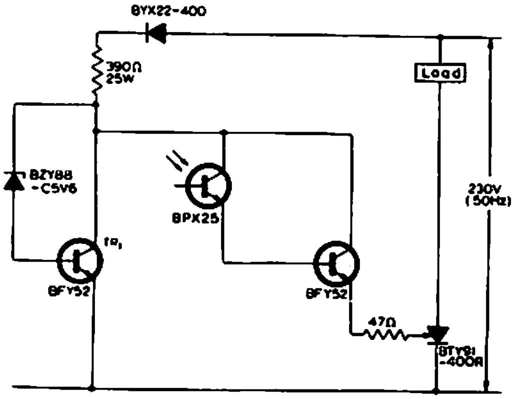

RESISTIVE TO 6AMPS
LOAD
15K
G-E
DIAC
G-E
SC40D
TRIAC
117V A.C.
60HZ
CL5M5
.047µF
200V
1.5K

CAN USE RCA-40431 IN PLACE OF BOTH SEMICONDUCTORS (OMIT 1.5K RES.)

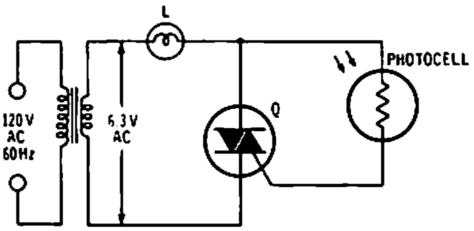
6-A TRIAC CONTROL—With illumination on photocell, triac turns off power to load.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.


24V
A
B
TO CONTROLLED CIRCUIT
CR
DC RELAY
R7
R2
R3
Q2
PHOTO-CELL NO. 1
R6
Q1
R1
PHOTO-CELL NO. 2
R5
R4

24-V SCHMITT TRIGGER—With connection A, relay is energized when light drops below value determined by setting of R1. With connection B, relay is energized when light rises above predetermined level. Values: R1 1K; R2, R3 2.2K; R4 300; R5 12; R6 10K; R7 75K; CR 40266; Q1, Q2 40084; photocell No. 1 SQ2508; photocell No. 2 SQ2519; relay 360 ohms 24 V.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 21.


BYX22-400
390Ω
25W
Load
BZY88
-C5V6
BPX25
TR1
230V
(50Hz)
BFY52
BFY52
47Ω
BTY91
-400R

A-C POWER CONTROL—When light on phototransistor rises above about 700 lux, thyristor is triggered and turns on load current up to 16 A from a-c line. Circuit does not latch on because thyristor disconnects supply from load at end of each positive half-cycle. Circuit retriggers about 6 deg past zero voltage if phototransistor still has sufficient illumination.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.


L
PHOTOCELL
120 V
AC
60 Hz
6.3 V
AC
Q

6.3-V A-C TRIAC CONTROL—Light makes photocell impedance drop, and resulting increase in cell current triggers triac on. Will handle lamp or other load currents up to 2.5 A, with 15 W maximum. Triac Q is RCA-40528 and photocell is SQ2519.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 21.

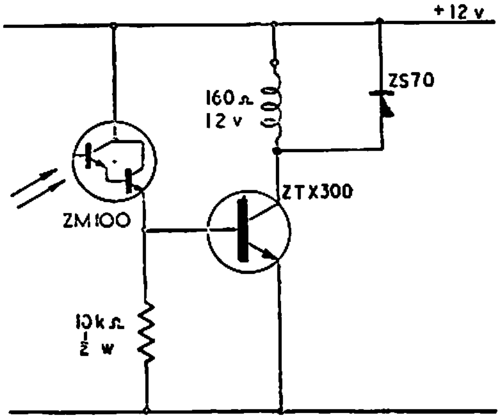

+12 v
ZS70
160 Ω
12 v
ZTX300
ZM100
10k Ω
½ W

PHOTO-DARLINGTON WITH AMPLIFIER—Transistor provides sufficient additional gain for operating relay when light level on Ferranti ZM100 photo-Darlington is below 50 lumens per sq ft.—A Photo Darlington Pair, Ferranti, Oldham, Lancs., England, No. 36, 1968.

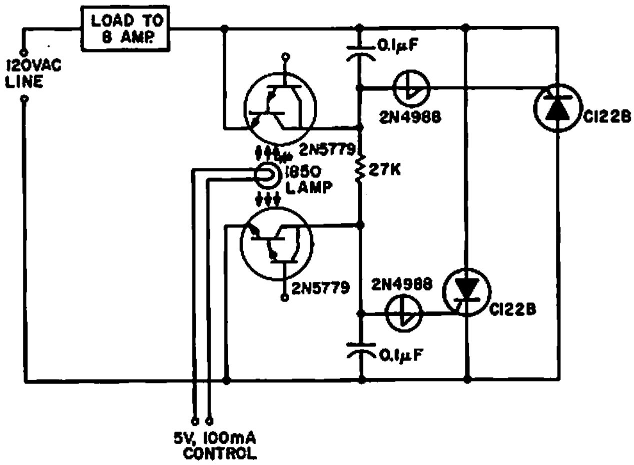
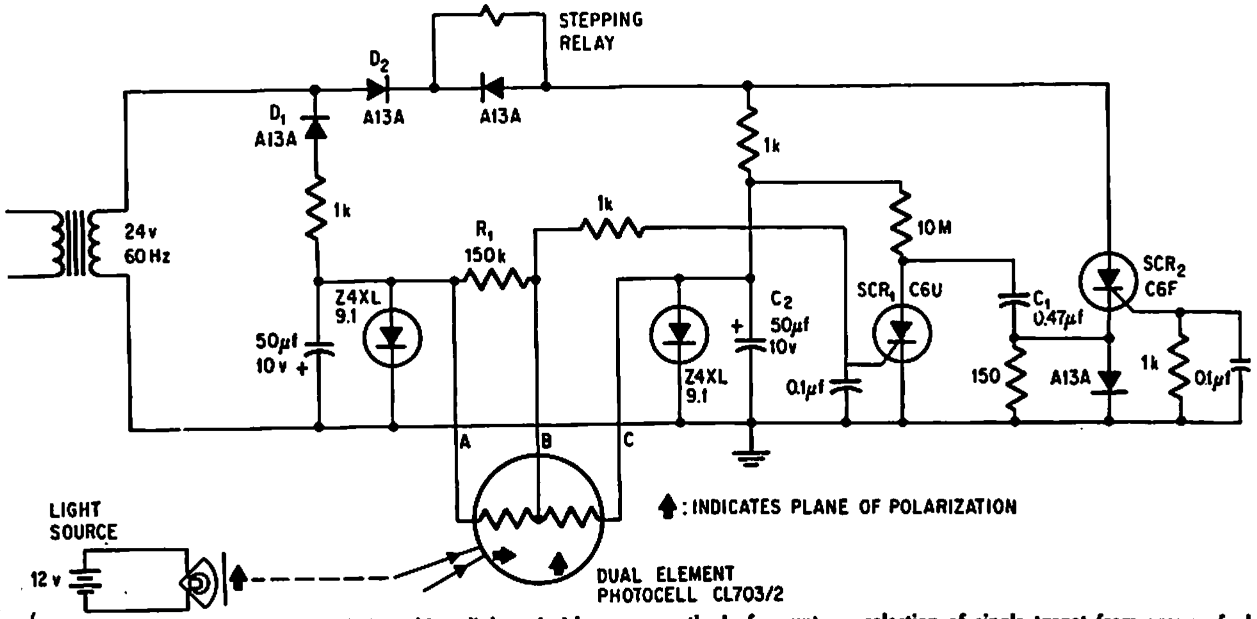
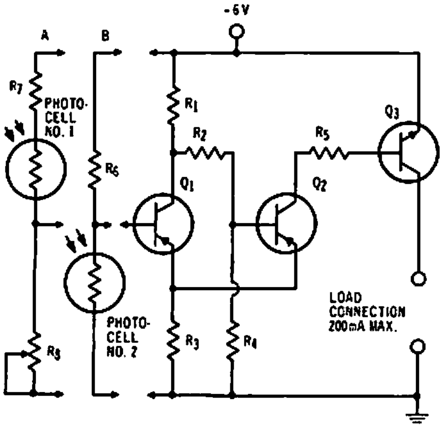

LOAD TO
8 AMP
120VAC
LINE
0.1μF
2N4988
C122B
2N5779
1850
LAMP
27K
2N5779
2N4988
C122B
0.1μF
5V, 100mA
CONTROL

PHOTO-DARLINGTON AMPLIFIER—Two 2N5779 npn planar silicon glass-housing transistors in Darlington connection are illuminated by lamp whose intensity varies with control current, for control of loads up to 1,000 W. By increasing 27K resistor to 56K and using C122D scr's, load can be 2,000 W at 240 V.—Light Sensor 2N5777-2N5780, General Electric, Syracuse, N.Y., No. 55.46, 1969.


STEPPING
RELAY
D₂
A13A
A13A
D₁
A13A
1k
1k
24 v
60 Hz
R₁
150k
1k
10M
Z4XL
9.1
50μf
10 v
Z4XL
9.1
C₂
50μf
10v
SCR₁ C6U
0.1μf
C₁
0.47μf
SCR₂
C6F
150
A13A
1k
0.1μf
A
B
C
: INDICATES PLANE OF POLARIZATION
LIGHT
SOURCE
12 v
DUAL ELEMENT
PHOTOCELL CL703/2

GARAGE-DOOR CONTROL—Polarized light source on moving vehicle can trigger photocell of control up to 50 feet away, without risk of accidental triggering by stray or ambient light. Article covers method of mounting horizontal and vertical polarizing filters in system. Can be adapted for variety of other remote control applications, including selection of single target from group of photocells.—E. K. Howell, Polarized Light Triggers Remote Control System, *Electronics*, Jan. 23, 1967, p 88–90.


-6V
A
B
R7
PHOTO-CELL NO. 1
R6
R1
R2
Q1
Q2
R5
Q3
PHOTO-CELL NO. 2
R3
R4
R8
LOAD CONNECTION 200mA MAX.

RCA PHOTOCELLS:
No.1, TYPE SQ2508
No.2, TYPE SQ2520

Q_1, Q_2: RCA-2N404
Q_3: RCA-2N388
R_1, R_2: 1200
R_3: 22
R_4: 1200
R_5: 390
R_6: 3900
R_7: 1000
R_8: 1000

6-V SCHMITT TRIGGER—With photocell connection A, load is energized when light drops below predetermined level set by R8. With connection B, load is energized when illumination rises above predetermined level.—"Solid-State Photosensitive Devices," RCA, Harrison, N.J., p 20.

SINGLE-APERTURE POSITION INDICATOR—If photocells are uniformly spaced on circumference of circle, with lamp and aperture mounted on radius arm, meter will indicate angular position of aperture by reading maximum voltage when only photocell No. 1 is illuminated and minimum voltage when lowest cell (No. 5) is illuminated. All resistors are equal, and can be any value that gives reasonable power dissipation for d-c voltage source used, while giving desired full-scale voltage at meter for light on first photocell. For conditions shown, with light on No. 3 cell, meter voltage is equal to source voltage multiplied by ratio of sum of R3, R4, and R5 to sum of all five resistances.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 26.

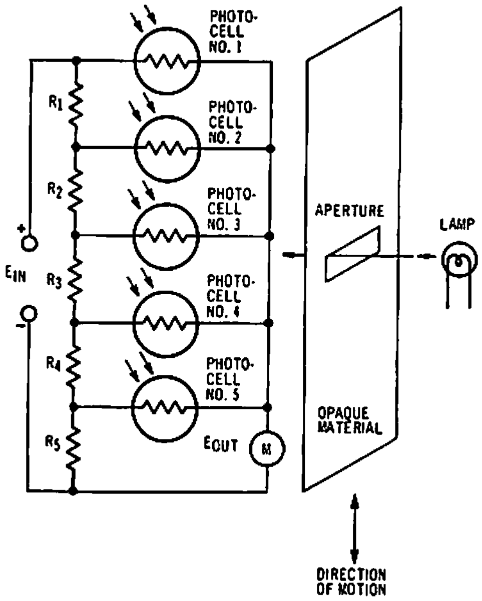
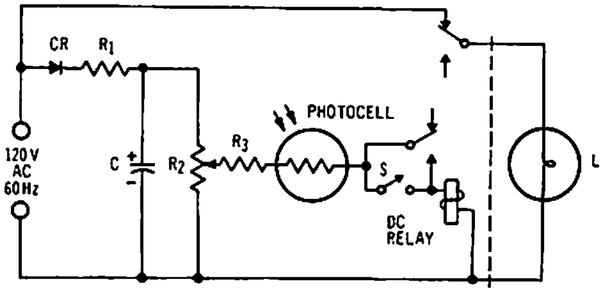
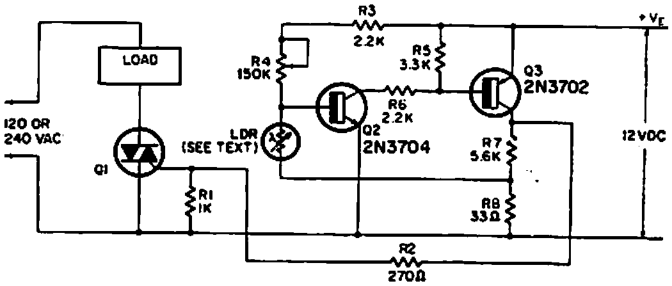


PHOTO-CELL NO. 1
PHOTO-CELL NO. 2
PHOTO-CELL NO. 3
PHOTO-CELL NO. 4
PHOTO-CELL NO. 5
R1
R2
R3
R4
R5
+
-
EIN
EOUT
M
APERTURE
LAMP
OPAQUE MATERIAL
DIRECTION OF MOTION


CR
R1
120V AC 60Hz
C
+
-
R2
R3
PHOTOCELL
S
DC RELAY
L

BURGLAR LAMP—When photocell is illuminated and switch S closed, current flows through photocell and relay, so lamp is not energized. At twilight, relay opens and lamp is connected directly across a-c line. Used to discourage burglars when home is unoccupied. Open S to reset. Values: R1 5.6; R2 25K; R3 2K; C 8 μF; CR 1N1763A; photocell 7163; relay 10K at 3.5 mA.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 23.

SENSITIVE LIGHT-OPERATED LINE SWITCH—Cadmium sulfide photocell turns triac on through Schmitt trigger Q2-Q3 when light level falls below preset value determined by R4. Circuit has very little backlash, so only small change in light level is needed to make triac turn on or off. Load can be up to 6 A, using RCA 40429 triac for 120 V and 40430 for 240 V.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.


LOAD
120 OR 240 VAC
Q1
R1 1K
R4 150K
LDR (SEE TEXT)
R3 2.2K
R5 3.3K
R6 2.2K
Q2 2N3704
Q3 2N3702
R7 5.6K
R8 33Ω
R2 270Ω
+VE
12VDC

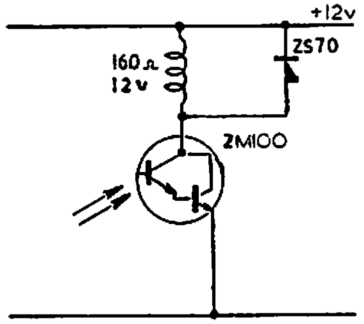
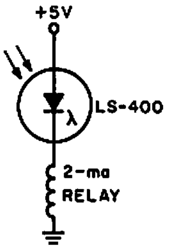
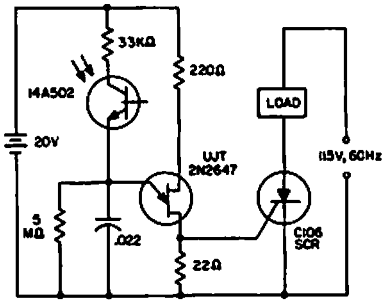

+12v
ZS70
160Ω
12v
ZM100

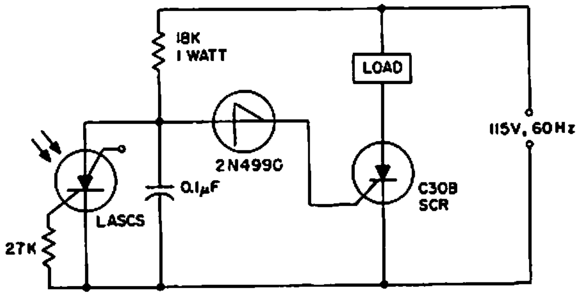
PHOTO-DARLINGTON RELAY—Uses Ferranti ZM100 photo-Darlington having high sensitivity at low light levels. Maximum dissipation rating of 300 mW at room temperature can be increased 50% by mounting on heat sink. 60-W lamp 8 inches away will produce the required 50 lumens per sq ft to switch relay.—A Photo Darlington Pair, Ferranti, Oldham, Lancs., England, No. 36, 1968.


+5V
LS-400
λ
2-ma
RELAY

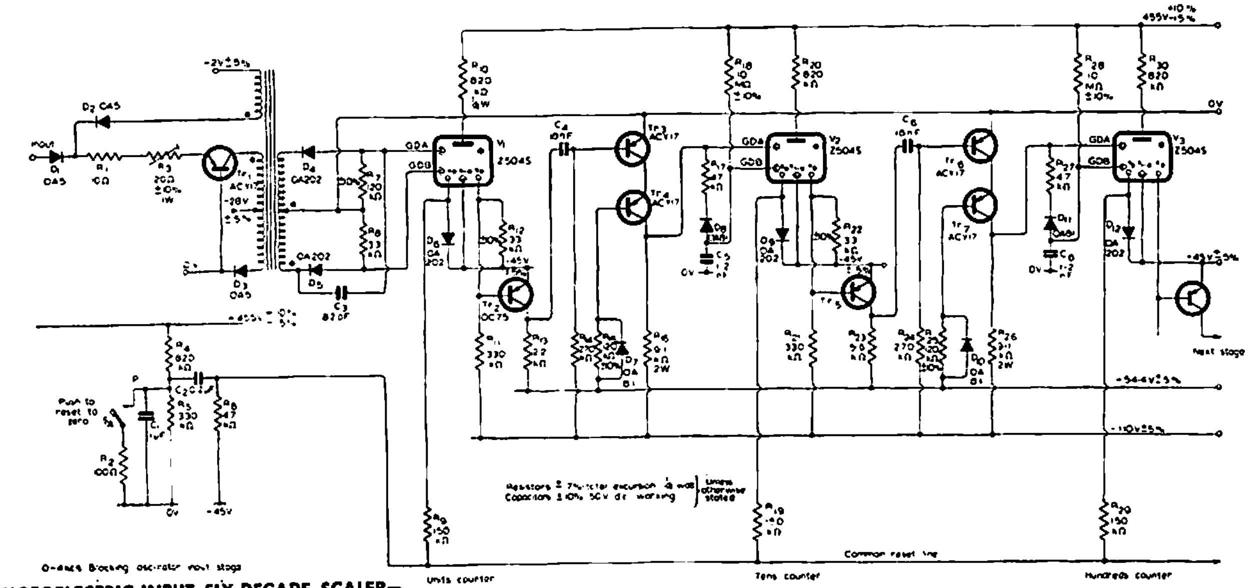
SENSOR AND RELAY—High sensitivity of Texas Instruments LS-400 npn silicon planar light sensor permits direct drive of 2-mA relay from 5-V source, eliminating need for transistor amplifier stage. Relay will pull in on minimum light intensity of 600 footcandles.—D. Abel, Light Sensors—Bright Future for an Expanding Technology, *Electronic Design*, Feb. 17, 1964, p 76–79.


33KΩ
220Ω
14A502
20V
LOAD
UJT
2N2647
115V, 60Hz
5
MΩ
.022
22Ω
C106
SCR

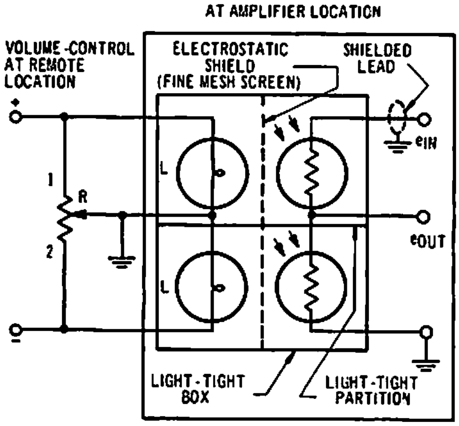
HIGH-SENSITIVITY LIGHT-PRESENCE DETECTOR—Phototransistor and ujt allow much lower levels of light to actuate scr. When light reaches phototransistor, ujt becomes relaxation oscillator, at frequency considerably above 60 Hz. Scr is then turned on early in positive half of each cycle.—"SCR Manual," 4th Edition, General Electric, 1967, p 299.


18K
1 WATT
LOAD
2N4990
115V, 60Hz
0.1μF
C30B
SCR
LASCS
27K

LIGHT-INTERRUPTION DETECTOR—When light on light-activated silicon controlled switch (lascs) is interrupted, anode voltage of 2N-4990 unilateral switch goes positive on next positive half-cycle, triggering switch and scr. Load is then energized for as long as there is no light on lascs.—"SCR Manual," 4th Edition, General Electric, 1967, p 298.

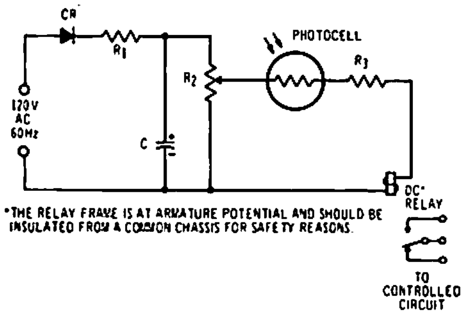

-2V±5%
D2 OA5
Input
D1
OA5
R1
100Ω
R3
200Ω
±10%
1W
Tr1
ACY17
-28V
±5%
D4
OA202
R7
120
kΩ
R8
33
kΩ
0V
D3
OA5
OA202
D5
C3
820F
R10
820
kΩ
¼W
GDA
GDB
V1
Z504S
C4
10nF
Tr3
ACY17
Tr4
ACY17
D6
OA
202
R12
33
kΩ
+45V
Tr2
OC75
R11
330
kΩ
R13
22
kΩ
R6
91
kΩ
2W
D7
OA
81
R17
47
kΩ
D8
C5
1·2
nF
0V
R4
820
kΩ
P
C2
Push to reset to zero
S1
C1
R5
330
kΩ
R8
47
kΩ
R2
100Ω
0V
-45V
Resistors ± 7% total excursion ¼ watt
Capacitors ±10% 50V dc working
unless otherwise stated
R9
150
kΩ
D-decade Blocking oscillator input stage
Units counter
+10%
455V-5%
R18
10
MΩ
±10%
R20
820
kΩ
0V
V2
Z504S
C6
10nF
Tr6
ACY17
Tr7
ACY17
D9
OA
202
R22
33
kΩ
+45V
Tr5
R21
330
kΩ
R23
56
kΩ
R24
270
kΩ
R25
120
kΩ
D10
OA
81
R26
91
kΩ
2W
R27
47
kΩ
D11
C8
1·2
nF
0V
R28
10
MΩ
±10%
R30
820
kΩ
V3
Z504S
D12
OA
202
+45V±5%
Next stage
+54·4V±5%
+10V±5%
R19
150
kΩ
Common reset line
Tens counter
R29
150
kΩ
Hundreds counter

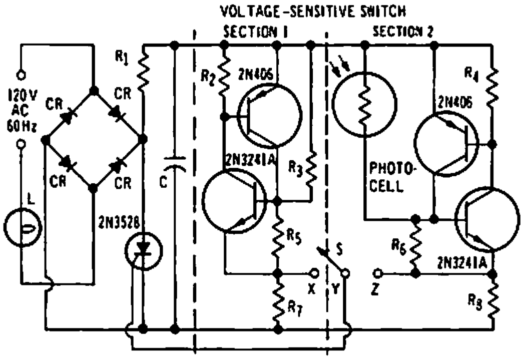
PHOTOELECTRIC-INPUT SIX-DECADE SCALER—Will count up to 25 objects per second moving through light beam if ORP60 cadmium sulfide cell is used with 2,000-lux level, and up to 13 objects per second with 1,000-lux RPY15 cell. Four additional decades may be added, each having gas-filled Z504S decade counter and three-transistor pulse-shaper coupler.—G. C. Chappell and G. F. Jeynes, Transistor Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 26–38.


AT AMPLIFIER LOCATION
VOLUME-CONTROL AT REMOTE LOCATION
ELECTROSTATIC SHIELD (FINE MESH SCREEN)
SHIELDED LEAD
eIN
eOUT
1
R
2
L
L
LIGHT-TIGHT BOX
LIGHT-TIGHT PARTITION

REMOTE POT—Permits adjusting volume of hi-fi or p-a system from practically any desired distance, using only battery and pot R at remote location. When arm of A is at 1, upper lamp is out and lower lamp is lit, so lower photocell has minimum resistance and provides maximum attenuation of audio signal.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 27.

120-V A-C PHOTORELAY—Will operate at light levels as low as 1 foot-candle. R2 adjusts sensitivity of circuit. Suitable for either on-off control or gradual changes in illumination. Values: R1 5.6; R2 25K; R3 2K; C 8 μF; CR 1N1763A; photocell 7163; relay 10K at 2.5 mA.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 21.


CR
R1
PHOTOCELL
R2
R3
120V AC 60Hz
C
DC* RELAY
*THE RELAY FRAME IS AT ARMATURE POTENTIAL AND SHOULD BE INSULATED FROM A COMMON CHASSIS FOR SAFETY REASONS.
TO CONTROLLED CIRCUIT


VOLTAGE-SENSITIVE SWITCH
SECTION 1
SECTION 2
120V AC 60Hz
CR
CR
CR
CR
R1
R2
2N406
R4
2N406
2N3241A
R3
PHOTO-CELL
L
C
2N3528
R5
S
R6
2N3241A
X
Y
Z
R7
R8

120-V A-C SCR CONTROL FOR 150 W—Switch S reverses operation of circuit; when set at X, scr is on when photocell is dark, and increase in light makes it turn off load. When set at Z, load is energized by increase in light level. Values: R1 4.7K; R2, R4 150; R3 56K; R5, R6 4.7K; R7, R8 15; C 0.22 μF; CR 1N2861A; photocell 7163; load L 150 W.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 22.

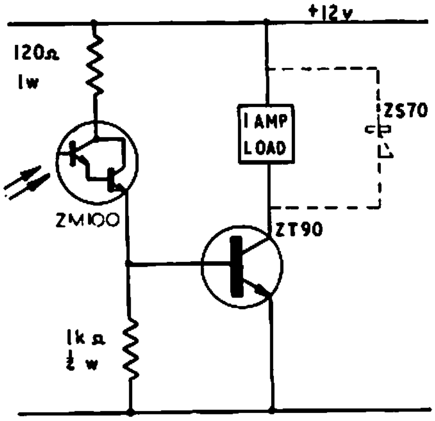
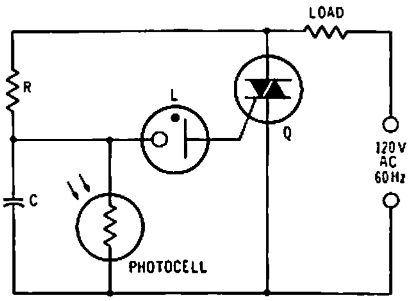
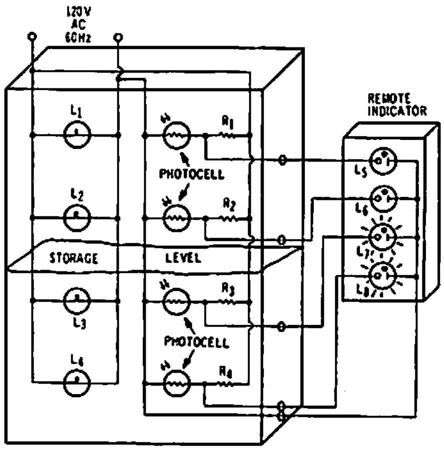

+12v
120Ω 1w
1 AMP LOAD
ZS70
ZM100
ZT90
1kΩ ¼ w

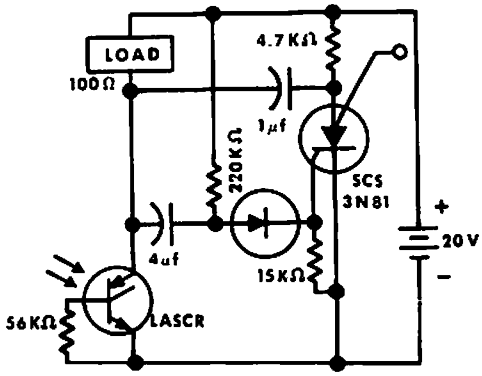
PHOTO-DARLINGTON FOR 1-A LOAD—When illumination on Ferranti ZM100 photo-Darlington is above 50 lumens per sq ft, only one transistor amplifier stage is required to turn on 1-A load. Inductive loads require diode in parallel to reduce voltage transients.—A Photo Darlington Pair, Ferranti, Oldham, Lancs., England, No. 36, 1968.


LOAD
R
L
Q
120V AC 60Hz
C
PHOTOCELL

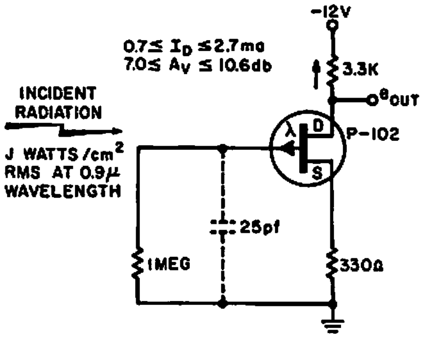
120-V A-C TRIAC CONTROL—When photocell is dark, its impedance is high and C charges to firing voltage of neon L, triggering triac on and delivering power to load. Increase in light reduces photocell impedance, so C cannot charge enough to fire neon and trigger triac; load is then off. Q can be RCA 40429, 40485, or 40575 silicon triac. Photocell is RCA 7163, L is 5AH neon, C is 0.1 μF, and R is 15K.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 22.


120V AC 60Hz
REMOTE INDICATOR
L1
R1
PHOTOCELL
L2
R2
STORAGE
LEVEL
L3
R3
PHOTOCELL
L4
R4
L5
L6
L7
L8

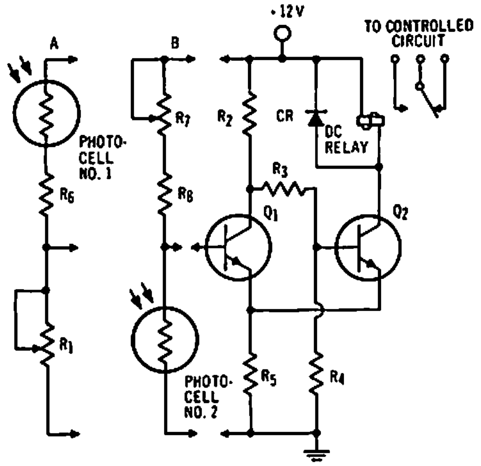
BIN LEVEL INDICATOR—Can be used with any number of levels. When grain or other dry material in bin blocks light from lamp to photocell, associated neon 3AG lamp comes on. Highest lamp glowing on indicator panel corresponds to level in bin. Photocells are RCA SQ 2503 and resistors are 330K.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 26.


LOAD
100Ω
4.7KΩ
1μf
220KΩ
SCS
3N81
+
20V
-
4uf
15KΩ
56KΩ
LASCR

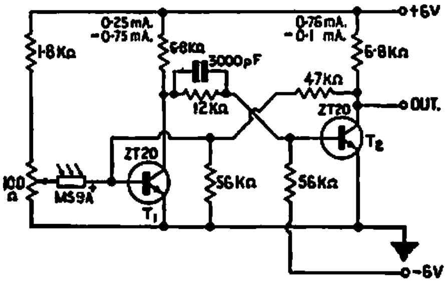
LIGHT-TRIGGERED ONE-SHOT—With no light on lascr, scs conducts but load is off. Short pulse of light on lascr turns it on and turns off scs. Load, which may be indicator lamp, is then energized. After delay of about 0.6 s while 4-μF capacitor charges through 220K, scs is turned on and lascr is commutated off. Useful for detecting presence of pulses of light lasting longer than some minimum time. For longer pulses, lascr remains conducting and indicator stays on.—L. M. Hertz, "Solid State Lamps—Part II," General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 16.


-12V
$0.7 \leq I_D \leq 2.7$ma
$7.0 \leq A_V \leq 10.6$db
3.3K
OUT
INCIDENT RADIATION
J WATTS/cm²
RMS AT 0.9μ
WAVELENGTH
D
P-102
S
25pf
1MEG
330Ω

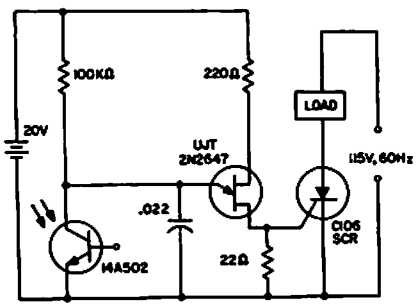
CHOPPED-LIGHT DETECTOR—Photo-fet in simple circuit provides 8 dB gain for chopped incident light, in much less space than photodiode-transistor combination. Upper frequency limit is about 7 kHz.—M. Shipley, Using Photo Field-Effect Transistors, *Electronic Design*, Aug. 31, 1964, p 76.


+12V
TO CONTROLLED CIRCUIT
A
B
PHOTO-CELL NO. 1
R7
R2
CR
DC RELAY
R3
R6
R8
Q1
Q2
R1
PHOTO-CELL NO. 2
R5
R4

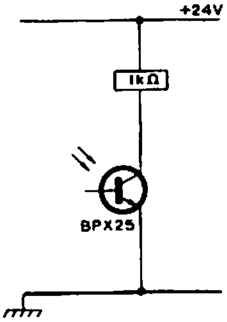
12-V SCHMITT TRIGGER—With connection A, relay is energized when light drops below value determined by setting of R1. With connection B, relay is energized when light rises above level set by R7. Values: R1 5K; R2 820; R3 270; R4 820; R5 10; R6 1K; R7 10K; R8 1.2K; CR 40266; Q1 40234; Q2 40084; photocell No. 1 SQ2508; photocell No. 2 SQ-2536; relay 96 ohms 12 V.—"Solid-State Photosensitive Devices," RCA, Harrison, N.J., p 20.


+6V
0·25mA.
-0·75mA.
0·75mA.
-0·1 mA.
1·8KΩ
68KΩ
3000pF
6·8KΩ
47KΩ
12KΩ
OUT.
2T20
2T20
T2
100 Ω
MS9A
T1
56KΩ
56KΩ
-6V

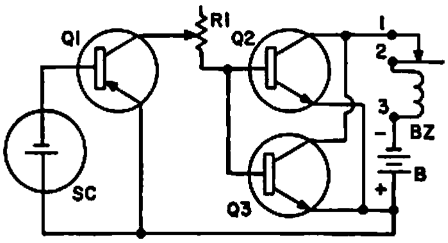
TAPE READER WITH ECCLES-JORDAN TRIGGER—Gives reliable reading of holes in moving punched cards or tape, for light intensities of 1,000 to 3,000 lumens per sq ft. Ambient temperature can be up to 100 C.—"Silicon Photocell Applications," Ferranti Ltd., Oldham, Lancs., England, No. 9, 1967, p 8.


100KΩ
220Ω
20V
LOAD
UJT
2N2647
115V, 60Hz
.022
C106
SCR
22Ω
14A502

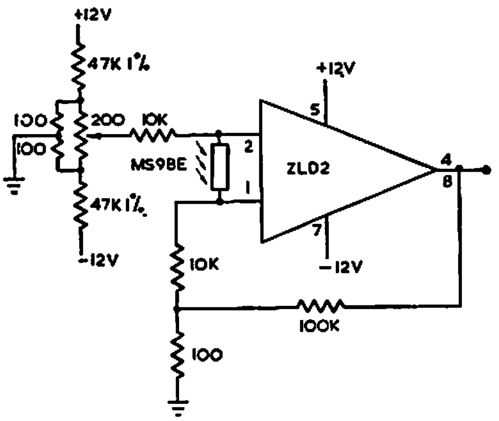
HIGH-SENSITIVITY LIGHT-ABSENCE DETECTOR—When phototransistor is dark, ujt operates as relaxation oscillator and energizes scr and load on positive half-cycles.—"SCR Manual," 4th Edition, General Electric, 1967, p 299.


+24V
1kΩ
BPX25

DIRECT CONTROL OF RELAY—With 24-V 1,000-ohm relay, illumination of about 10,000 lux will energize relay. Lower illumination can be used with higher-resistance relay.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.

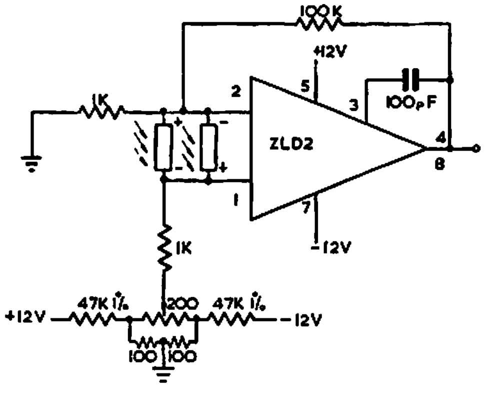

Q1
R1
Q2
1
2
3
BZ
B
SC
Q3
-
+

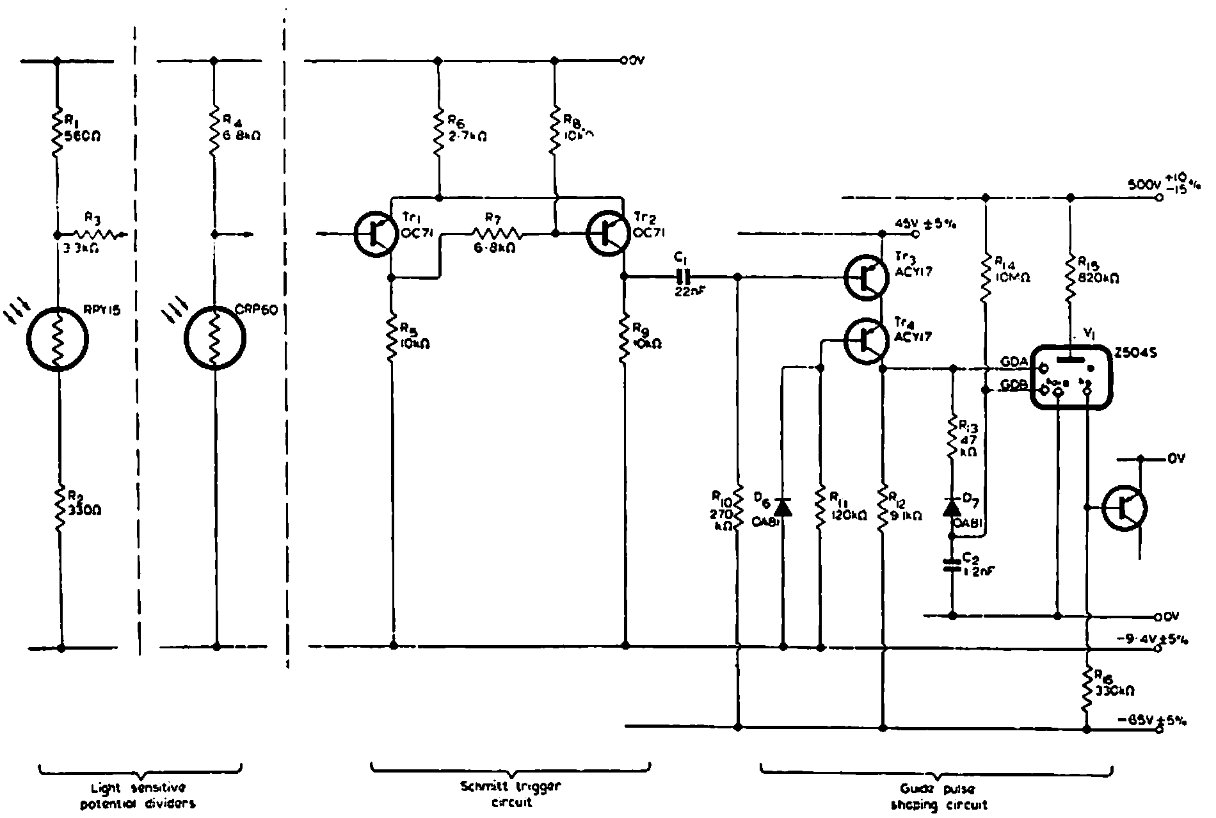
SOLAR-CELL BUZZER—Flashlight beam on solar cell makes pnp transistor Q1 turn on paralleled npn transistors Q2 and Q3 to close 3-V flashlight-cell circuit to small buzzer. R1 is 50K pot. Transistor types are not critical, and may be low-cost units. Solar cell and other parts are available from Radio Shack, 730 Commonwealth Ave., Boston, Mass.—Light Operated Buzzer, *Elementary Electronics*, Jan.–Feb. 1968, p 14.


+12V
47K 1%
100
100
200
10K
MS9BE
2
1
ZLD2
+12V
5
4
8
7
-12V
47K 1%
-12V
10K
100K
100

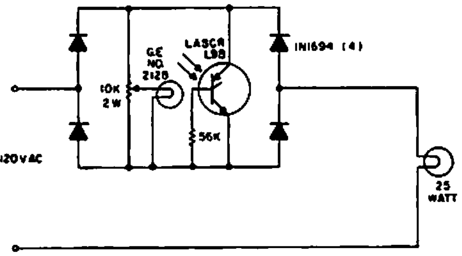
IC TRIGGER—Ferranti ZLD2 IC differential amplifier is operated with positive feedback to give triggering when silicon photocell generates voltage in excess of 5-mV input hysteresis value. Potentiometer serves to compensate for offset voltage of amplifier.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 19.

POSITION-SENSING SERVO—Two silicon MS-9B photocells mounted side by side are illuminated by single narrow beam of light. Relative movement between beam and photocells causes one photocell to generate more output than the other, for amplification by Ferranti ZLD2 IC differential amplifier. Polarity of output depends on which photocell has more illumination. Output is zero for equal illumination. Gain is 100 with parallel voltage feedback as shown.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 20.

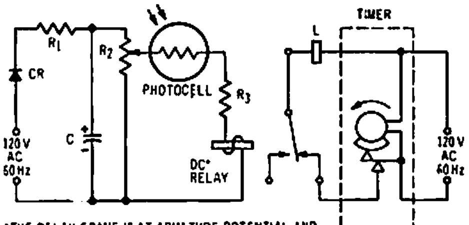

100K
+12V
2
5
3
100pF
1K
ZLD2
4
8
1
7
-12V
1K
+12V
47K 1%
200
47K 1%
-12V
100
100


0V
R1 560Ω
R4 6·8kΩ
R6 2·7kΩ
R8 10kΩ
R3 3·3kΩ
RPY15
ORP60
Tr1 OC71
R7 6·8kΩ
Tr2 OC71
R5 10kΩ
R9 10kΩ
C1 22nF
500V +10% −15%
45V ±5%
Tr3 ACY17
Tr4 ACY17
R14 10MΩ
R15 820kΩ
V1
Z504S
GDA
GDB
R13 47kΩ
D7 OA81
C2 1·2nF
R10 270kΩ
D6 OA81
R11 120kΩ
R12 9·1kΩ
R2 330Ω
0V
0V
-9·4V ±5%
R16 330kΩ
-85V ±5%
Light sensitive potential dividers
Schmitt trigger circuit
Guide pulse shaping circuit

25-HZ PHOTOELECTRIC COUNTER—Will count objects moving through light beams at speeds up to 25 objects per second if ORP60 cadmium sulfide input network is used; this requires illumination level of at least 2,000 lux, falling to background level below 10 lux when object interrupts light beam. Alternative RPY15 cell requires only 1,000 lux but counting speed is limited to 13 objects per second. Photocell drives Schmitt trigger that generates pulse with required rise time to operate ACY17 cascode circuit feeding Z504S cold-cathode decade stepping tube.—G. C. Chappell and G. F. Joynes, Transistor Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 26–38.

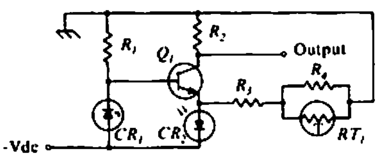

IN1694 (4)
GE NO. 2120
LASCR L9B
10K 2W
56K
120VAC
25 WATT

TINY 25-W PHASE CONTROL—Consists only of miniature lamp, lascr, four small diodes, and two resistors, almost fitting in walnut shell. Can be used for continuous phase control of small heating element such as soldering iron and for dimming lamps up to 25 W. At low applied voltages, miniature lamp will still reach lascr firing level in about 3 Hz because of its small low-mass filament. Lamp voltage drops to zero when lascr fires, protecting lamp and resetting it for next half-cycle. Lamp should touch lascr.—E. K. Howell, The Light Activated SCR, General Electric, Syracuse, N.Y., No. 200.34, 1965.


TIMER
L
R1
R2
CR
PHOTOCELL
R3
120V AC 60Hz
C
DC* RELAY
120V AC 60Hz

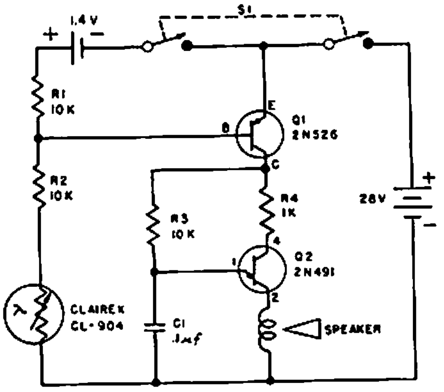
*THE RELAY FRAME IS AT ARMATURE POTENTIAL AND SHOULD BE INSULATED FROM A COMMON CHASSIS FOR SAFETY REASONS.

TWILIGHT TURN-ON AND CLOCK TURN-OFF—For window display lights in stores. 24-hour timer is set so its contacts close in mid-afternoon and open at desired turn-off time for display in late evening. Lights cannot come on in daylight, however, because relay is energized when photocell is illuminated. At twilight, photocell impedance goes up, relay drops out, current flows through lamp load, and timer takes over. Values: R1 5.6; R2 25K; R3 2K; C 8 μF; CR 1N1763A; photocell 7163; timer Intermatic T101.—"Solid State Photosensitive Devices," RCA, Harrison, N.J., p 23.

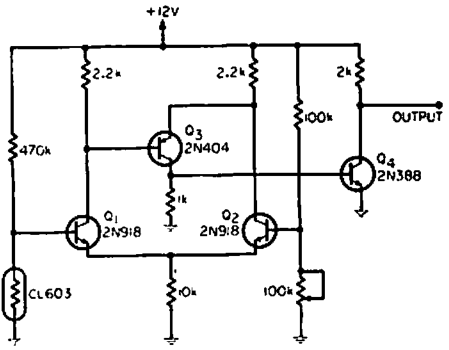

R_1
R_2
Q_1
Output
R_3
R_4
CR_1
CR_2
RT_1
-Vdc

Supply	−4 V dc
CR_1	1N758
CR_2	1N2175
R_1	1.2K
R_2	510K
R_3	82K
R_4	1.8 Ω

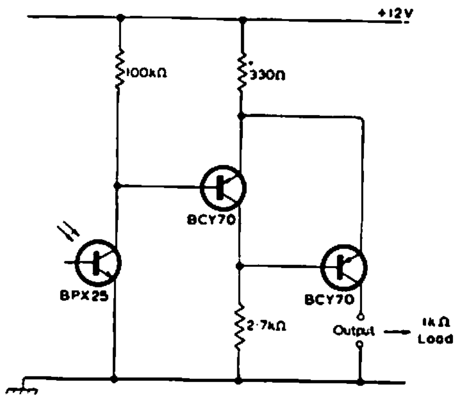
DIRECT-COUPLED PHOTODIODE SWITCH—Uses low-cost components to provide temperature compensation, for accurate sensing of light in control applications. Responds to very slow changes in illumination.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 88.


1.4 V
S1
R1 10K
R2 10K
Q1 2N526
E
B
C
R3 10K
R4 1K
28V
Q2 2N491
C1 .1μf
CLAIREX CL-904
SPEAKER

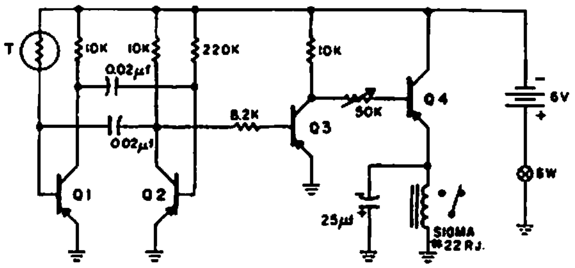
VIEWING PANEL LAMP REMOTELY—Photocell in housing is taped or otherwise fastened over panel lamp, to actuate 1,000-Hz oscillator that drives speaker. When lamp comes on, tone can be heard by technician working at rear of equipment or elsewhere. Eliminates need for setting up mirrors or walking around equipment to observe effect of each change on front-panel indicator lamp.—E. S. Kennedy, Monitor for Hidden Indicators, *Electronics World*, Aug. 1968, p 76.


+12V
2.2k
2.2k
2k
100k
OUTPUT
470k
Q3 2N404
Q4 2N388
1k
Q1 2N918
Q2 2N918
CL603
10k
100k

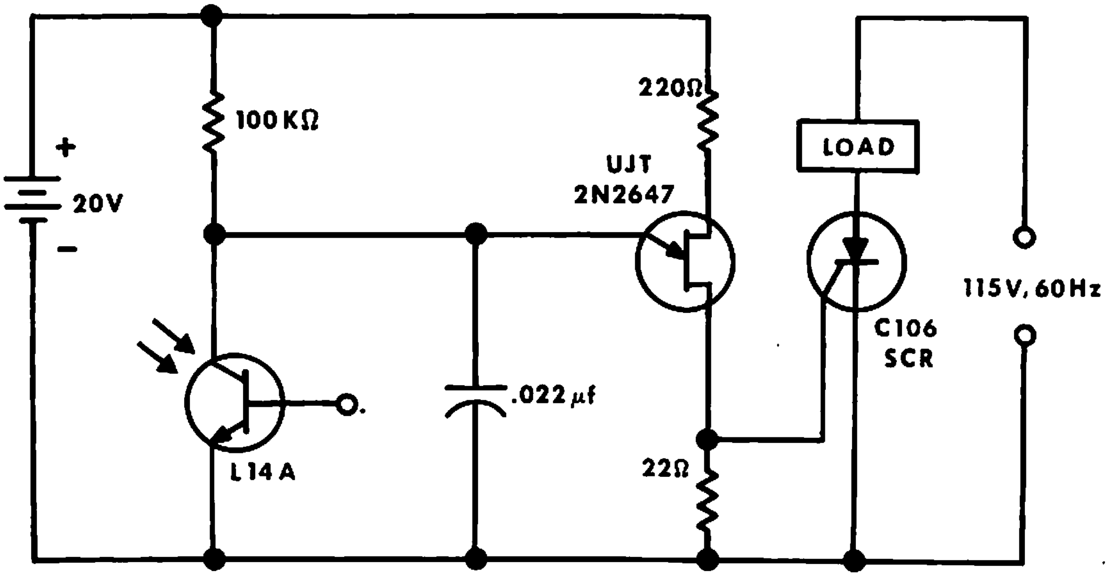
VARIABLE-THRESHOLD AMPLIFIER—When incident light on photocell reaches predetermined threshold level set by 100K pot, circuit switches rapidly from 12 V output to 0 output, for driving standard logic. Low current drain permits battery operation. Developed to detect change from daylight to darkness and automatically select best operating frequency for radio transmitter. Will function equally well for other applications with thermistor or humidity sensor in place of photocell.—C. Becklein, Photocell Threshold Circuit, *EEE*, April 1967, p 139.



BISTABLE AMPLIFIER—Operates with illumination levels as low as 50 lux. Will drive electronic counter at speeds up to 6,000 counts per second. When phototransistor is illuminated above 50 lux, circuit has no output. Without illumination, output is 8 mA at 8 V into 1K load. Suitable for elevator door-safety control, level indicator, card reader, batch counter, or burglar alarm applications.—Applications of Silicon Planar Phototransistor BPX25, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 316, 1967.



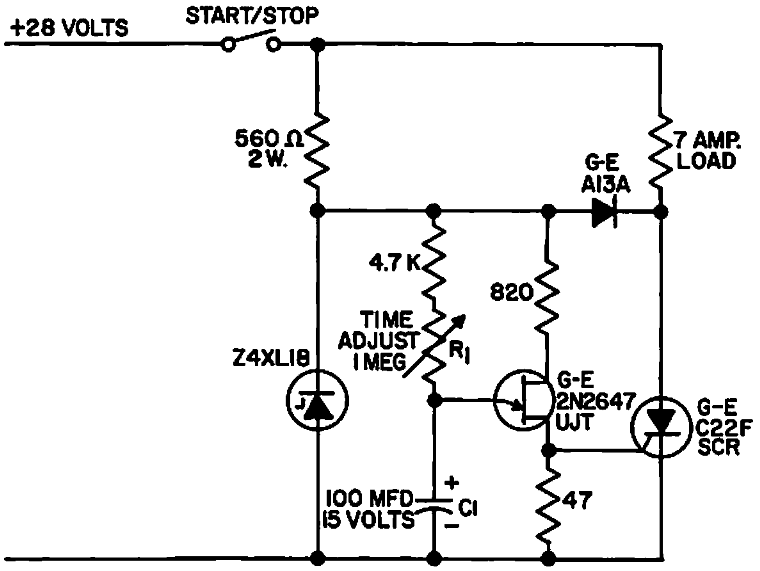
BURGLAR ALARM—Hupp class-2 cadmium sulfide photocell T varies frequency of free-running mvbr Q1-Q2 in accordance with variations of incident light. With full illumination, duty cycle of oscillator pulse train is about 15%. When beam of light is interrupted, as by intruder, duty cycle increases to about 65%. Amplifier Q3 drives emitter-follower Q4 to keep relay normally energized. Relay opens when beam is broken or power fails, to trip alarm connected to contacts. With small focusing lens on photocell, interruption of beam from ordinary two-cell flashlight over 200 ft away will trip alarm, even in presence of high ambient light. Transistor types are not critical.—J. Porter, A Cadmium Sulfide Photocell Indicator, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 103.



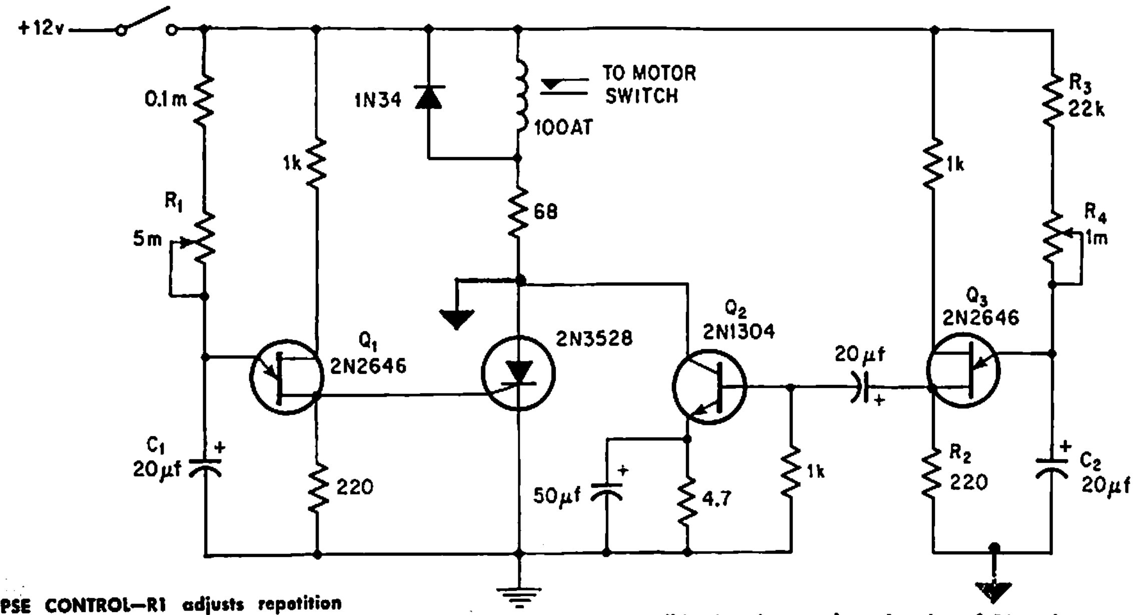
HIGH-SENSITIVITY LIGHT DETECTOR—Energizes load on positive half-cycles when light is removed from phototransistor, with ujt then operating as relaxation oscillator.—L. M. Hertz, "Solid State Lamps—Part II," General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 11.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

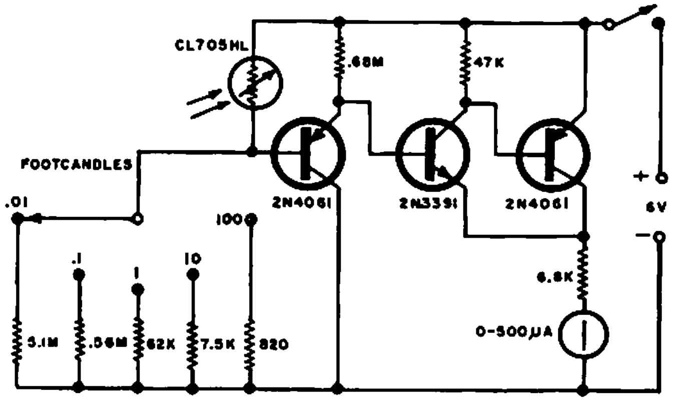
CHAPTER 63
Photography Circuits


+28 VOLTS
START/STOP
560 Ω
2 W.
7 AMP.
LOAD
G-E
A13A
4.7 K
820
TIME
ADJUST
1 MEG
R1
Z4XL18
G-E
2N2647
UJT
G-E
C22F
SCR
100 MFD
15 VOLTS
C1
47

D-C DELAY RELAY—Turns off 7-A load at precise predetermined time after switch is closed, from 1 to 60 s, as determined by setting of R1. For shorter delays, use smaller values for R1 and C1. Applications include enlarger control in photography, process control, alarms, etc.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 3.

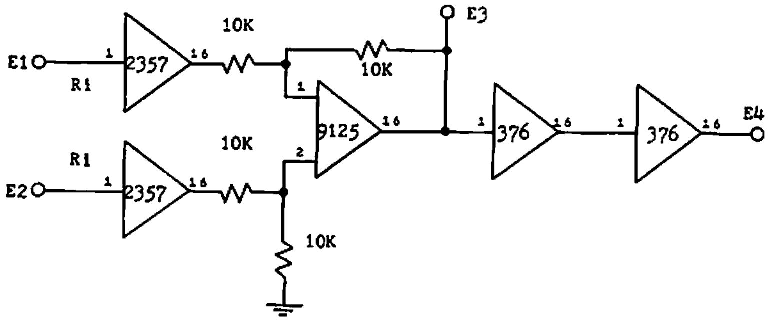

+12v
0.1 m
R1
5 m
1k
1N34
100AT
TO MOTOR
SWITCH
68
Q1
2N2646
2N3528
Q2
2N1304
20 μf
Q3
2N2646
R3
22k
1k
R4
1m
C1
20 μf
220
50 μf
4.7
1k
R2
220
C2
20 μf

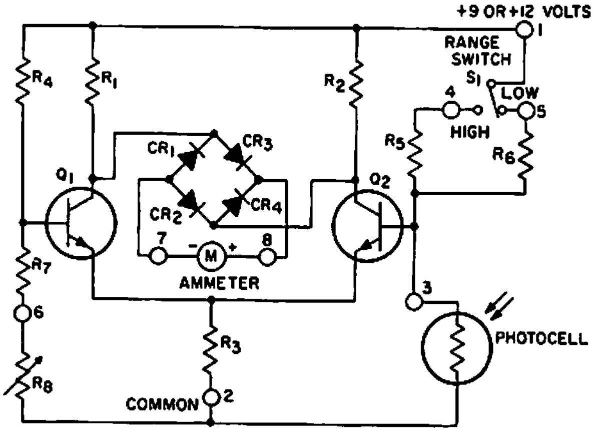
TIME-LAPSE CONTROL—R1 adjusts repetition rate of output pulse over range of 2–60 s between pulses, and R4 adjusts pulse duration from 0.5 to 25 s. Applications include shutter control in time-lapse photography, control of strip-chart recorders, starting and stopping of motors connected to relay contacts, and handling of other small loads either directly or through relay. When C1 is charged to firing voltage of ujt Q1, scr is turned on and relay is energized. Since scr has negligible voltage drop when conducting, its anode is at virtual ground. This places junction of R2 and C2 also at virtual ground, and C2 charges until it fires Q3 and thereby turns on Q2 to open scr and relay. Cycle then repeats.—T. T. Kalal, Pulse Width Varied by a "Switched Ground," *Electronics*, April 28, 1969, p 77.


CL705HL
.68M
47K
FOOTCANDLES
.01
.1
1
10
100
2N4061
2N3391
2N4061
+
6V
−
6.8K
0-500µA
5.1M
.56M
62K
7.5K
820

FIVE-RANGE PHOTOMETER—Ranges from 0.01 to 100 foot-candles are in decade steps. Load resistors for photocell are chosen so each range gives full-scale meter reading.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.

SPECTROPHOTOMETER OUTPUT CONVERTER—First three modules convert measured transmission value at particular wavelength to density value by obtaining difference of two logarithms. Next two modules (complement of 2357) are required only when obtaining exposure from density. Dynamic range is 90 dB for d-c to 1 kHz, or 40 dB for d-c to 100 kHz. Ri is 1,000 ohms for 10-V full-scale input. Light-sensitive current devices may be used in place of E1 and E2.—Conversion of Transmission to Density and Density to Exposure, Optical Electronics, Tucson, Ariz., No. 10133.


E1
R1
1
2357
16
10K
10K
E3
1
9125
2
16
1
376
16
1
376
16
E4
R1
E2
1
2357
16
10K
10K


+9 OR +12 VOLTS
1
RANGE SWITCH
S1
4
LOW
5
HIGH
R4
R1
R2
R5
R6
CR1
CR3
CR2
CR4
Q1
Q2
7
8
M
AMMETER
R7
6
R3
3
PHOTOCELL
R8
COMMON
2

ENLARGER EXPOSURE METER—After correct exposure time is determined experimentally with test negative, photocell of meter is placed on easel at center of interest, and R8 is adjusted for zero meter deflection with test negative. Negative to be printed is then inserted in enlarger, photocell is moved to center of interest for that negative, and iris of enlarger is adjusted for zero deflection. Photocell is removed, printing paper inserted, and exposure made for same time as test negative. Low range of meter covers 0.2–6 foot-candles, and high range 6–400 foot-candles.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 78.

$CR_1CR_2CR_3CR_4$ = silicon rectifier, type 1N270

M = meter, 0 to 1 milliampere, 12 volt, or 0 to 500 microamperes, 9 volt

Photocell = RCA KD2106

Q_1Q_2 = transistor, RCA SK3020

$R_1R_2R_7$ = 4700 ohms, 1/2 watt, 10%

R_3 = 2200 ohms (12 volts), 3300 ohms (9 volts), 1/2 watt, 10%

R_4 = 47,000 ohms, 1/2 watt, 10%

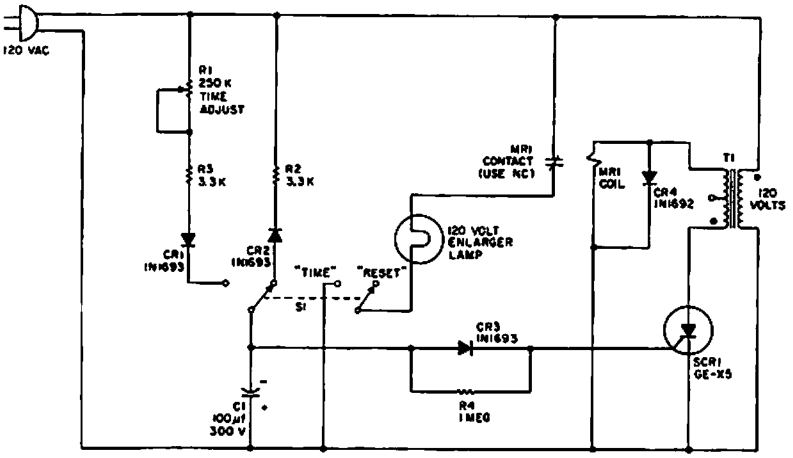
R_5 = 100,000 ohms, 1/2 watt, 10%

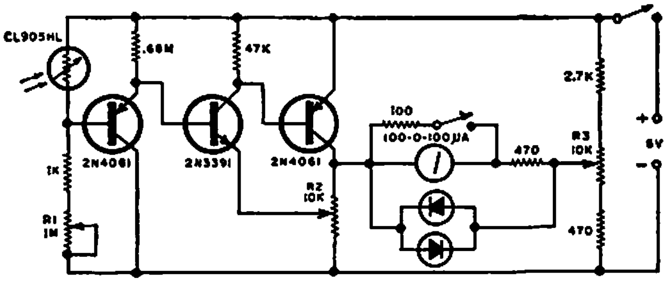
R_6 = 10,000 ohms, 1/2 watt, 10%

R_8 = potentiometer, 50,000 ohms, linear taper

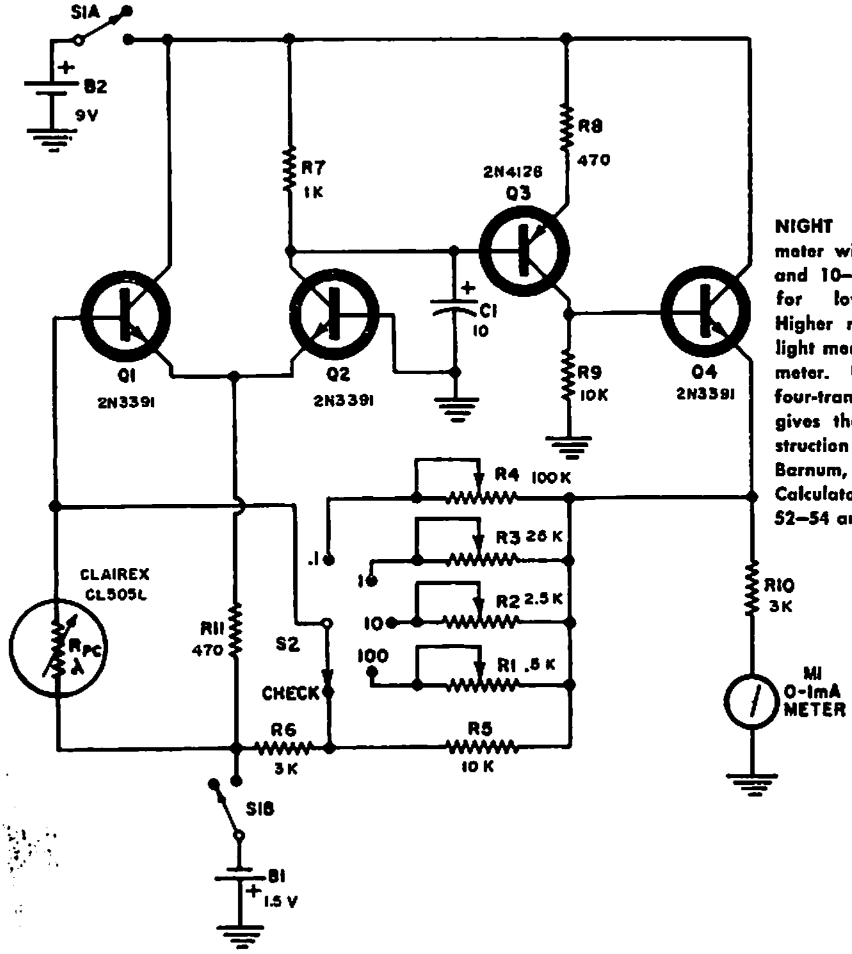
S_1 = range switch, single-pole, double-throw

TIMER FOR ENLARGER—Print-exposure timer gives adjustable delays from fraction of second to 1 min for automatic turn-off of printer or enlarger after exposure is started. Timing accuracy is 2%. Will handle relay or other loads up to 5 A. T1 is 12.6-V filament transformer such as Triad F25X. MR1 is 24-V a-c relay such as Potter & Brumfield MR5A.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 164.


120 VAC
R1
250 K
TIME
ADJUST
R3
3.3K
R2
3.3K
CR1
1N1693
CR2
1N1693
"TIME"
"RESET"
S1
MR1
CONTACT
(USE NC)
120 VOLT
ENLARGER
LAMP
MR1
COIL
CR4
1N1692
T1
120
VOLTS
CR3
1N1693
SCR1
GE-X5
C1
100 μf
300 V
R4
1 MEG

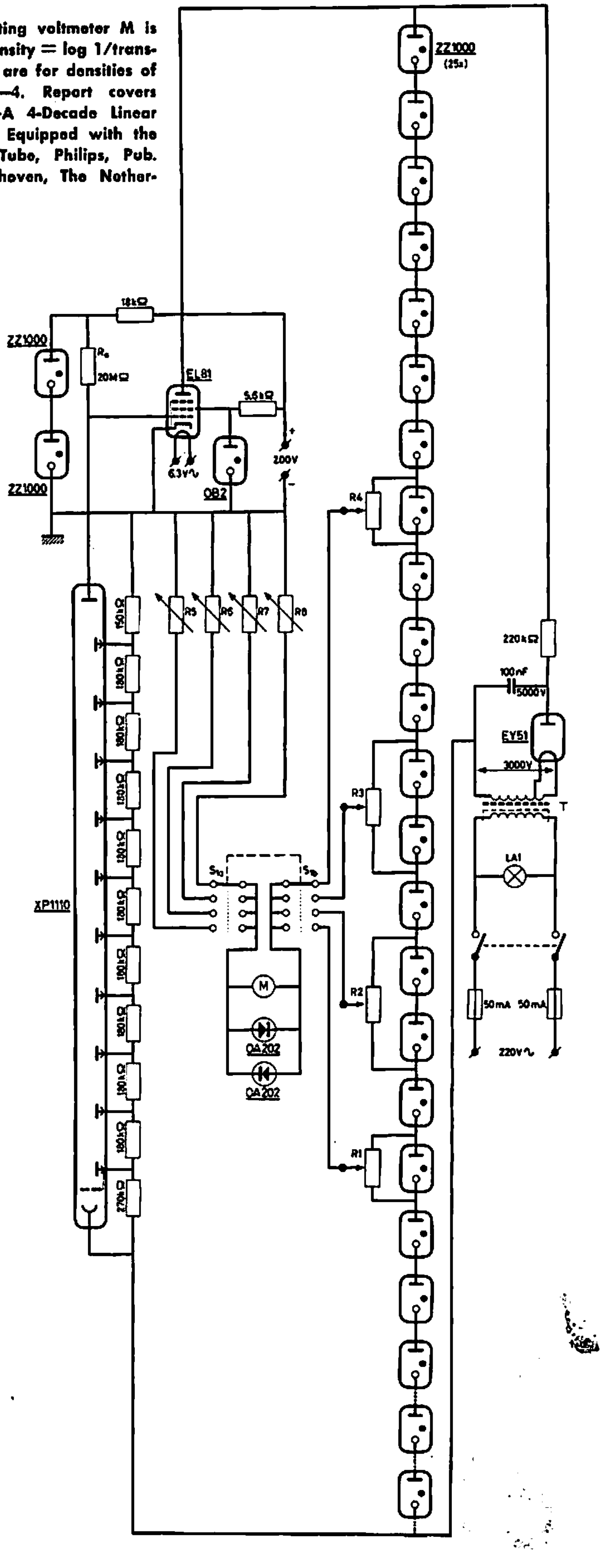

CL905HL
.68M
47K
2N4061
2N3391
2N4061
1K
R1
1M
R2
10K
100
100-0-100μA
470
R3
10K
2.7K
470
+
6V
−

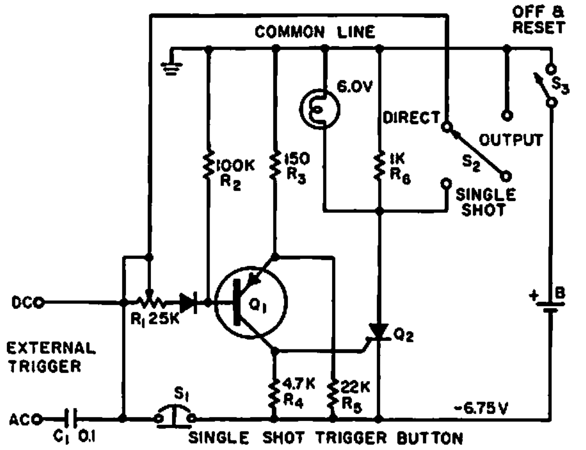
DARKROOM EASEL PHOTOMETER—Sensitive circuit can be used for measurements or comparisons over wide range of light levels. R1 may be calibrated in exposure time, R2 in paper contrast or filter number, and R3 in relative paper speed.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.


S1A
+
B2
9V
R7
1K
2N4128
Q3
R8
470
+
C1
10
Q1
2N3391
Q2
2N3391
R9
10K
Q4
2N3391
R4 100K
.1
R3 25 K
1
R2 2.5K
10
R1 .5 K
100
CLAIREX
CL505L
R_{PC}
λ
R11
470
S2
CHECK
R6
3K
R5
10 K
R10
3K
M1
0-1mA
METER
S1B
B1
+
1.5 V

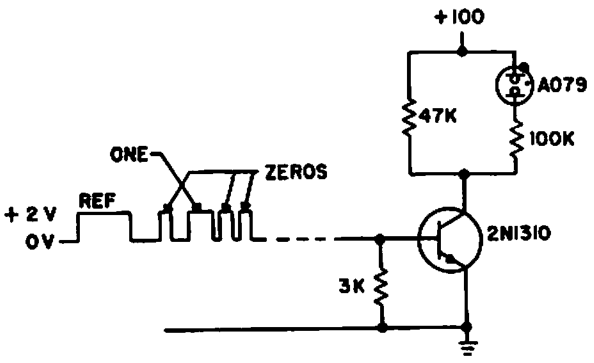
NIGHT EXPOSURE METER—Incident-reading meter with ranges of 0.01–0.1, 0.1–1, 1–10, and 10–100 footcandles is sensitive enough for low-light-level night photography. Higher ranges can serve also for reflected-light measurements and as enlarger exposure meter. Uses cadmium sulfide photocell with four-transistor differential amplifier. Article gives theory of operation, along with construction and calibration procedures.—J. L. Barnum, Design of a Light Meter & Exposure Calculator, *Electronics World*, May 1969, p 52–54 and 78–79.

LAB PHOTOMETER—Gives high sensitivity, wide range, and high accuracy for measurement of film transmission density, reflection coefficient, and very low values of light intensity. Logarithmic relation of anode voltage to light flux, necessary for linear density scale, is obtained by stabilizing anode current of XP1110 photomultiplier with EL81. High-voltage supply is stabilized at about 2,000 V with series connection of 25 ZZ1000 gas tubes. When indicating voltmeter M is calibrated in densities (density = log 1/transmission), the four ranges are for densities of 0–1, 1–2, 2–3, and 3–4. Report covers design and calibration.—A 4-Decade Linear Density Scale Photometer Equipped with the XP1110 Photomultiplier Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 318, 1967.

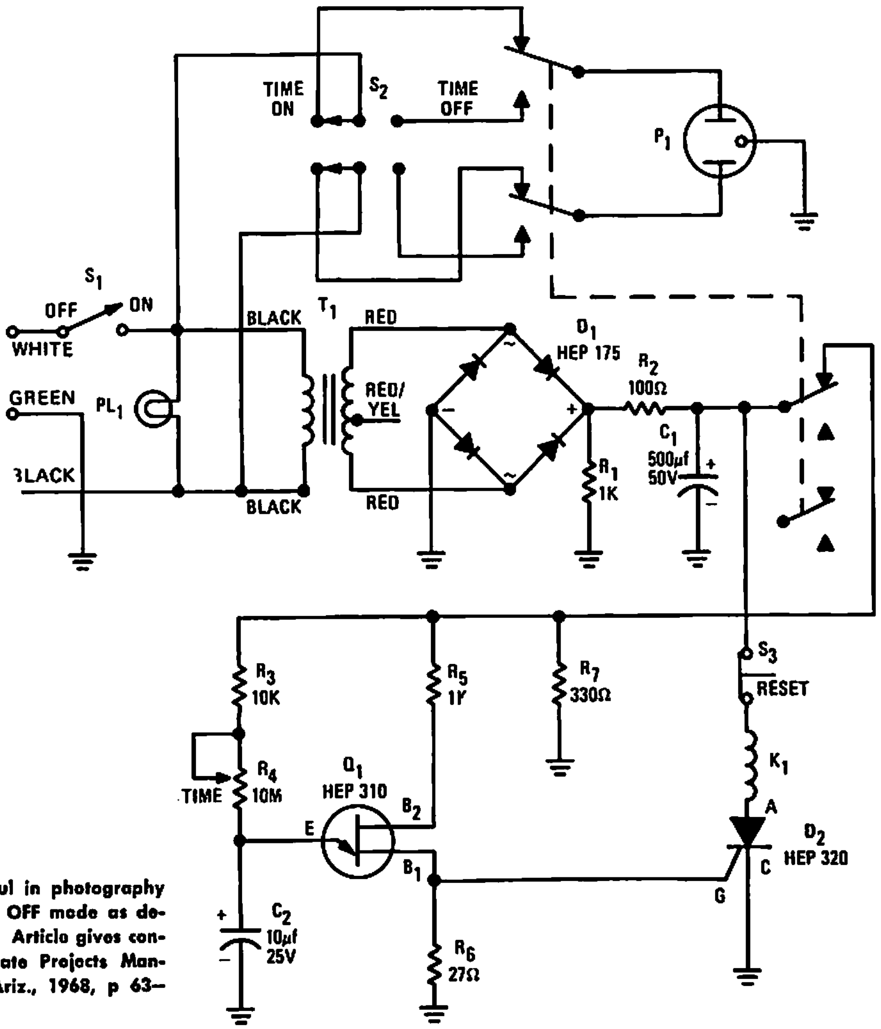

ZZ1000
(25x)
18kΩ
ZZ1000
R₀
20MΩ
EL81
5.6kΩ
6.3V~
OB2
200V
ZZ1000
R4
XP1110
150kΩ
180kΩ
180kΩ
180kΩ
180kΩ
180kΩ
180kΩ
180kΩ
180kΩ
180kΩ
270kΩ
R5
R6
R7
R8
R3
R2
R1
S1a
S1b
M
OA202
OA202
220kΩ
100nF
5000V
EY51
3000V
T
LA1
50mA
50mA
220V~


COMMON LINE
OFF &
RESET
S3
6.0V
DIRECT
OUTPUT
S2
SINGLE
SHOT
100K
R2
150
R3
1K
R6
DC
R1 25K
Q1
Q2
B
EXTERNAL
TRIGGER
S1
4.7K
R4
22K
R5
-6.75V
AC
C1 0.1
SINGLE SHOT TRIGGER BUTTON

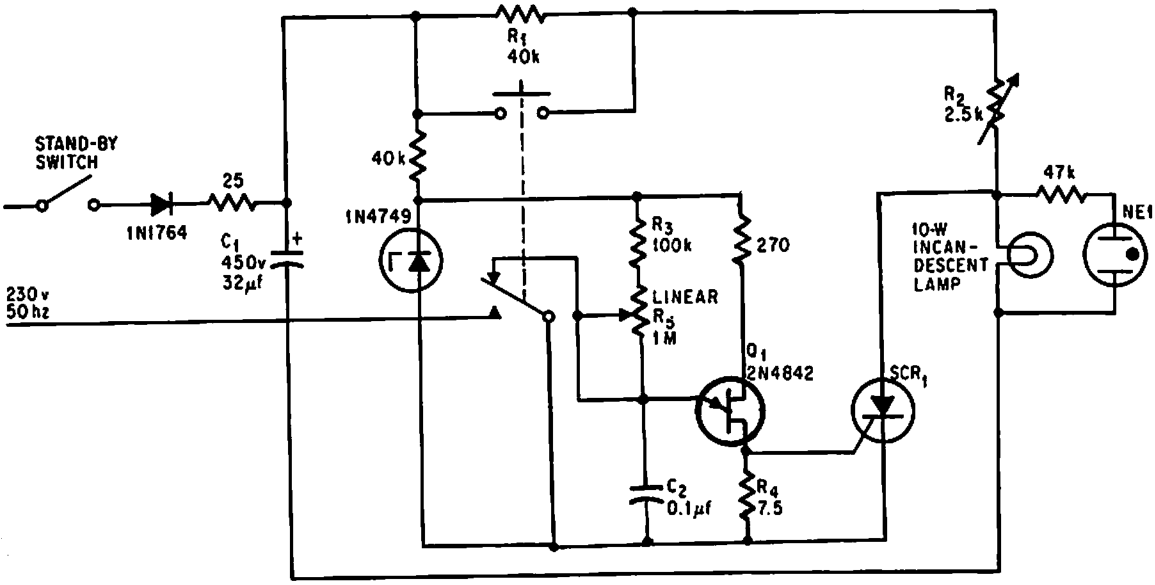
ONE-SHOT TRIGGER FOR SINGLE-SWEEP PHOTO—Camera lens is opened, sweep is triggered by applying external trigger or pushing button, and lens is closed. Eliminates smearing that occurs when recurrent trace is not completely synchronized with sweep speed. Input signal of about 0.6 V will fire trigger and give 6-V output for external-trigger input of scope. Q2 is operated at low voltage and current, so can be any inexpensive scr. Q1 can be almost any pnp transistor.—A. M. Schotz, One Shot Triggers Scope For Single Sweep, *Electronic Design*, Jan. 6, 1964, p 82 and 84.


+100
47K
A079
100K
ONE
ZEROS
REF
+2 V
0V
2N1310
3K

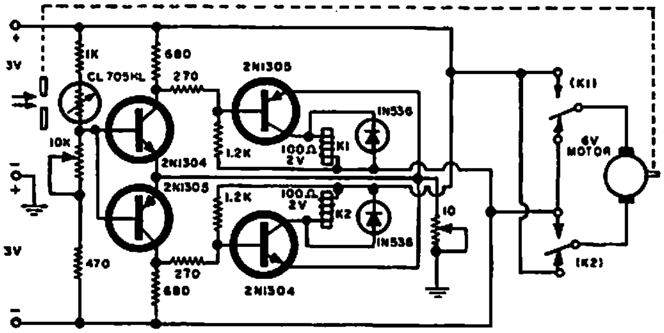
FILM TIME-CODE MARKER—Light from transistor-driven neon lamp marks time information in binary code on 35-mm instrumentation film.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 153.


TIME ON
S_2
TIME OFF
P_1
S_1
OFF
ON
WHITE
GREEN
PL_1
BLACK
BLACK
T_1
RED
RED/YEL
RED
D_1 HEP 175
R_2 100Ω
C_1 500µf 50V
R_1 1K
R_3 10K
R_5 1K
R_7 330Ω
S_3 RESET
K_1
R_4 10M
TIME
Q_1 HEP 310
B_2
E
B_1
A
D_2 HEP 320
C
G
C_2 10µf 25V
R_6 27Ω

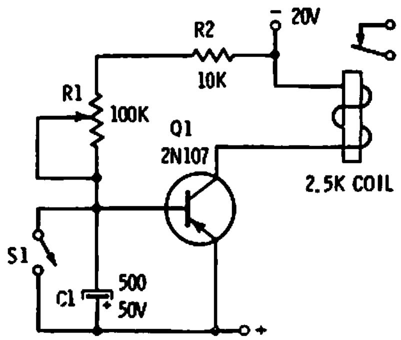
0.5–180 S FET TIMER—Useful in photography either in TIME ON or TIME OFF mode as determined by position of S2. Article gives construction details.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 63–68.


STAND-BY SWITCH
1N1764
25
C_1 450v 32µf
230v 50hz
R_1 40k
40k
1N4749
R_3 100k
270
LINEAR R_5 1M
Q_1 2N4842
SCR_1
C_2 0.1µf
R_4 7.5
R_2 2.5k
47k
NE17
10-W INCANDESCENT LAMP

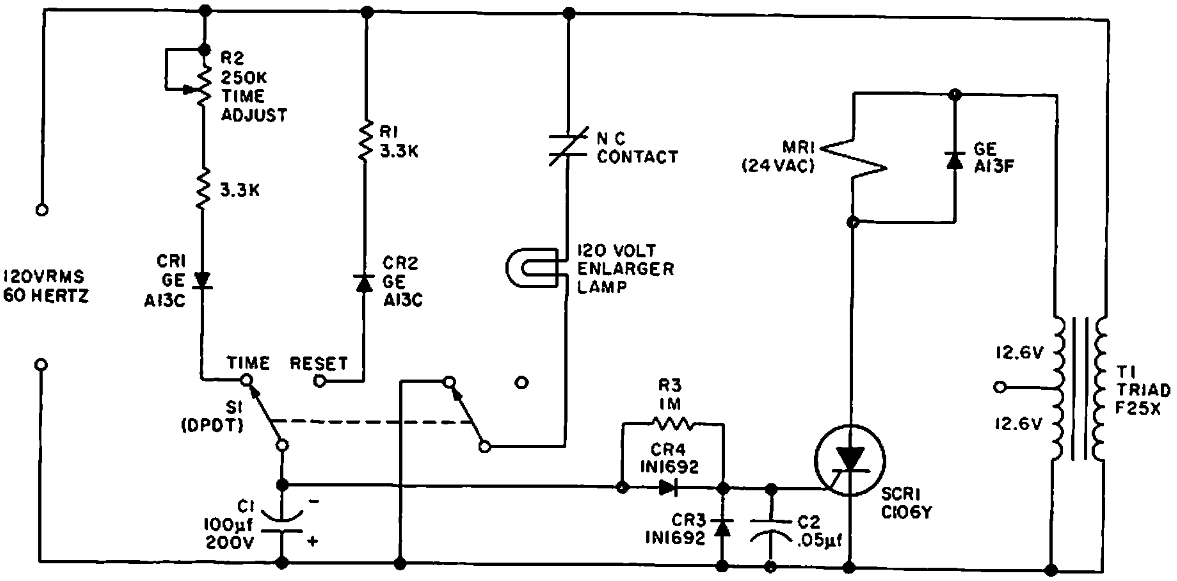
PRINTER CONTROL—When standby switch is closed, rectified 320 V d-c across C1 supplies 6.2 mA to 10-W incandescent lamp for photographic printer, to keep filament temperature close to visible illumination point. Pressing switch of ujt-scr timer shorts R1 to send 43 mA through lamp to give maximum illumination for printing and initiate timing. C2 then charges through R3 and R5 until Q1 fires and gates scr on, to shunt lamp and terminate exposure. Releasing timer switch then restores standby condition. R5 controls time.—D. Lior, Photographic Printer Controlled by UJT-SCR Timer, *Electronics*, March 18, 1968, p 96–97.


+
3V
10K
+
-
3V
-
1K
CL 705HL
680
270
2N1305
IN536
1.2K
100Ω
2V
K1
2N1304
2N1305
1.2K
100Ω
2V
K2
IN536
470
270
680
2N1304
10
(K1)
6V
MOTOR
(K2)

PHOTOELECTRIC APERTURE CONTROL—Servo motor moves shutter to adjust aperture until resistance of photocell equals that of load circuit potentiometer. Uses two complementary Schmitt triggers to actuate motor control relays.—J. G. Rabinowitz, Photocells—Types, Characteristics, and Applications, *Electronics World*, Sept. 1968, p 23–26.


- 20V
R2
10K
R1
100K
Q1
2N107
2.5K COIL
S1
C1
500
50V
+

PHOTOGRAPHIC TIMER—Timing cycle begins when S1 is opened, removing short across C1. When C1 charges sufficiently, base current flows through Q1 and relay is energized, opening relay contacts and cutting off power to lamp or other load. Increasing value of R1 lengthens timing cycle.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 91.

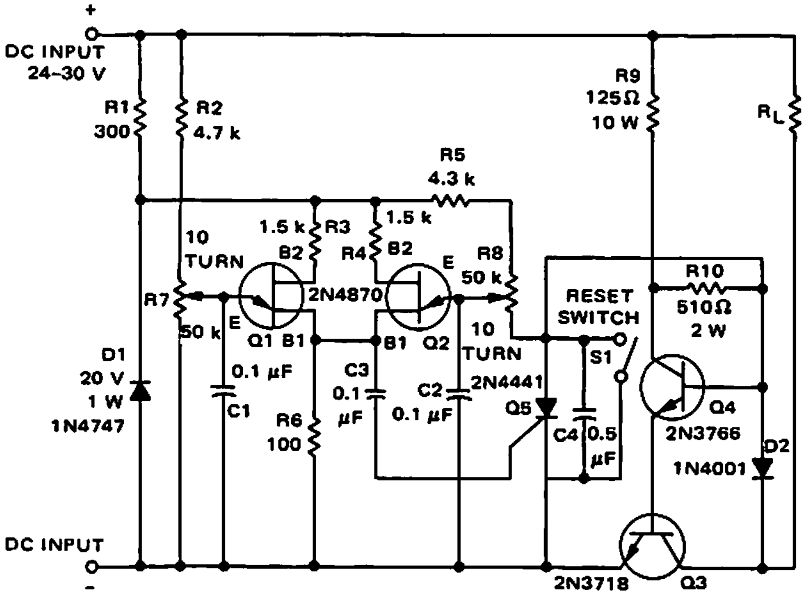

R2
250K
TIME
ADJUST
3.3K
R1
3.3K
N C
CONTACT
MR1
(24VAC)
GE
A13F
120VRMS
60 HERTZ
CR1
GE
A13C
CR2
GE
A13C
120 VOLT
ENLARGER
LAMP
TIME
RESET
S1
(DPDT)
R3
1M
CR4
IN1692
12.6V
12.6V
T1
TRIAD
F25X
C1
100µf
200V
CR3
IN1692
C2
.05µf
SCR1
C106Y

ENLARGER PHOTOTIMER—When S1 is at RESET, C1 is charged to peak negative value of supply voltage (165 V) and enlarger lamp is off. When S1 is set at TIME, enlarger lamp comes on and C1 discharges at rate determined by setting of R2 until its voltage has become sufficiently positive (about 2 V) to trigger scr and energize relay to turn off enlarger lamp. R2 gives range of 0.01 to 60 s for exposures.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 29.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

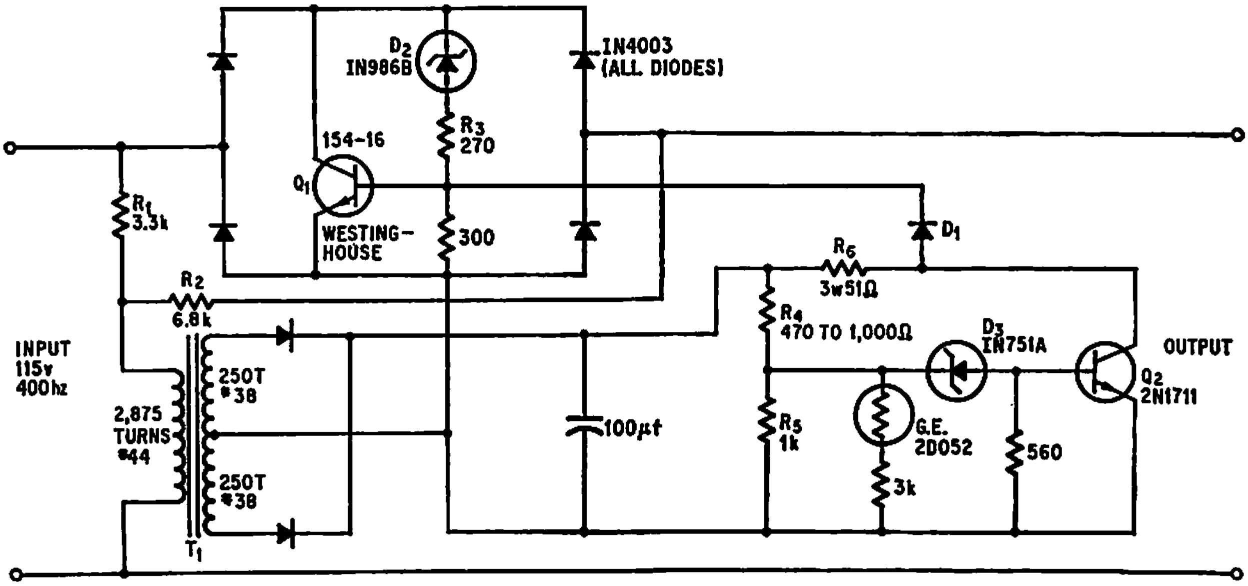
CHAPTER 64

Power Supply Protection Circuits



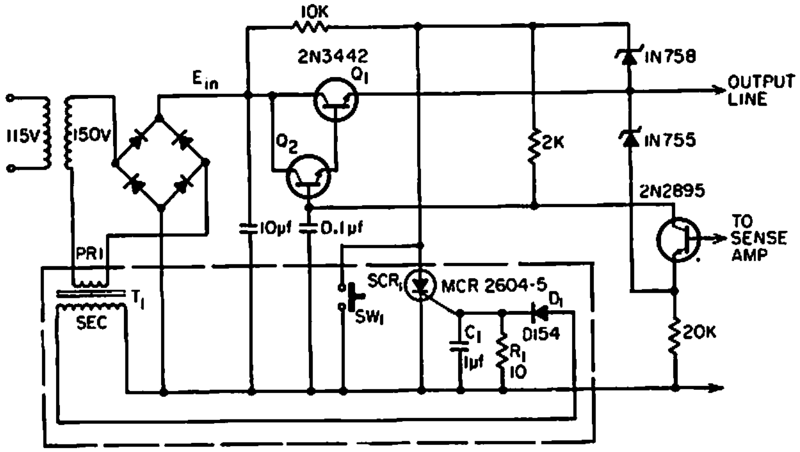
+
DC INPUT
24-30 V
R1
300
R2
4.7 k
R9
125Ω
10 W
RL
R5
4.3 k
1.5 k
R3
1.5 k
R4
B2
B2
E
R8
50 k
10
TURN
R7
50 k
E
2N4870
Q1 B1
B1 Q2
10
TURN
RESET
SWITCH
S1
R10
510Ω
2 W
D1
20 V
1 W
1N4747
0.1 μF
C1
C3
0.1
μF
C2
0.1 μF
2N4441
Q5
C4
0.5
μF
Q4
2N3766
D2
1N4001
R6
100
DC INPUT
-
2N3718
Q3

D-C CIRCUIT BREAKER—Protects load against transient voltage or current overload. Acts in 4 to 10 μs, as compared to 8 ms for mechanical circuit breakers. Requires momentary closing of S1 for resetting. R8 sets overcurrent trip point and R7 sets overvoltage point; both are precision 10-turn pots.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–18.



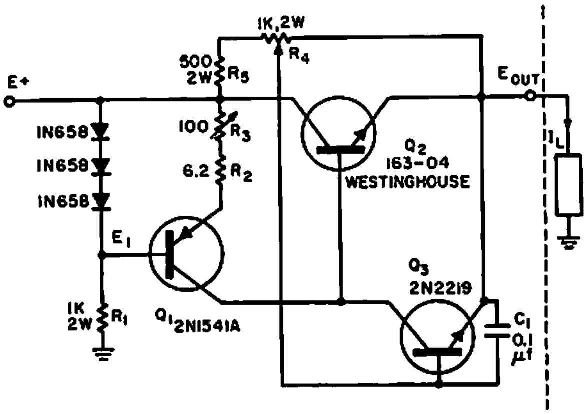
D2
IN986B
IN4003
(ALL DIODES)
R3
270
154-16
Q1
WESTING-
HOUSE
300
R1
3.3k
D1
R2
6.8k
R6
3w51Ω
R4
470 TO 1,000Ω
D3
IN751A
OUTPUT
Q2
2N1711
INPUT
115v
400hz
2,875
TURNS
#44
250T
#38
250T
#38
T1
100μf
R5
1k
G.E.
2D052
3k
560

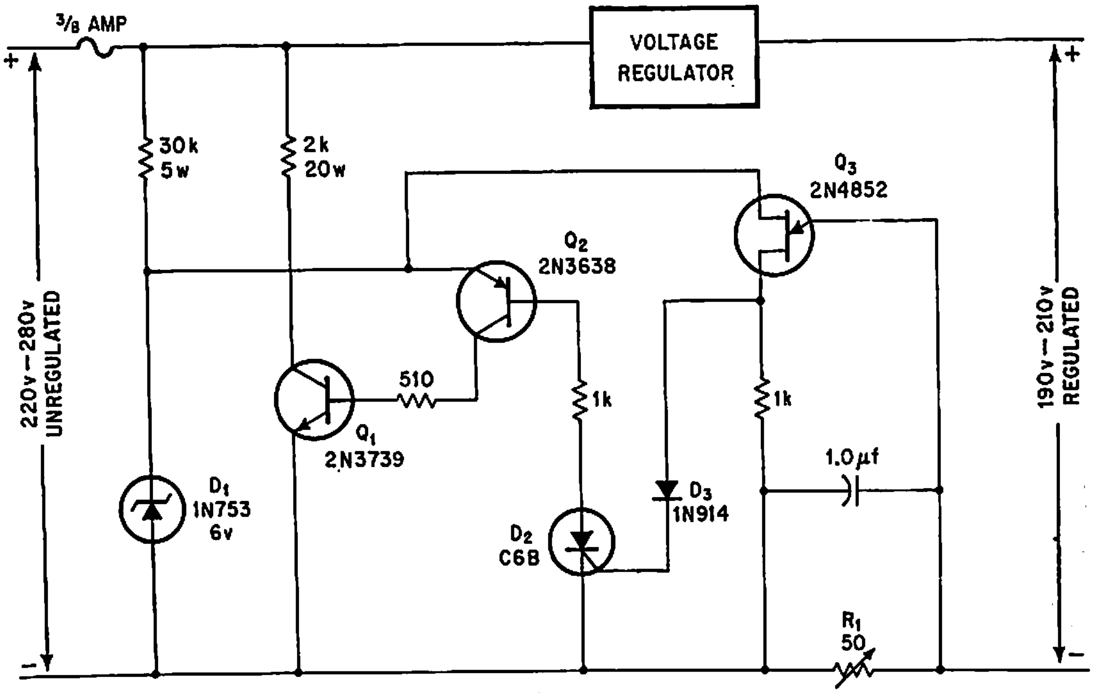
SURGE LIMITER—Circuit shown was designed for use in series-type regulator for airborne military power supplies requiring protection from long-term voltage transients on both a-c and d-c supply lines. Circuit shown is for system normally drawing 1 A and having turn-on surge of 3 A. For normal output, series transistor is saturated. When output exceeds preset level, error voltage is developed and amplified to bring series transistor out of saturation and thereby maintain output at desired level.—M. Kanner, Nonstop Limiter Absorbs Transients, *Electronics*, May 26, 1969, p 106–107.


10K
2N3442
Q1
E in
115V
150V
Q2
PRI
T1
SEC
10μf
0.1μf
SCR1
MCR 2604-5
SW1
C1
1μf
D154
D1
R1
10
2K
1N758
1N755
OUTPUT LINE
2N2895
TO SENSE AMP
20K

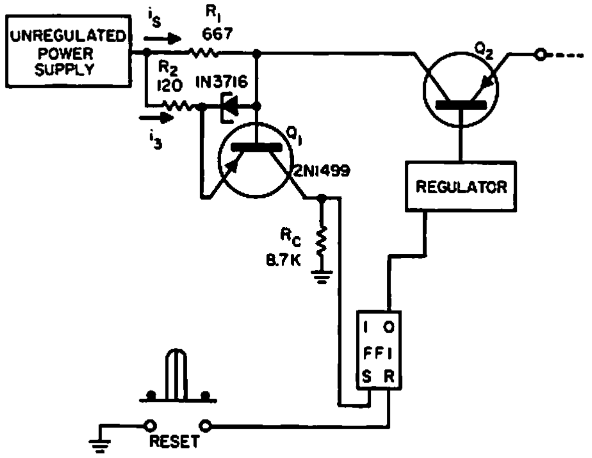
OVERLOAD-SAMPLING CURRENT TRANSFORMER—T1 samples current supplied to series voltage regulator. Rectified sample of current triggers scr when predetermined value of overload current is reached. This removes base current from Q1 and Q2, turning off both transistors. Circuit can be reset manually with SW1 or by interrupting input voltage. T1 has 8-turn primary and 120-turn secondary on EI-187 core.—S. J. Arnold, Current Transformer Gives Fast Overload Protection, *EEE*, Sept. 1966, p 146.

TRANSISTOR CURRENT LIMITERS—Protects current-limiting series transistor Q2 from excessive power dissipation by breaking circuit for overloads, short-circuits, or excessive supply voltage. Load current is adjustable and stable over range of 1 to 10 A, and output voltage is only 3 V below 35-V supply voltage. C1 slows down rate of current interruption, to prevent breaking of circuit by transients; for faster current interruption, C1 may be omitted.—R. K. Manherz, Solid-State Current-Limiter Functions as Circuit Breaker, *Electronic Design*, March 15, 1965, p 59–60.

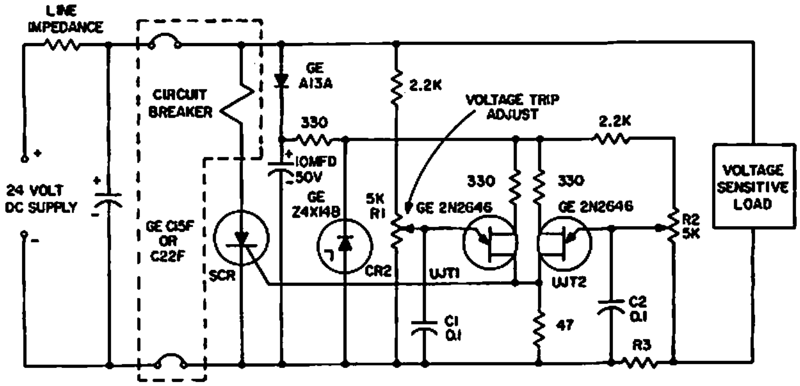

E+
1K,2W
R4
500 2W R5
100 R3
6.2 R2
1N658
1N658
1N658
E1
1K 2W R1
Q1 2N1541A
Q2
163-04
WESTINGHOUSE
Q3
2N2219
C1
0.1 μf
E OUT
IL


3/8 AMP
+
VOLTAGE REGULATOR
30k 5w
2k 20w
220v–280v UNREGULATED
Q3
2N4852
Q2
2N3638
510
Q1
2N3739
1k
1k
D1
1N753
6v
D2
C6B
D3
1N914
1.0μf
R1
50
190v–210v REGULATED
+
–
–

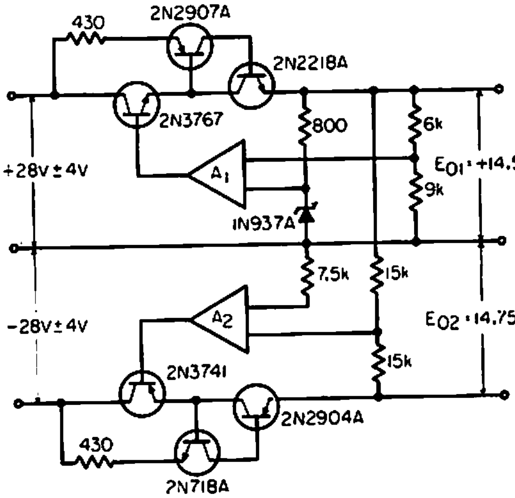
OVERCURRENT—Ujt circuit is activated only when current capability of associated regulated power supply is exceeded. Current-sensing resistor R1 is initially adjusted to keep ujt Q3 off until current rating of supply is exceeded. Overcurrent then turns on Q3, scr D2, Q2, and Q1 in turn, and current drawn by Q1 blows fuse to protect transistors of voltage regulator.—J. Durnin and M. DeCicco, Unijunction Circuit Prevents Damage to Transistors, *Electronics*, June 9, 1969, p 100–101.


UNREGULATED POWER SUPPLY
i_S
R_1 667
R_2 120
IN3716
i_3
Q_1
2N1499
Q_2
REGULATOR
R_C 8.7K
I O
FF I
S R
RESET

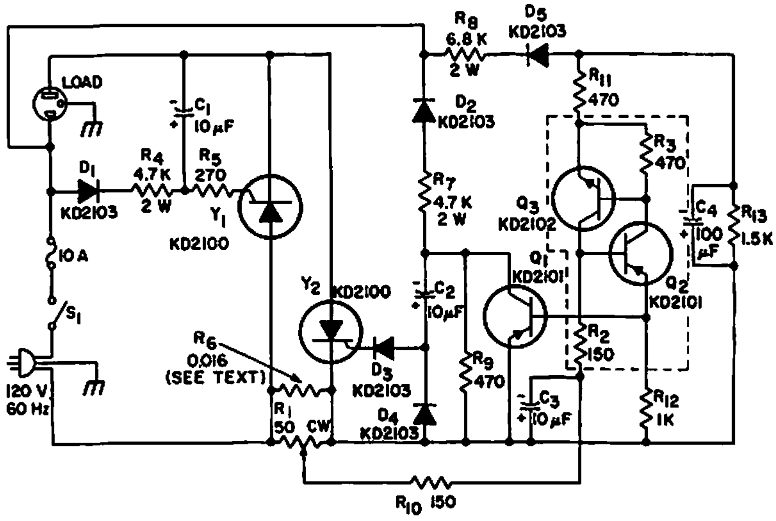
CURRENT OVERLOAD—Tunnel diode and transistor provide better protection than fuse against current overload of power supply. Fast switching speed of diode provides shutdown before overload current can damage series-regulating transistor Q2. Values shown give cutoff at 1 A; article gives design equations for other cutoff values.—R. B. Jones, Tunnel Diode Provides Fast Current-Overload Detection, *Electronic Design*, Nov. 22, 1965, p 62.


LINE IMPEDANCE
CIRCUIT BREAKER
GE A13A
2.2K
VOLTAGE TRIP ADJUST
330
2.2K
10MFD 50V
GE Z4X14B
5K R1
GE 2N2646
330
330
GE 2N2646
R2 5K
VOLTAGE SENSITIVE LOAD
24 VOLT DC SUPPLY
+
-
GE C15F OR C22F
SCR
CR2
UJT1
UJT2
C1 0.1
47
C2 0.1
R3

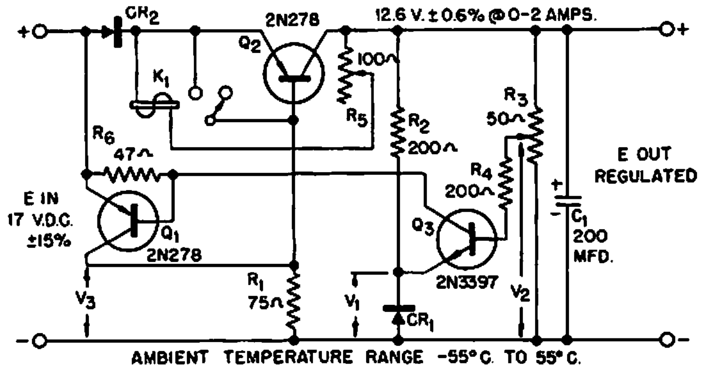
HIGH-SPEED CROWBAR—Useful for protecting d-c circuits against input line voltage transients and load shorts. If d-c supply voltage exceeds value determined by setting of R1, UJT1 fires and triggers SCR. Full supply voltage is then applied to trip coil of circuit breaker to open supply line. Circuit also loads d-c bus instantly to prevent load voltage from rising until breaker has time to operate.—"SCR Manual," 4th Edition, General Electric, 1967, p 158–159.


430
2N2907A
2N2218A
2N3767
800
6k
A_1
E_{01} = +14.5V
9k
IN937A
+28V ± 4V
7.5k
15k
A_2
E_{02} = 14.75V
-28V ± 4V
2N3741
15k
2N2904A
430
2N718A

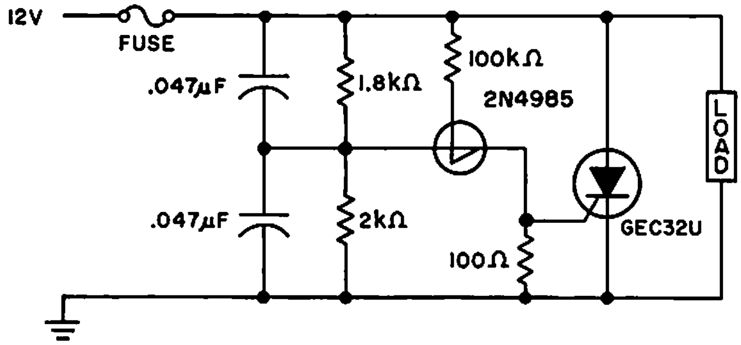
BUILT-IN PROTECTION—Addition of upper two transistors and 430-ohm resistor to conventional series regulator having IC opamp provides overvoltage protection for IC if series regulator fails or becomes shorted. Similar protection circuit is used in lower regulator providing regulated −14.75 V from −28 V.—A. P. Bjork, Overvoltage-Protection Circuit for EC Power Supplies, *EEE*, Dec. 1968, p 101–102.


R_8 6.8 K 2 W
D_5 KD2103
LOAD
C_1 10 μF
R_{11} 470
D_2 KD2103
R_3 470
R_4 4.7 K 2 W
R_5 270
D_1 KD2103
Y_1 KD2100
R_7 4.7 K 2 W
Q_3 KD2102
C_4 100 μF
R_{13} 1.5K
Q_1 KD2101
Q_2 KD2101
10 A
S_1
Y_2 KD2100
C_2 10μF
R_6 0.016 (SEE TEXT)
D_3 KD2103
R_9 470
R_2 150
C_3 10 μF
R_{12} 1K
120 V 60 Hz
R_1 50 CW
D_4 KD2103
R_{10} 150

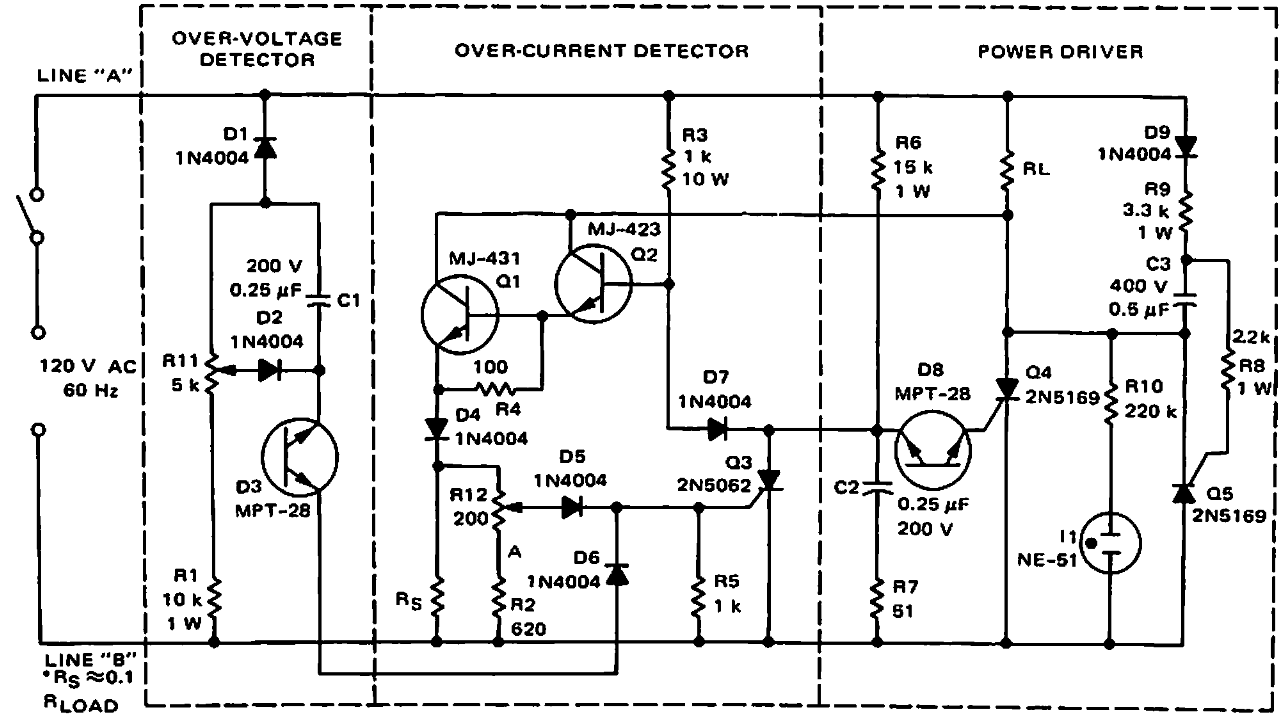
600-KW OVERLOAD SWITCH—Uses regenerative switch (dashed rectangle) that conducts when overload condition as preset by R1 occurs. This turns off scr's Y1 and Y2, interrupting power to load. Line switch must be opened momentarily to reset after overload clears up.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 123.


+O
CR2
2N278
Q2
12.6 V. ± 0.6% @ 0-2 AMPS.
O+
K1
100Ω
R5
R3
50Ω
R6
47Ω
R2
200Ω
R4
200Ω
E OUT
REGULATED
E IN
17 V.D.C.
±15%
Q1
2N278
Q3
2N3397
C1
200
MFD.
R1
75Ω
V3
V1
V2
CR1
-O
O-
AMBIENT TEMPERATURE RANGE -55°C. TO 55°C.

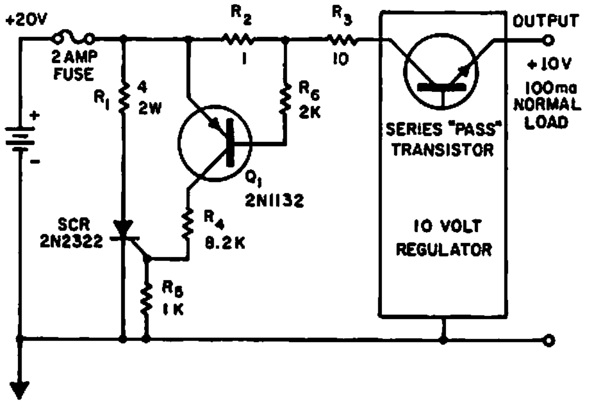
RELAY-PROTECTED VOLTAGE REGULATOR—Consists of proportional voltage regulator that delivers constant 12.6 V d-c output within 0.6% while 17-V d-c input is varying 15%. When voltage across series regulator transistor Q2 rises above preset value determined by setting of R5, voltage-sensitive relay K1 operates and shorts emitter of Q2 to its base, thereby turning off collector current of Q2. Excess voltage could be caused by large increase in input voltage, overload, or shorted output. Fuse or circuit breaker would not react in time to protect circuit from damage under these conditions. CR1 is 1N1770 and CR2 is 1N3491.—Voltage Regulator, Delco Radio, Kokomo, Indiana, No. 3-8, 1965.


12V
FUSE
.047μF
.047μF
1.8kΩ
2kΩ
100kΩ
2N4985
100Ω
GEC32U
LOAD

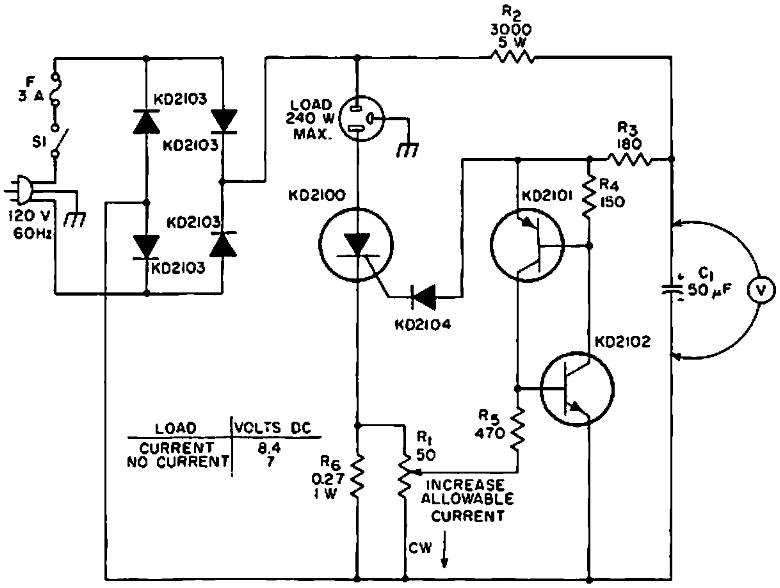
OVERVOLTAGE PROTECTION—Combination of 2N4985 silicon unilateral switch and scr blows line fuse for overvoltage. Circuit triggers between 13.2 and 14 V for rapidly rising voltages, and between 14 and 17 V for slowly increasing voltages. May also be used with 2N4989 sus.—Silicon Unilateral Switch 2N-4984/2N4985, General Electric, Syracuse, N.Y., No. 65.27, 3/67.


OVER-VOLTAGE DETECTOR
OVER-CURRENT DETECTOR
POWER DRIVER
LINE "A"
120 V AC
60 Hz
D1
1N4004
200 V
0.25 μF
C1
D2
1N4004
R11
5 k
D3
MPT-28
R1
10 k
1 W
LINE "B"
*Rs ≈ 0.1 RLOAD
R3
1 k
10 W
MJ-423
Q2
MJ-431
Q1
100
R4
D4
1N4004
D5
1N4004
R12
200
A
D6
1N4004
Rs
R2
620
D7
1N4004
Q3
2N5062
R5
1 k
R6
15 k
1 W
RL
D9
1N4004
R9
3.3 k
1 W
C3
400 V
0.5 μF
2.2 k
R8
1 W
D8
MPT-28
Q4
2N5169
R10
220 k
C2
0.25 μF
200 V
I1
NE-51
Q5
2N5169
R7
51

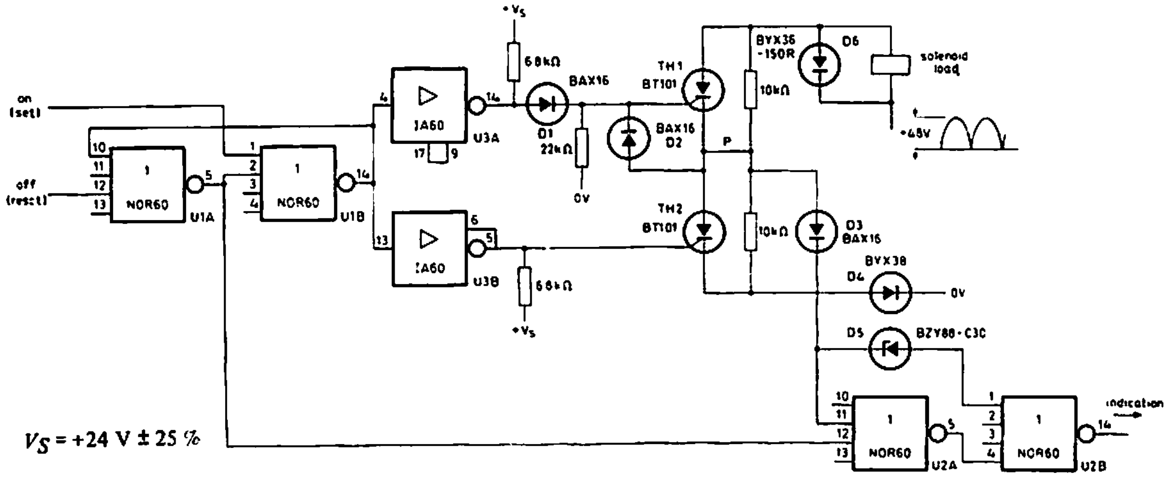
A-C OVERVOLTAGE AND OVERCURRENT PROTECTION—Protects resistive load RL in power driver from excessive voltage as well as excessive current. Scr Q5 is slave-fired by Q4 which carries load current. Overcurrent detector prevents D8 from firing Q4 and thus prevents load from being connected across line in event of short-circuit. Overvoltage detector senses negative half-cycles of line voltage and similarly prevents Q4 from turning on as long as overvoltage exists. Setting of R11 determines overvoltage level at which load is disconnected. Circuit resets automatically.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–14.


+20V
2 AMP FUSE
R1
4
2W
R2
1
R3
10
R6
2K
Q1
2N1132
SCR
2N2322
R4
8.2K
R5
1K
SERIES "PASS" TRANSISTOR
10 VOLT REGULATOR
OUTPUT
+10V
100ma NORMAL LOAD

FUSE BLOWER—Protects series-pass transistor from burnout even for direct short across regulator output, by acting faster than series transistor. R2 provides voltage drop proportional to short-circuit current, which turns Q1 on when drop is about 0.7 V. Scr then turns on quickly and blows fuse. R3 prevents turn-on surge current from blowing fuse.—P. Galluzzi, SCR Arrangement Improves Short-Circuit Protection, *Electronic Design*, Sept. 28, 1964, p 55–56.

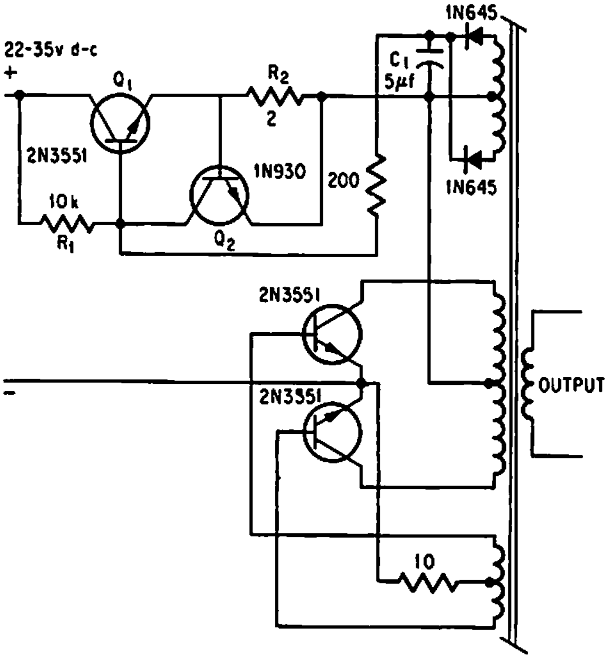

R2
3000
5 W
F
3 A
S1
120 V
60Hz
KD2103
KD2103
KD2103
KD2103
LOAD
240 W
MAX.
KD2100
KD2104
R3
180
R4
150
KD2101
KD2102
C1
50 μF
V
R5
470
R1
50
INCREASE ALLOWABLE CURRENT
CW
R6
0.27
1 W
LOAD | VOLTS DC
CURRENT | 8.4
NO CURRENT | 7

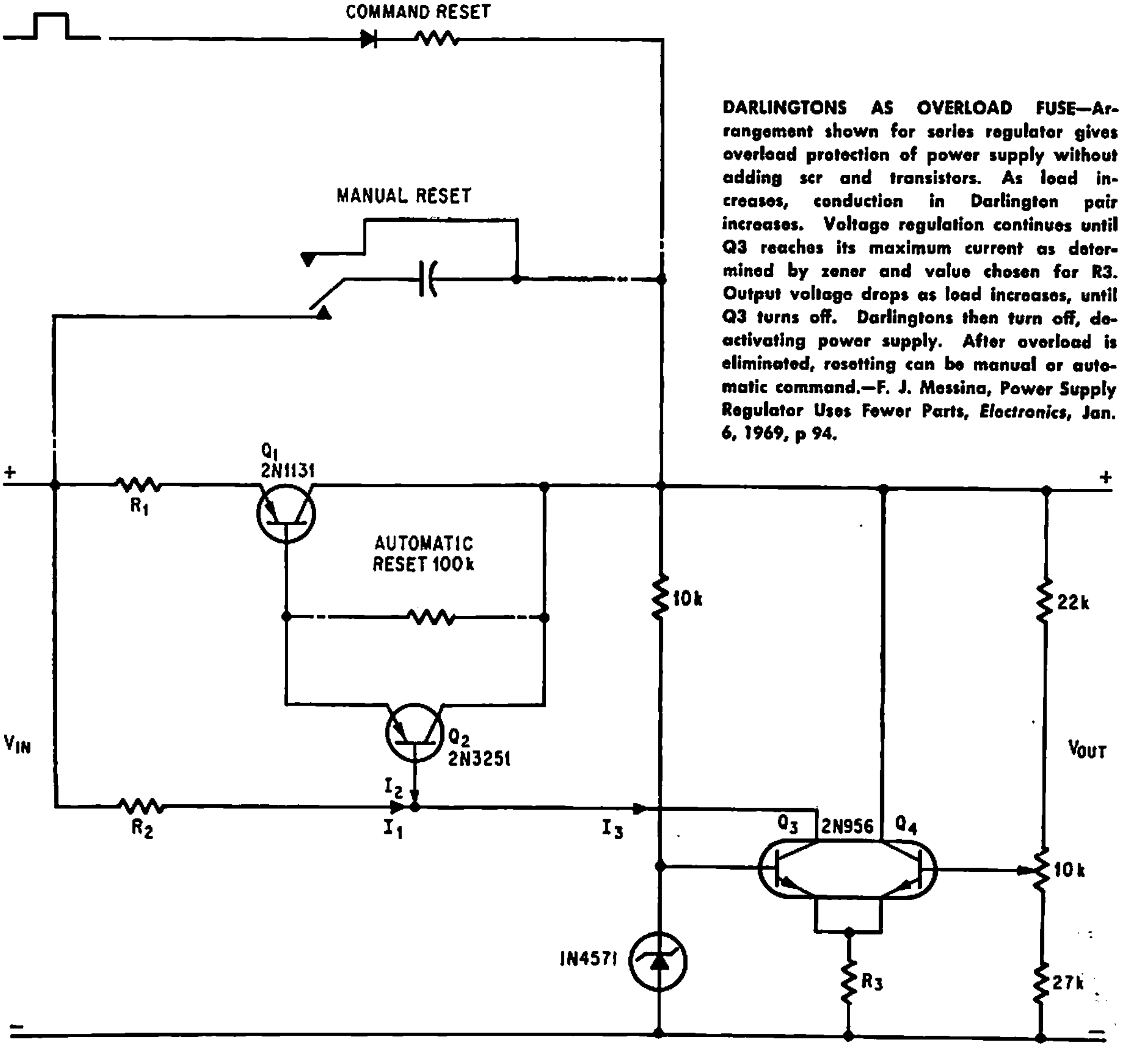
OVERLOAD SWITCH—Serves as electronic circuit breaker that interrupts power to load at predetermined overload point determined by setting of R1. Can be used for heater and universal motor loads up to 240 W. Incandescent lamp load can be protected only if R1 is turned to maximum-current setting before S1 is closed, to allow for high starting current through low cold resistance of lamp, then turned back to desired trip setting. Photoflood lamps cannot be used.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 120.


on (set)
off (reset)
NOR60
U1A
NOR60
U1B
1A60
U3A
1A60
U3B
+Vs
68kΩ
BAX16
D1
22kΩ
0V
BAX16
D2
TH1
BT101
TH2
BT101
P
BYX36-150R
10kΩ
10kΩ
D6
solenoid load
+48V
D3
BAX16
BYX38
D4
0V
D5
BZY88-C3C
NOR60
U2A
NOR60
U2B
indication
$V_S = +24\text{ V} \pm 25\ \%$

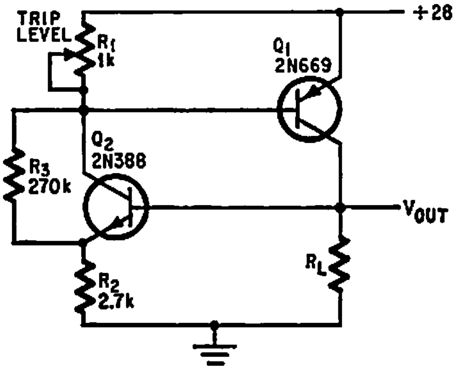
THYRISTOR SHORT-CIRCUIT ALARM—Combination of Philips IC gates and opamps trips alarm when either of series thyristors conducts when trigger is off. Solenoid then pulls in and removes power from thyristors. Used to prevent unwanted and possibly dangerous operation of machine when thyristors control electromagnetic clutch.—D. Hofman, Fault Detection and Display Circuit For a Thyristor Operated Load, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 73.

PROTECTING SATELLITE SUPPLY—Current-limiting feedback loop between inverter and d-c supply of spacecraft prevents inverter or output shorts from draining battery pack. When high-surge current boosts drop across R2 and biases Q2 into conduction, Q1 is forced into cutoff. Current-limiting resistor R1 and Q2 are then in series with line in place of R2, to limit battery current drain.—R. Burkett, Feedback Protects Spacecraft's Power Supply, *Electronics*, Jan. 8, 1968, p 91.


22-35v d-c
+
Q1
2N3551
10k
R1
R2
2
1N930
Q2
200
C1
5μf
1N645
1N645
2N3551
2N3551
OUTPUT
10
-

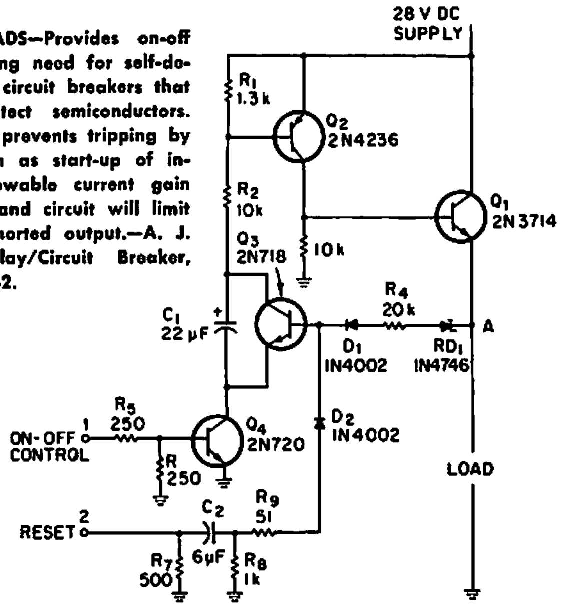

COMMAND RESET
MANUAL RESET
+
R1
Q1
2N1131
AUTOMATIC
RESET 100k
Q2
2N3251
VIN
R2
I2
I1
I3
10k
Q3
2N956
Q4
1N4571
R3
22k
VOUT
10k
27k
+
-
-

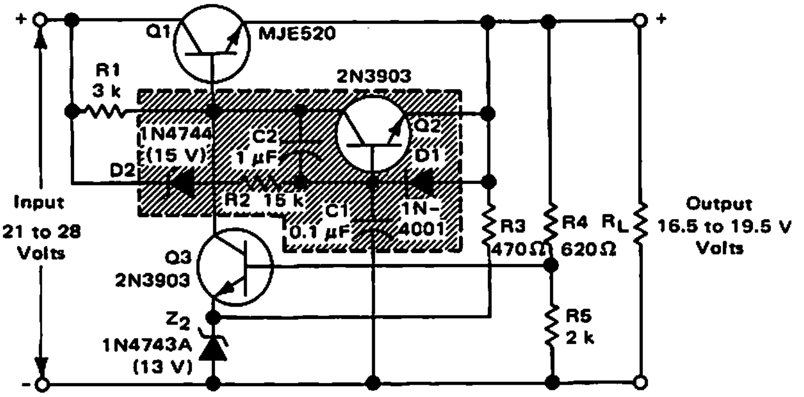
DARLINGTONS AS OVERLOAD FUSE—Arrangement shown for series regulator gives overload protection of power supply without adding scr and transistors. As load increases, conduction in Darlington pair increases. Voltage regulation continues until Q3 reaches its maximum current as determined by zener and value chosen for R3. Output voltage drops as load increases, until Q3 turns off. Darlingtons then turn off, deactivating power supply. After overload is eliminated, resetting can be manual or automatic command.—F. J. Messina, Power Supply Regulator Uses Fewer Parts, *Electronics*, Jan. 6, 1969, p 94.


TRIP LEVEL
R1 1k
Q1 2N669
+28v
Q2 2N388
R3 270k
VOUT
RL
R2 2.7k

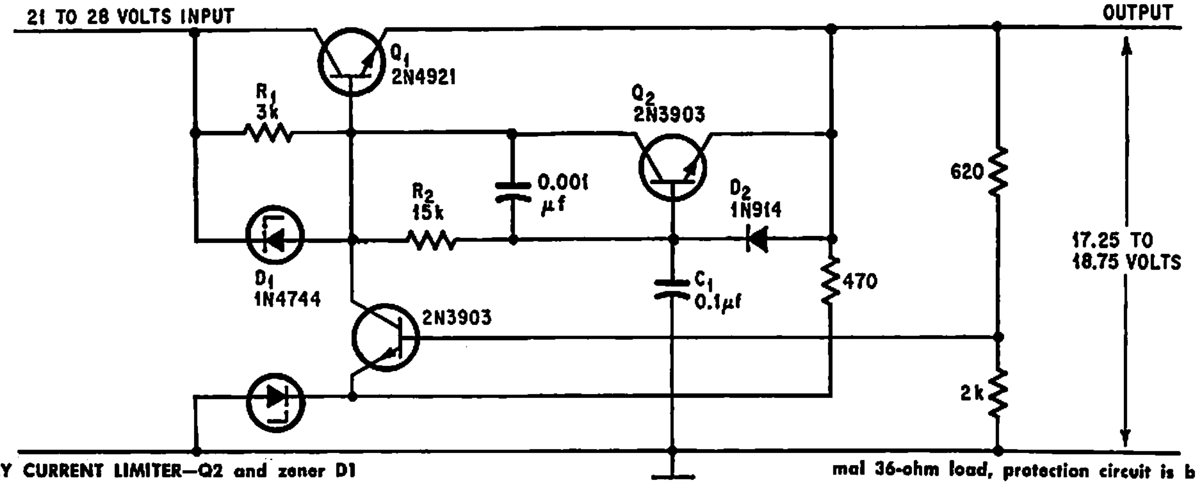
AUTOMATIC-RESET BREAKER—Solid-state breaker trips within 100 µs after load is shorted, and reduces fault current to zero within 500 µs, for protection of printed-circuit wiring and interconnections. Ideal for universal lab power supplies. Automatic reset reapplies power after interval depending on leakage in Q1.—C. J. Ulrick, Power Supply Breaker Acts in 100 Microseconds, *Electronics*, Feb. 3, 1969, p 79.

FAULTS AND OVERLOADS—Provides on-off power control, eliminating need for self-destructing fuses and for circuit breakers that are too slow to protect semiconductors. Time constant of R2-C1 prevents tripping by transient overloads such as start-up of incandescent lamps. Allowable current gain for load is 0 to 5 A, and circuit will limit overload to 7 A for shorted output.—A. J. Marek, Solid-State Relay/Circuit Breaker, *EEE*, June 1969, p 141–142.


28 V DC SUPPLY
R1 1.3k
Q2 2N4236
R2 10k
Q1 2N3714
Q3 2N718
10k
R4 20k
C1 22 µF
D1 1N4002
RD1 1N4746
A
1
ON-OFF CONTROL
R5 250
Q4 2N720
D2 1N4002
R 250
LOAD
2
RESET
C2 6µF
R9 51
R7 500
R8 1k

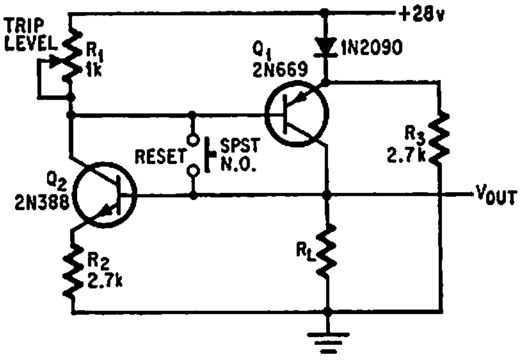

+
+
Q1
MJE520
R1 3 k
2N3903
1N4744 (15 V)
C2 1 µF
Q2
D1
D2
R2 15 k
C1 0.1 µF
1N-4001
R3 470Ω
R4 620Ω
RL
Input 21 to 28 Volts
Output 16.5 to 19.5 V Volts
Q3 2N3903
Z2 1N4743A (13 V)
R5 2 k
-

PROTECTING SERIES-PASS REGULATOR—Addition of inexpensive components shown in shaded area protects series-pass regulator against shorted output and restores normal operation automatically when short is removed. Under normal operating conditions, protective circuit is biased off and does not affect regulator action. Speed of protective action is limited only by storage and fall time of series-pass transistor Q1, which is about 1 ms.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–30.

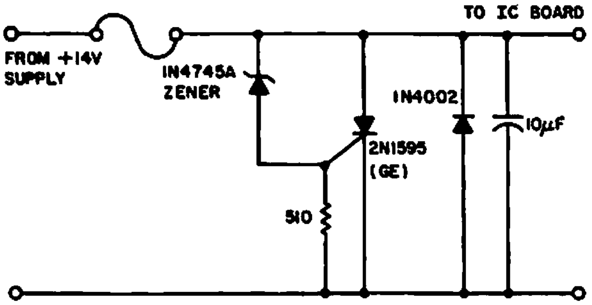

21 TO 28 VOLTS INPUT
OUTPUT
Q1 2N4921
R1 3k
Q2 2N3903
0.001 µf
R2 15k
D2 1N914
620
D1 1N4744
C1 0.1µf
470
17.25 TO 18.75 VOLTS
2N3903
2k

SUPPLY CURRENT LIMITER—Q2 and zener D1 are added to regulated power supply to prevent series transistor Q1 from damage by load short before fuse blows. With short, zener D1 draws reverse current and drives Q2 into saturation, cutting off Q1. With normal 36-ohm load, protection circuit is biased off and does not affect regulation.—B. Phillips, Transistor and Zener Protect Series Regulator, *Electronics*, July 8, 1968, p 92.

MANUAL-RESET BREAKER—Solid-state breaker trips within 100 μs after load is shorted, and reduces fault current to zero within 500 μs, for protection of printed-circuit wiring and interconnections. Ideal for universal lab power supplies. Pushbutton must be momentarily pressed manually to reset breaker after short. Leakage current of Q1 must be low enough so it cannot turn itself on and reapply power to load after fault.—C. J. Ulrick, Power Supply Breaker Acts in 100 Microseconds, *Electronics*, Feb. 3, 1969, p 79.

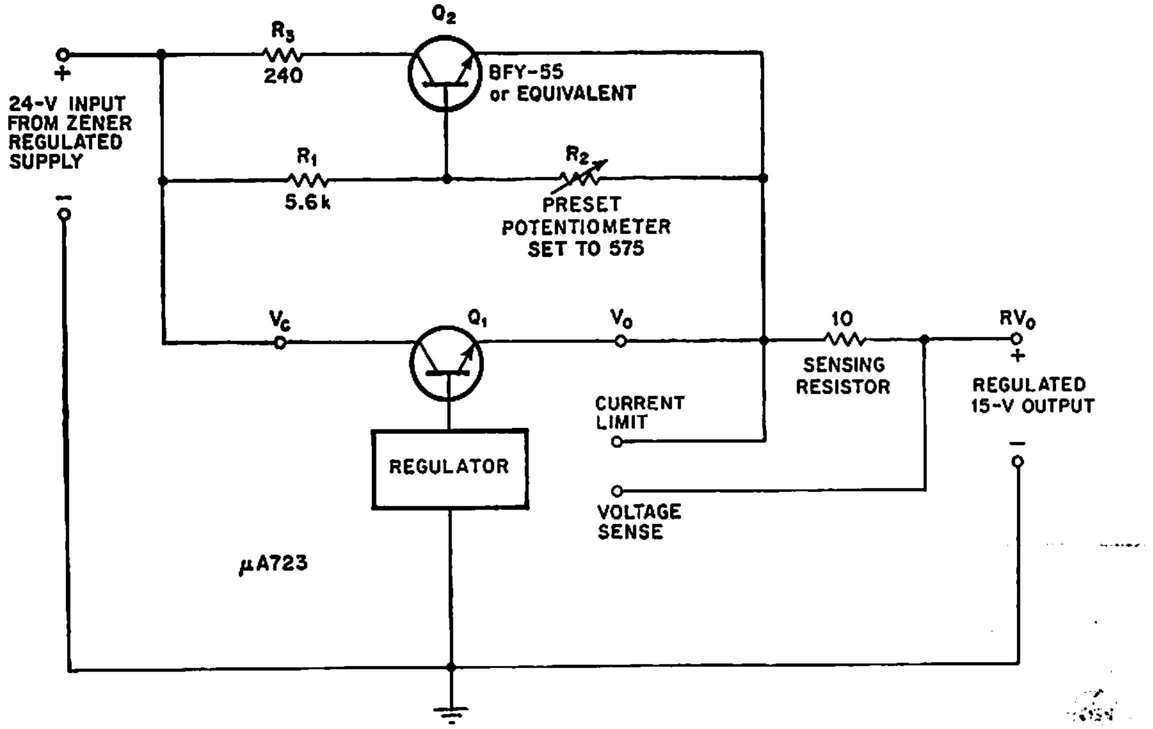


+28v
TRIP LEVEL
R1 1k
Q1 2N669
1N2090
R3 2.7k
RESET
SPST N.O.
Q2 2N388
VOUT
R2 2.7k
RL



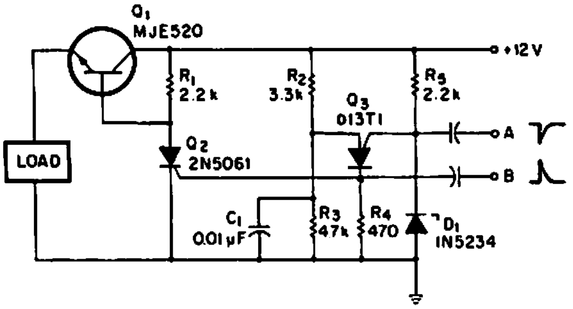
TO IC BOARD
FROM +14V SUPPLY
1N4745A ZENER
1N4002
10μF
2N1595 (GE)
510

$6 INSURANCE FOR IC—Inserted between 14-V supply and IC load to protect against overvoltages caused by supply failures or noise spikes, and against wrong polarities caused by human errors. Uses 1N4002 silicon diode to blow fuse before reverse voltage damages IC's. Capacitor protects against spikes and prevents them from producing unnecessary crowbar action by scr and diode.—A. Geiersbach, Low-Cost Circuit Can Protect a Boardful of High-Cost ICs, *Electronic Design*, May 10, 1969, p 138.



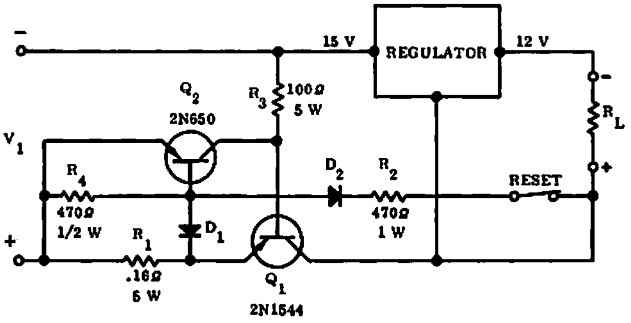
Q2
R3 240
BFY-55 or EQUIVALENT
+
24-V INPUT FROM ZENER REGULATED SUPPLY
−
R1 5.6k
R2
PRESET POTENTIOMETER SET TO 575
Vc
Q1
Vo
10
SENSING RESISTOR
RVo
+
REGULATED 15-V OUTPUT
−
CURRENT LIMIT
REGULATOR
VOLTAGE SENSE
μA723

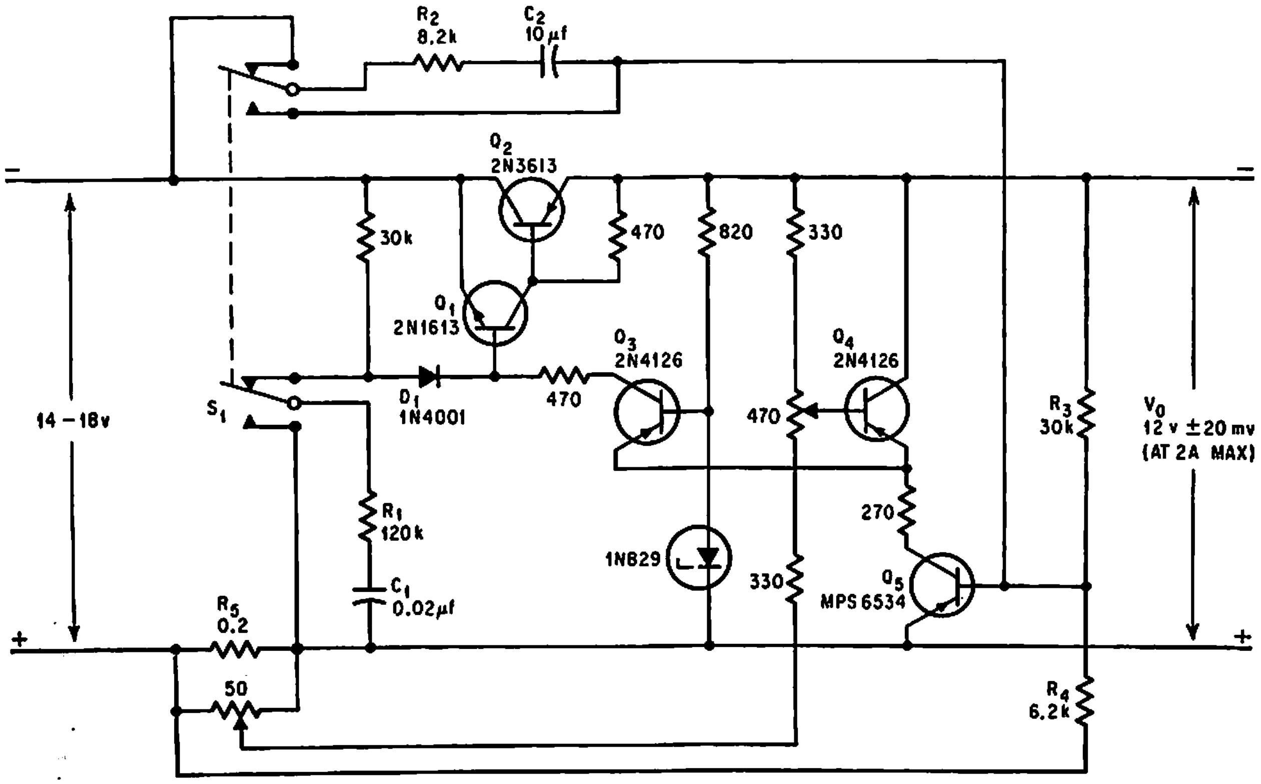
SERIES REGULATOR PROTECTION—Addition of Q2 network across series-pass transistor terminals of μA723 IC voltage regulator provides short-circuit protection. Article tells how to compute resistor values for use with other voltages and currents in series-type voltage regulators.—W. Grantler, Short-Circuit Protection for Voltage Regulators, *Electronics*, April 27, 1970, p 91.


Q1
MJE520
+12V
R1
2.2k
R2
3.3k
Q3
013T1
R5
2.2k
A
B
LOAD
Q2
2N5061
C1
0.01μF
R3
47k
R4
470
D1
1N5234

OVERVOLTAGE TRIP CIRCUIT—When supply voltage rises above value set by ratio R2-R3, programmable ujt Q3 fires and generates complementary pulses A and B that may be used to trigger alarm circuits or serve other functions. In addition, firing of Q3 turns on Q2, to cut off Q1 and load. Circuit stays off after circuit trips, until supply voltage is shut off so Q2 can commutate and reset circuit.—V. R. Laul, Adjustable-Overvoltage Circuit Breaker, *EEE*, April 1970, p 101.

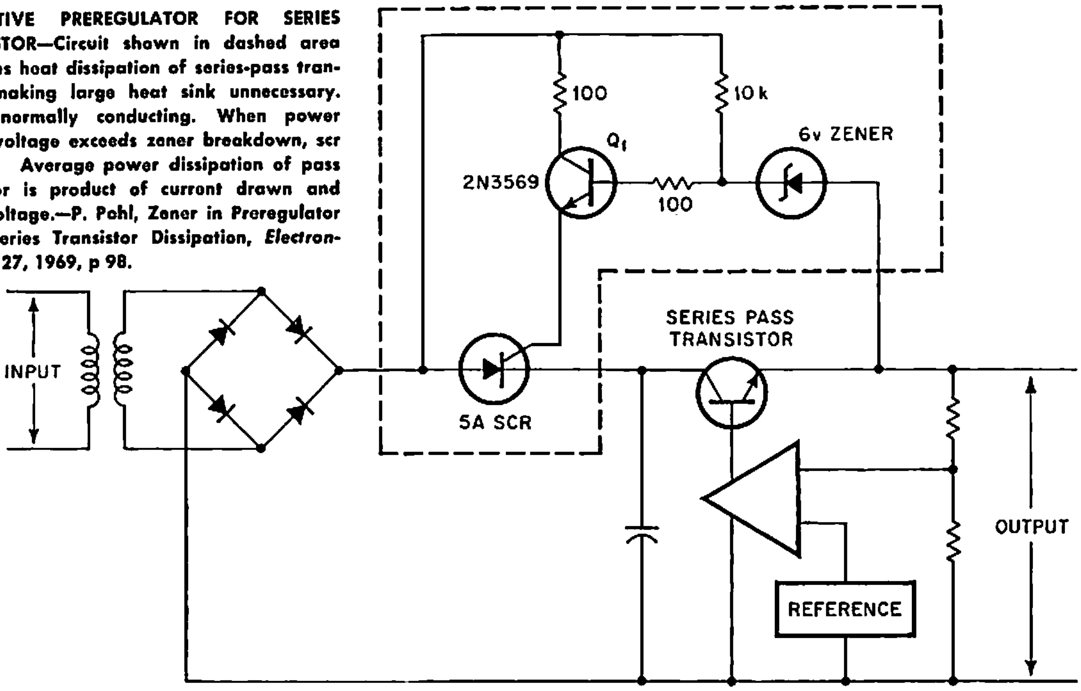
5.5-A ELECTRONIC FUSE—Switching action occurs in 90 μs, for protection of transistors in 12-V 5-A regulated power supply. When fuse acts, Q2 is on and Q1 off, so power is bypassed around transistors in regulator. Circuit is reset, after removing overload, by momentarily opening reset switch to remove power.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 8–2–3.


−
15 V
REGULATOR
12 V
−
Q2
2N650
R3
100Ω
5 W
RL
V1
R4
470Ω
1/2 W
D2
R2
470Ω
1 W
RESET
+
+
R1
.16Ω
6 W
D1
Q1
2N1544


R2
8.2k
C2
10μf
Q2
2N3613
−
−
30k
470
820
330
Q1
2N1613
Q3
2N4126
Q4
2N4126
D1
1N4001
470
470
14 − 18v
S1
R3
30k
V0
12 v ±20 mv
(AT 2A MAX)
R1
120k
270
C1
0.02μf
1N829
330
Q5
MPS 6534
R5
0.2
+
+
50
R4
6.2k

SERIES REGULATOR OVERLOAD—Single transistor Q5 is cut off by drop across R5 when output current of regulated 12-V supply increases beyond permissible maximum value, turning off regulator. Circuit has good temperature stability. Protection is achieved at much lower cost than with conventional flip-flop or scr and separate d-c supply.—S. Walko, Single Transistor Protects Power Supply from Overload, *Electronics*, June 12, 1967, p 102–103.

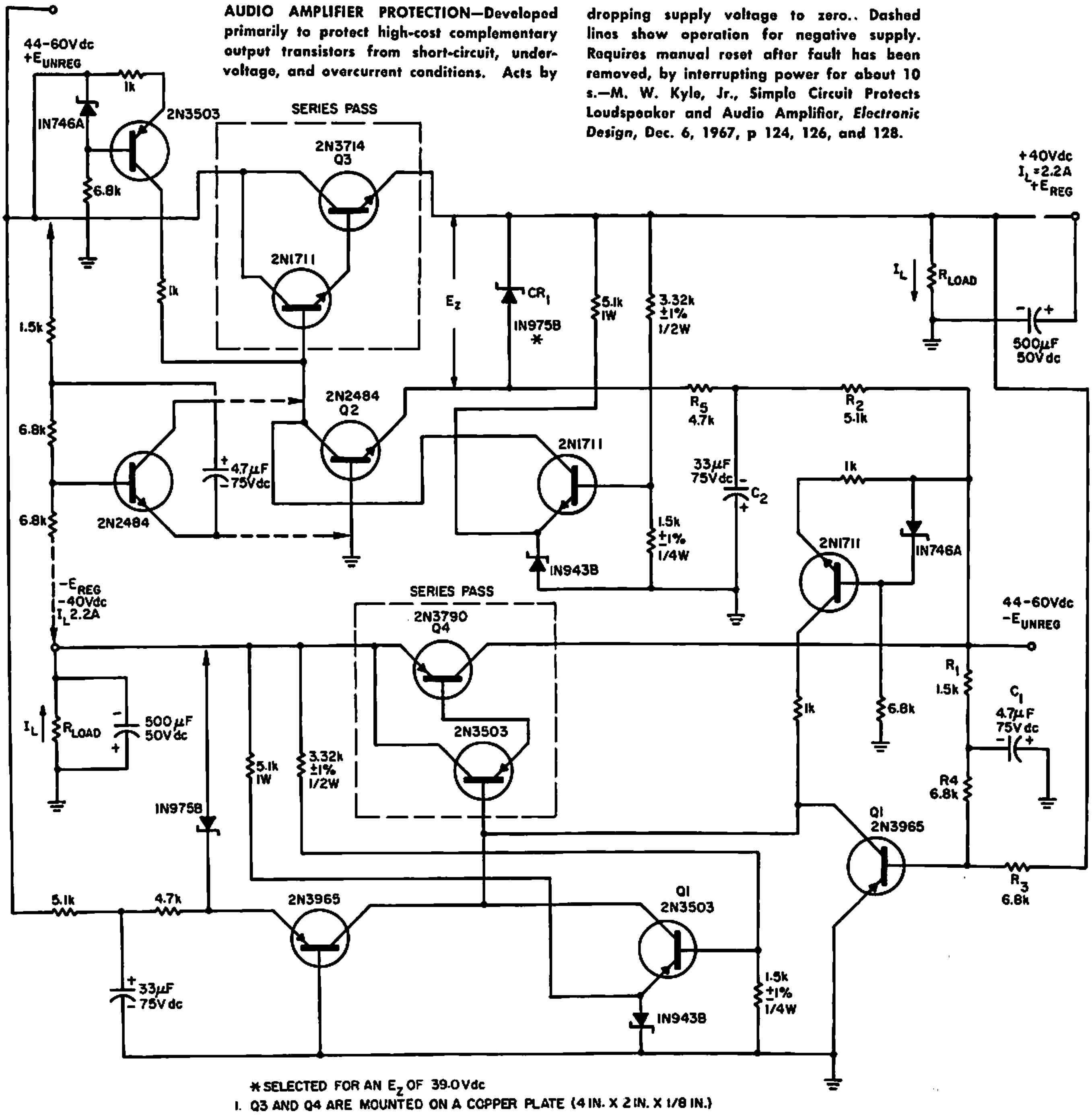
PROTECTIVE PREREGULATOR FOR SERIES TRANSISTOR—Circuit shown in dashed area decreases heat dissipation of series-pass transistor, making large heat sink unnecessary. Scr is normally conducting. When power supply voltage exceeds zener breakdown, scr cuts off. Average power dissipation of pass transistor is product of current drawn and zener voltage.—P. Pohl, Zener in Preregulator Limits Series Transistor Dissipation, *Electronics*, Oct. 27, 1969, p 98.


100
10 k
Q1
6v ZENER
2N3569
100
INPUT
SERIES PASS
TRANSISTOR
5A SCR
OUTPUT
REFERENCE

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 65

Protection Circuits

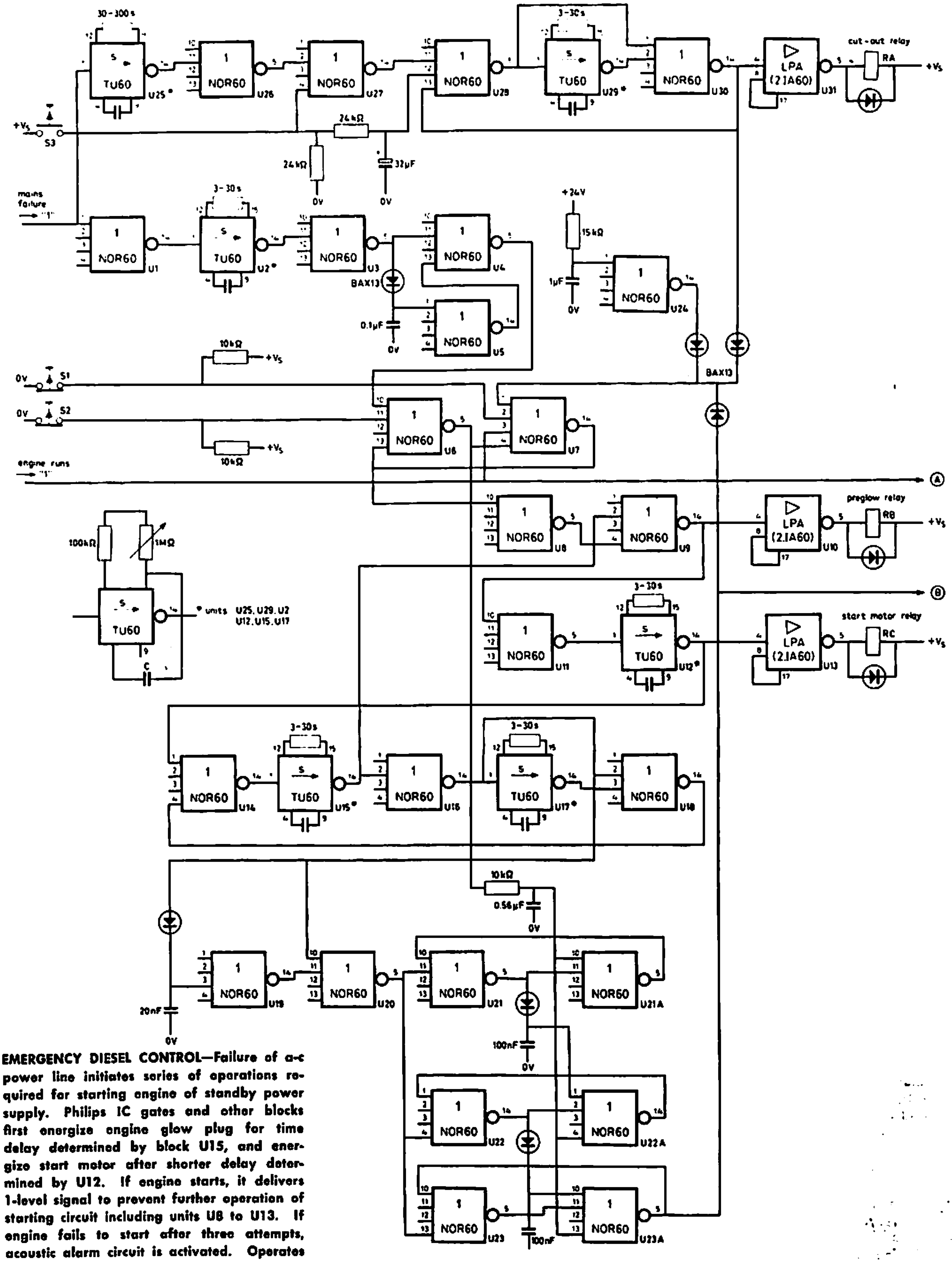


44-60Vdc
+E_UNREG
1k
IN746A
2N3503
6.8k
SERIES PASS
2N3714
Q3
2N1711
1k
1.5k
6.8k
6.8k
2N2484
4.7μF
75Vdc
2N2484
Q2
E_Z
CR_1
IN975B
*
5.1k
1W
3.32k
±1%
1/2W
+40Vdc
I_L=2.2A
+E_REG
I_L
R_LOAD
500μF
50Vdc
R_5
4.7k
R_2
5.1k
33μF
75Vdc
C_2
2N1711
1.5k
±1%
1/4W
IN943B
1k
2N1711
IN746A
-E_REG
-40Vdc
I_L 2.2A
SERIES PASS
2N3790
Q4
44-60Vdc
-E_UNREG
I_L
R_LOAD
500μF
50Vdc
5.1k
1W
3.32k
±1%
1/2W
2N3503
1k
6.8k
R_1
1.5k
C_1
4.7μF
75Vdc
R4
6.8k
IN975B
Q1
2N3965
R_3
6.8k
5.1k
4.7k
2N3965
Q1
2N3503
1.5k
±1%
1/4W
IN943B
33μF
75Vdc

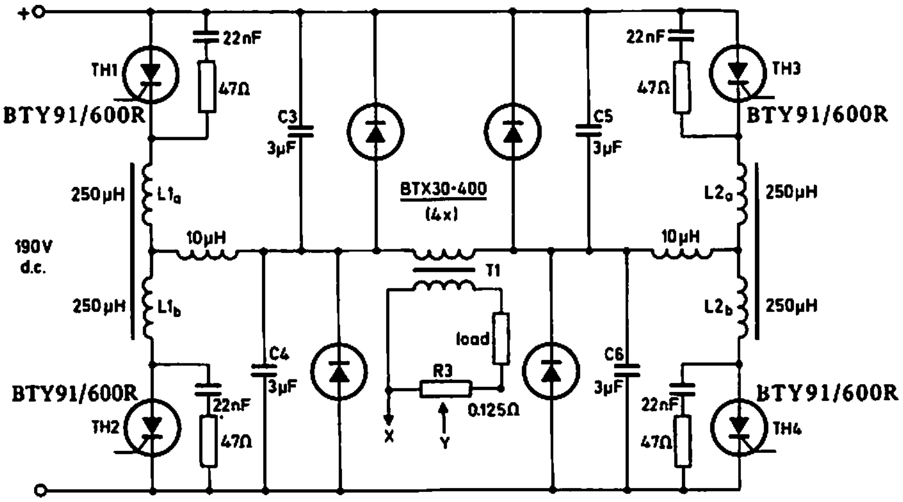
AUDIO AMPLIFIER PROTECTION—Developed primarily to protect high-cost complementary output transistors from short-circuit, undervoltage, and overcurrent conditions. Acts by dropping supply voltage to zero.. Dashed lines show operation for negative supply. Requires manual reset after fault has been removed, by interrupting power for about 10 s.—M. W. Kyle, Jr., Simple Circuit Protects Loudspeaker and Audio Amplifier, *Electronic Design*, Dec. 6, 1967, p 124, 126, and 128.

*SELECTED FOR AN E_Z OF 39.0Vdc

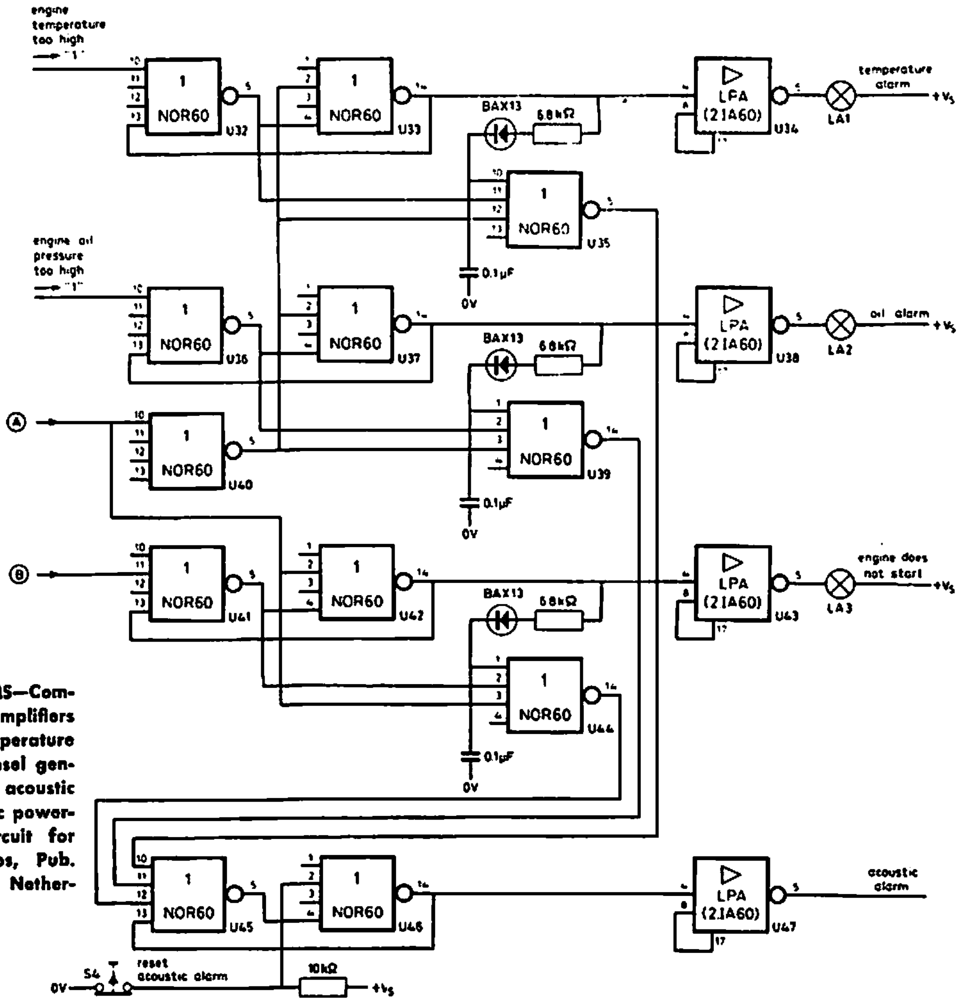
1. Q3 AND Q4 ARE MOUNTED ON A COPPER PLATE (4 IN. X 2 IN. X 1/8 IN.)


30-300 s
TU60
U25*
NOR60
U26
U27
U28
3-30 s
U29*
U30
LPA (2JA60)
U31
cut-out relay
RA
+Vs
S3
24kΩ
32μF
0V
mains failure "1"
U1
U2*
U3
U4
BAX13
0.1μF
U5
+24V
15kΩ
1μF
U24
BAX13
10kΩ
S1
S2
U6
U7
engine runs "1"
A
U8
U9
U10
preglow relay
RB
100kΩ
1MΩ
* units U25, U29, U2, U12, U15, U17
C
U11
U12*
U13
B
start motor relay
RC
U14
U15*
U16
U17*
U18
0.56μF
20nF
U19
U20
U21
U21A
100nF
U22
U22A
U23
U23A

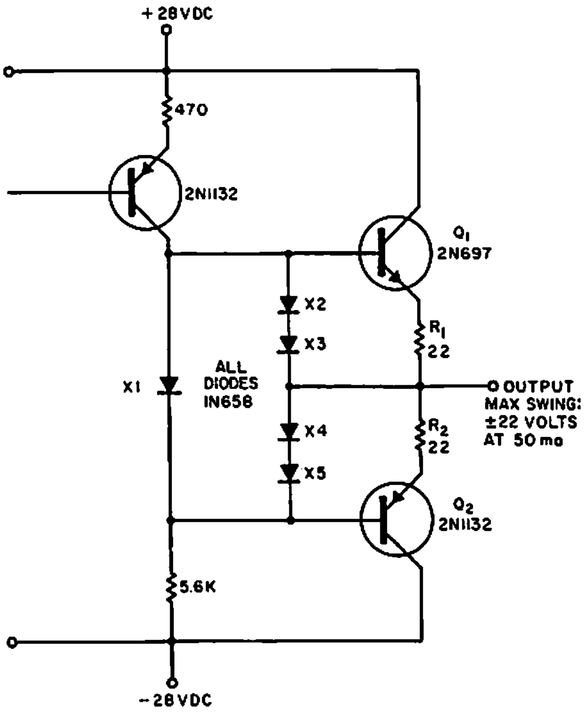
EMERGENCY DIESEL CONTROL—Failure of a-c power line initiates series of operations required for starting engine of standby power supply. Philips IC gates and other blocks first energize engine glow plug for time delay determined by block U15, and energize start motor after shorter delay determined by U12. If engine starts, it delivers 1-level signal to prevent further operation of starting circuit including units U8 to U13. If engine fails to start after three attempts, acoustic alarm circuit is activated. Operates from 24-V battery. Timer capacitor for U25 is 320 μF and all other timer capacitors are 32 μF. Leads at right go to warning and alarm circuit.—W. Klein, Control Circuit for Emergency Diesel Generator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 74.


+
22nF
TH1
47Ω
BTY91/600R
C3
3µF
BTX30-400
(4x)
C5
3µF
22nF
47Ω
TH3
BTY91/600R
250µH
L1a
190V
d.c.
10µH
10µH
L2a
250µH
250µH
L1b
T1
L2b
250µH
load
C4
3µF
R3
C6
3µF
BTY91/600R
22nF
TH2
47Ω
X
Y
0.125Ω
22nF
47Ω
BTY91/600R
TH4

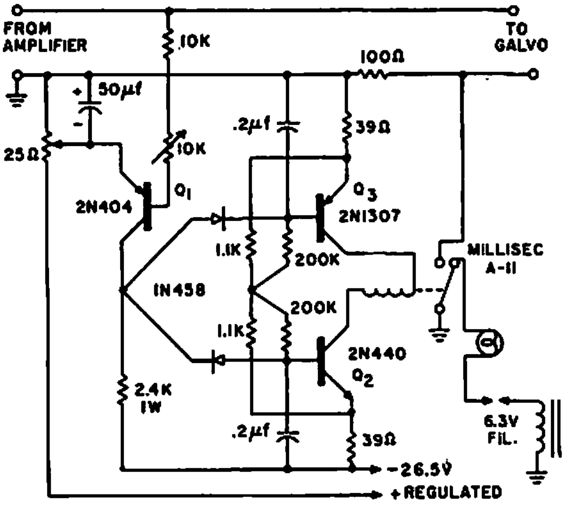
1.5-KW THYRISTOR BRIDGE INVERTER—Converts 190-V d-c to 220-V 400-Hz power. Includes trigger connected to thyristor gates and overload sensor connected to points X and Y, for protecting thyristors from overload. T1 has 190-turn primary and 220-turn secondary.—N. Bergstra and R. v. d. Linden, Overload Current Protection for a Bridge Inverter, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 95, 1970.


engine temperature too high "1"
NOR60
U32
NOR60
U33
BAX13
68kΩ
LPA (2IA60)
U34
temperature alarm
+V_S
LA1
NOR60
U35
0.1µF
0V
engine oil pressure too high "1"
NOR60
U36
NOR60
U37
BAX13
68kΩ
LPA (2IA60)
U38
oil alarm
+V_S
LA2
A
NOR60
U40
NOR60
U39
0.1µF
0V
B
NOR60
U41
NOR60
U42
BAX13
68kΩ
LPA (2IA60)
U43
engine does not start
+V_S
LA3
NOR60
U44
0.1µF
0V
NOR60
U45
NOR60
U46
LPA (2IA60)
U47
acoustic alarm
S4
reset acoustic alarm
0V
10kΩ
+V_S

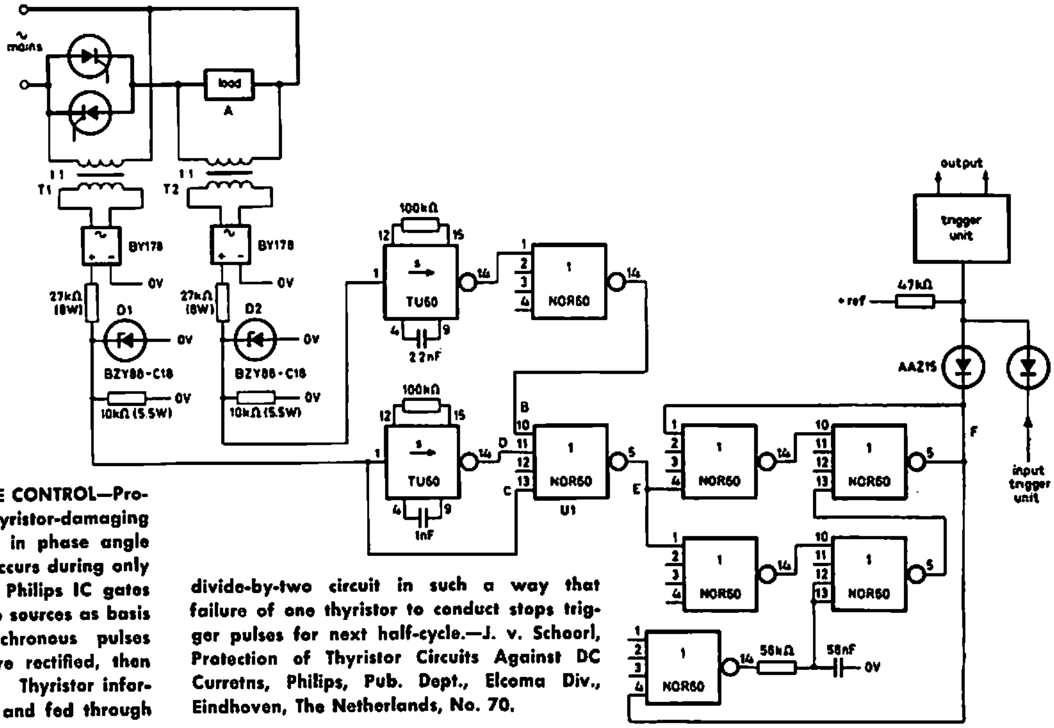
EMERGENCY DIESEL START-UP ALARMS—Combination of Philips IC gates and amplifiers energizes indicator lamps for temperature and oil pressure after emergency diesel generator starts, and both lamp and acoustic alarm if engine fails to start after a-c power-line failure.—W. Klein, Control Circuit for Emergency Diesel Generator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 74.


+28VDC
470
2N1132
Q1
2N697
X2
X3
R1
22
X1
ALL
DIODES
IN658
OUTPUT
MAX SWING:
±22 VOLTS
AT 50 ma
X4
R2
22
X5
Q2
2N1132
5.6K
-28VDC

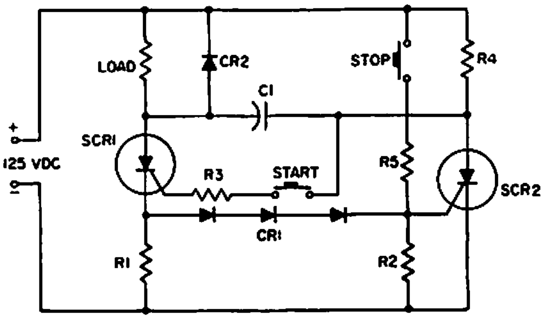
OUTPUT TRANSISTOR PROTECTION—Maximum current through either output transistor of complementary pair Q1-Q2 is limited to 50 mA. Diode X1 provides forward bias that is self-compensating for temperature and minimizes crossover distortion.—R. S. Young, Complementary Output Stage Provides Short Circuit Protection, *Electronic Design*, June 22, 1964, p 71–73.


FROM
AMPLIFIER
10K
TO
GALVO
100Ω
50μf
.2μf
39Ω
25Ω
10K
Q1
2N404
Q3
2N1307
1.1K
200K
MILLISEC
A-II
IN458
200K
1.1K
2N440
Q2
2.4K
1W
.2μf
39Ω
6.3V
FIL.
-26.5V
+REGULATED

GALVANOMETER GUARD—Overload safety circuit prevents damage to high-frequency galvanometer driven by very low impedance amplifier. Protection is achieved by using relay to switch 100-ohm resistor into ground line to bypass galvanometer current on either positive or negative overvoltage. 10K pot in base circuit of Q1 adjusts sensitivity.—T. B. Whiteley, Transistor, Relay Switch Safeguard Sensitive Galvanometer, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 145.


mains
load
A
1:1
T1
1:1
T2
BY178
0V
BY178
0V
27kΩ
(8W)
D1
0V
27kΩ
(8W)
D2
0V
BZY88-C18
BZY88-C18
10kΩ (5.5W)
0V
10kΩ (5.5W)
0V
100kΩ
TU60
2.2nF
100kΩ
TU60
1nF
NOR60
B
D
C
U1
E
NOR60
NOR60
NOR60
NOR60
NOR60
56kΩ
56nF
0V
output
trigger
unit
+ref
47kΩ
AA215
F
input
trigger
unit

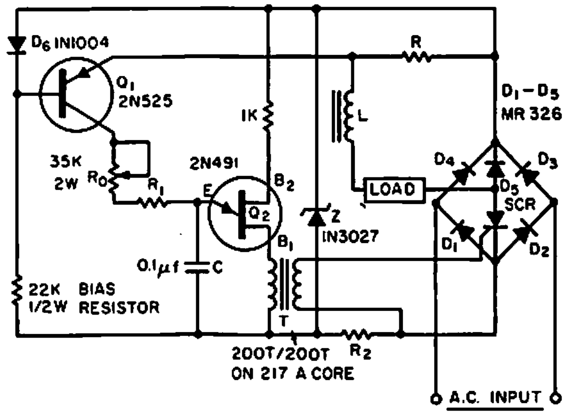
THYRISTORS IN PHASE ANGLE CONTROL—Provides protection against thyristor-damaging direct current that can flow in phase angle control circuit if conduction occurs during only half of cycle. Circuit using Philips IC gates obtains information from two sources as basis for protective action. Synchronous pulses from line transformer T1 are rectified, then limited to 18 V by zener D1. Thyristor information is obtained from T2 and fed through divide-by-two circuit in such a way that failure of one thyristor to conduct stops trigger pulses for next half-cycle.—J. v. Schoorl, Protection of Thyristor Circuits Against DC Curretns, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 70.


LOAD
CR2
C1
STOP
R4
+
125 VDC
SCR1
R3
START
R5
SCR2
CR1
R1
R2

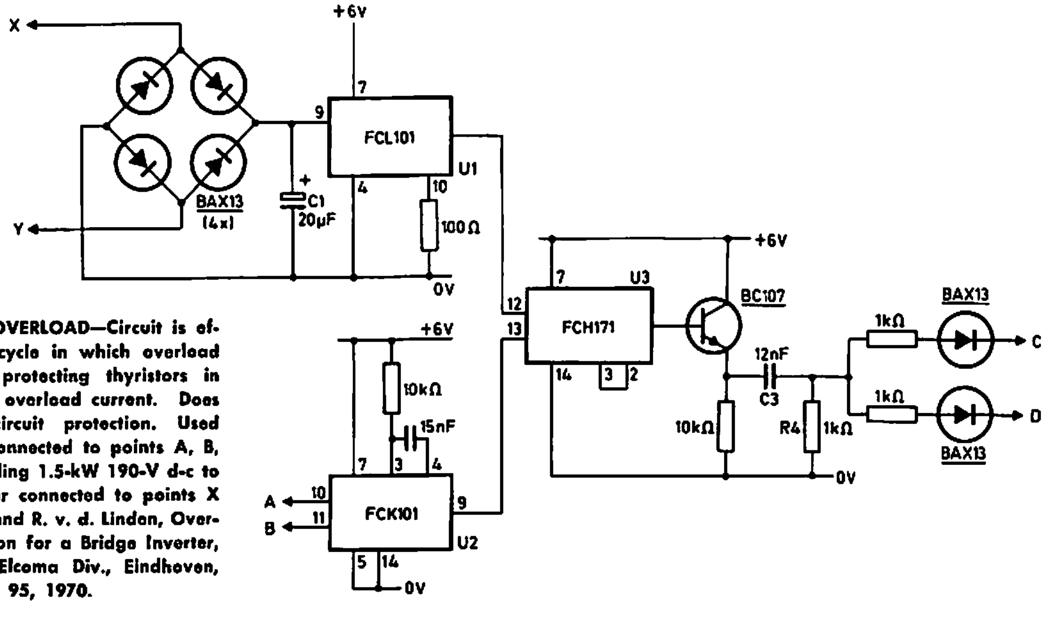
R1 ≅ 3/I_{trip} OHMS NON-INDUCTIVE
R2 - 220 OHMS, 1/2 WATT
R3 - 100 OHMS, 1/2 WATT
R4 - 2200 OHMS, 10 WATTS
R5 - 2200 OHMS, 5 WATTS

C1 ≳ 0.4 I_{trip} MFD
SCR1 - G E C40B
SCR2 - G E C40B
CR1 - (3) G.E. A13A
CR2 - G E IN2158

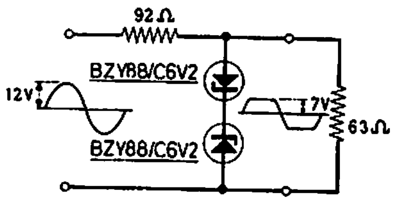
16-A D-C SCR FLIP-FLOP CIRCUIT BREAKER—Circuit is basically parallel capacitor-commutated flip-flop. Pressing start button momentarily makes SCR1 conduct and deliver power to load. Pressing stop button momentarily will interrupt load. If load current exceeds forward voltage drop across diode string CR1 and gate firing requirement of SCR2, load is interrupted automatically in less than half a cycle. Value of R1 and number of diodes determine level at which circuit will trip out. For values shown, maximum trip current should not exceed 100 A. Even with fault current rise of 10 million amperes per second, breaker will interrupt fault in 20 μs and keep peak fault current below 50 A.—"SCR Manual," 4th Edition, General Electric, 1967, p 156–158.


D6 IN1004
Q1
2N525
R
IK
L
D1-D5
MR 326
35K
2W
R0
R1
2N491
E
Q2
B2
B1
Z
IN3027
LOAD
D4
D3
D5
SCR
D1
D2
0.1μf
C
22K BIAS
1/2W RESISTOR
T
200T/200T
ON 217 A CORE
R2
A.C. INPUT

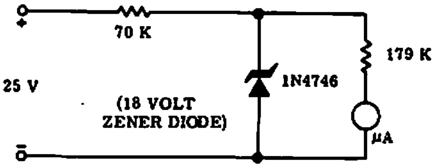
STARTING-CURRENT SURGE LIMITER—Protects components from damage by initial current surge through loads having low initial impedance, such as capacitors and incandescent lamps. Circuit converts voltage source seen by load into current source for duration of start-up. R-L time constant should be chosen to match duration of transient.—B. Berman, Q-R-L Network Limits Surge to Low-Starting Loaded SCR, *Electronic Design*, April 12, 1965, p 52–53.


X
Y
BAX13
(4x)
+6V
7
9
FCL101
U1
4
10
C1
20μF
100Ω
0V
+6V
7
U3
12
13
FCH171
14
3
2
BC107
12nF
C3
10kΩ
R4
1kΩ
0V
1kΩ
1kΩ
BAX13
BAX13
C
D
+6V
10kΩ
15nF
7
3
4
A
B
10
11
FCK101
9
U2
5
14
0V

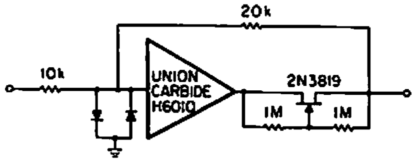
THYRISTOR BRIDGE OVERLOAD—Circuit is effective on first half-cycle in which overload current occurs, for protecting thyristors in bridge inverter from overload current. Does not provide short-circuit protection. Used with trigger circuit connected to points A, B, C, and D, for controlling 1.5-kW 190-V d-c to 220-V 400-Hz inverter connected to points X and Y.—N. Bergstra and R. v. d. Linden, Overload Current Protection for a Bridge Inverter, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 95, 1970.


92Ω
BZY88/C6V2
12V
7V
63Ω
BZY88/C6V2

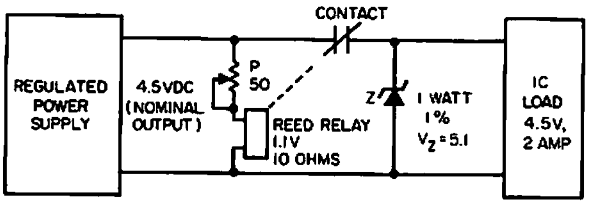
ZENER SPIKE CLIPPER—Two zeners in antiphase serve as full-wave stabilized amplitude limiter than can be used to protect other circuit elements against voltage surges or spikes. Clipping occurs at zener voltage level regardless of input voltage, but higher input makes output waveform more square so load takes more power.—Zener Diodes and Their Applications, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1966.


+
70 K
179 K
25 V
1N4746
(18 VOLT ZENER DIODE)
μA
−

ZENER PROTECTS MICROAMMETER—18-V zener prevents overloading of 100-μA meter movement without affecting meter linearity. Chief advantage over thermal protection is instantaneous action of zener, provided repeatedly and indefinitely with no reset time. —"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 7–13.

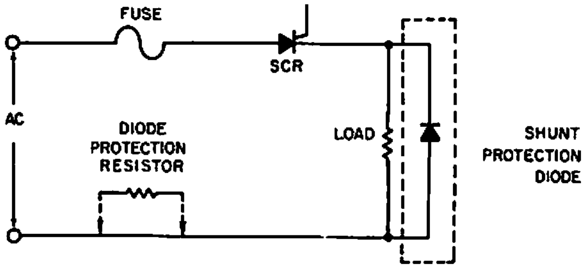

20k
10k
UNION CARBIDE H6010
2N3819
1M
1M

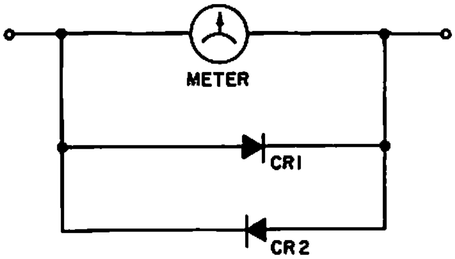
OPAMP PROTECTION—Inexpensive fet at output of opamp provides protection against voltage source up to 40 V applied even momentarily to output by limiting maximum output current to 10 mA. Effect on performance of opamp is almost negligible. Diodes similarly protect against excessive input voltages.—J. D. Spaihts, FET Protection for Opamps, *EEE*, Feb. 1970, p 115.


REGULATED POWER SUPPLY
4.5VDC (NOMINAL OUTPUT)
P 50
CONTACT
REED RELAY 1.1V 10 OHMS
Z
1 WATT 1% V_Z=5.1
IC LOAD 4.5V, 2 AMP

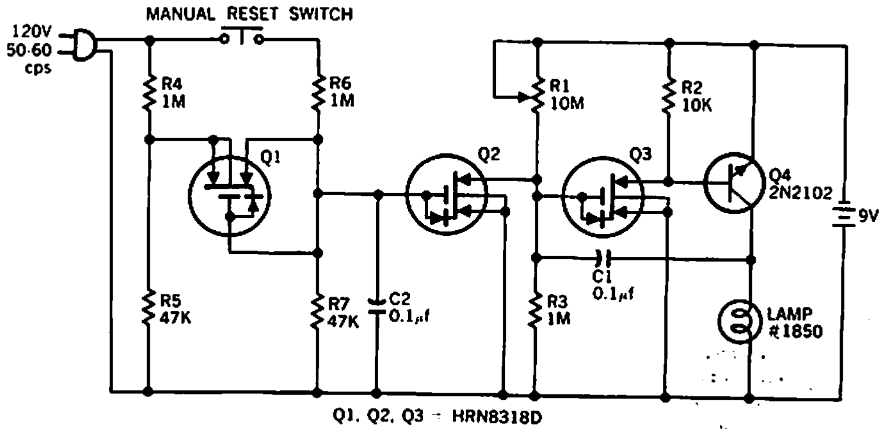
IC OVERVOLTAGE PROTECTION—Reed relay and zener diode protect low-voltage IC module from regulated power supply defect by clamping supply voltage at safe 5.1 V if, for example, failure of series-pass transistor in supply shoots voltage up to 9 V. Reed relay is then energized to open IC supply circuit before zener gets too hot.—J. J. McManus, Integrated Circuit Protected by Reed Relay-Diode Combination, *Electronic Design*, Nov. 29, 1965, p 78.

SCR LOAD PROTECTION—Prevents shorted scr from dumping excessive current into load. Bucking diode across load draws high current during normally missing half-cycle when scr fails, forcing fuse to blow. Load-shunting diode may be damaged before fuse blows unless application permits inserting sufficiently high limiting resistance in series with load. —J. T. Lamb, Shunt Diode Protects Load in SCR Circuit, *Electronic Design*, Oct. 25, 1969, p 109.

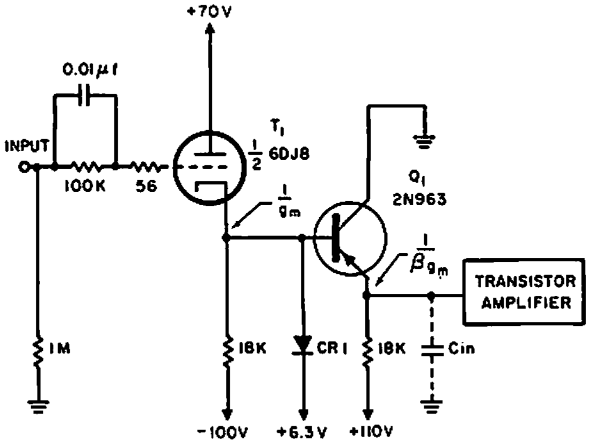

FUSE
SCR
AC
DIODE PROTECTION RESISTOR
LOAD
SHUNT PROTECTION DIODE


METER
CR1
CR2

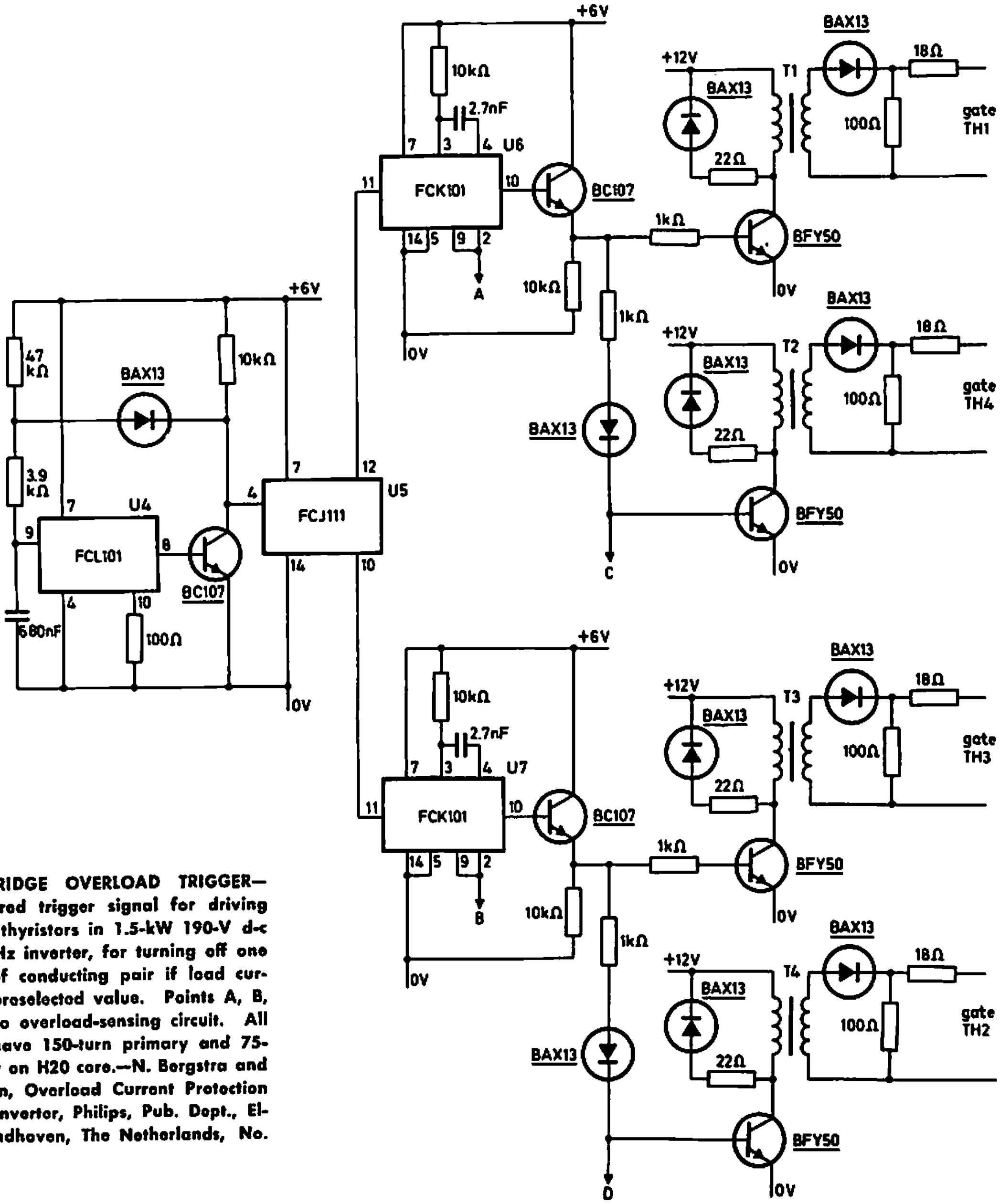
D-C METER PROTECTION—Low-cost low-voltage low-current silicon rectifiers such as 1N1692, connected across meter with opposite polarity as shown, will protect 50-μA meter of typical multimeter against heavy fault currents without introducing more than 1% error. With 1-A overload current, meter current is less than 1 mA because rectifiers begin conducting heavily when voltage across them exceeds about 0.5 V. For higher fault current, use higher-current rectifiers such as GE-X4.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 156.


120V 50-60 cps
MANUAL RESET SWITCH
R4 1M
R6 1M
Q1
Q2
R1 10M
R2 10K
Q3
Q4 2N2102
9V
C1 0.1μf
R5 47K
R7 47K
C2 0.1μf
R3 1M
LAMP #1850
Q1, Q2, Q3 = HRN8318D

POWER FAILURE INDICATOR—Flasher is turned on by a-c line power failure, and keeps flashing until manual reset switch is operated, as indication that a-c line power has been interrupted. One application is for a-c power system serving unattended refrigerators or freezers, where power failure could cause food spoilage.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 46.

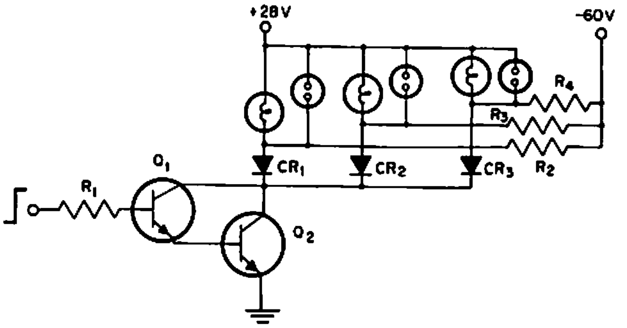

+70V
0.01μf
INPUT
100K
56
T1
1/2 6DJ8
1/gm
Q1
2N963
1/βgm
TRANSISTOR AMPLIFIER
1M
18K
CR1
18K
Cin
-100V
+6.3V
+110V

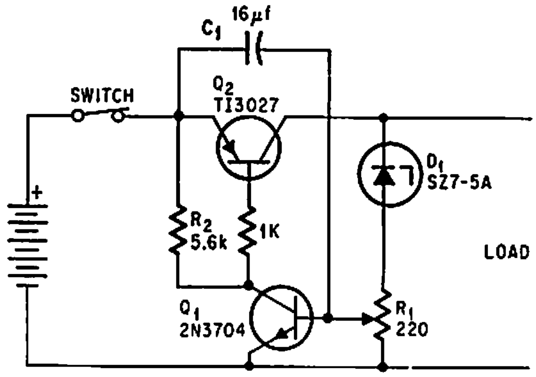
OVERLOAD PROTECTION—Triode cathode follower in cascade with emitter follower provides very low output impedance (below 10 ohms) and protects against large d-c overloads. Article describes operation.—L. A. Egherman, Emitter-Follower Circuit Protects Against Overloads, *Electronic Design*, March 15, 1965, p 61–62.


+6V
10kΩ
2.7nF
7
3
4
U6
11
FCK101
10
BC107
14
5
9
2
A
10kΩ
0V
1kΩ
BFY50
0V
BAX13
+12V
BAX13
T1
18Ω
100Ω
gate TH1
22Ω
1kΩ
BAX13
+12V
BAX13
T2
18Ω
100Ω
gate TH4
22Ω
BAX13
BFY50
0V
C
+6V
47 kΩ
10kΩ
BAX13
3.9 kΩ
7
U4
4
9
FCL101
8
BC107
680nF
4
10
100Ω
0V
7
12
U5
FCJ111
14
10
+6V
10kΩ
2.7nF
7
3
4
U7
11
FCK101
10
BC107
14
5
9
2
B
10kΩ
0V
1kΩ
BFY50
0V
1kΩ
BAX13
+12V
BAX13
T3
18Ω
100Ω
gate TH3
22Ω
BAX13
+12V
BAX13
T4
18Ω
100Ω
gate TH2
22Ω
BAX13
BFY50
D
0V

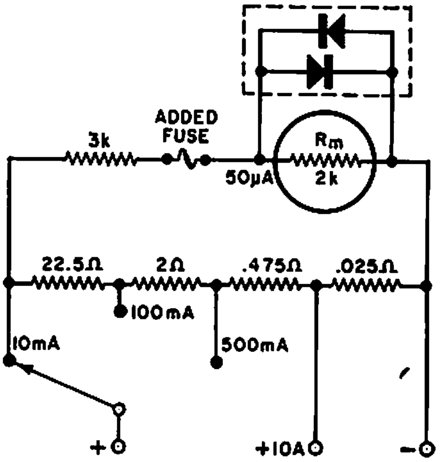
THYRISTOR BRIDGE OVERLOAD TRIGGER—Provides required trigger signal for driving gates of four thyristors in 1.5-kW 190-V d-c to 220-V 400-Hz inverter, for turning off one of thyristors of conducting pair if load current exceeds preselected value. Points A, B, C, and D go to overload-sensing circuit. All transformers have 150-turn primary and 75-turn secondary on H20 core.—N. Borgstra and R. v. d. Linden, Overload Current Protection for a Bridge Invertor, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 95, 1970.

MULTIPLE-LAMP FAILURE—NE2 neons, shunting 28-V incandescent lamps connected as loads for Darlington Q1-Q2, glow only for lamp failure. Circuit values are not critical and depend mainly on current ratings of lamps. Q1 can be 2N718A, Q2 2N1613, diodes 1N-4245, R1 47K, and other resistors 100K.—D. A. Vaughan, Combination Lamp Driver and Failure Indicator, *EEE*, May 1969, p 117–118.

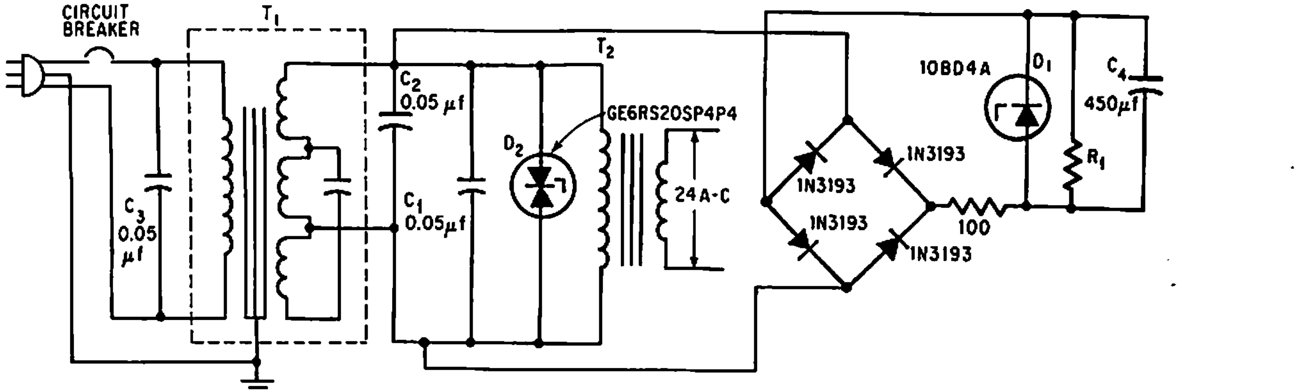

+28V
-60V
R4
R3
R2
CR1
CR2
CR3
Q1
Q2
R1


C1
16μf
SWITCH
Q2
TI3027
+
R2
5.6k
1K
D1
SZ7-5A
LOAD
Q1
2N3704
R1
220

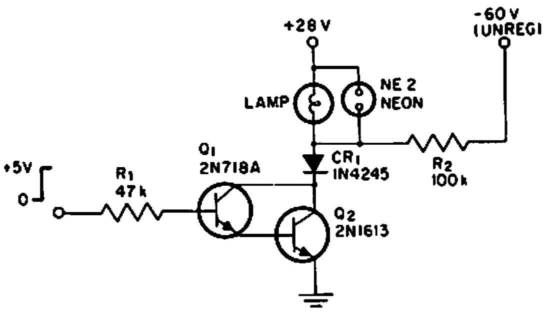
NICKEL-CADMIUM BATTERY—Prevents complete discharge by sensing when battery voltage falls below zener point of D1 and then turning off Q2 to open circuit. Prevents buildup of gas pressure and rupturing of cell, and increases battery life. Switch must be opened after each protective action, so C1 can discharge and permit turn-on.—D. L. Haskard, Voltage Sensor Limits Discharge in Batteries, *Electronics*, April 1, 1968, p 62.


ADDED FUSE
3k
Rm
2k
50μA
22.5Ω
2Ω
.475Ω
.025Ω
100mA
10mA
500mA
+
+10A
−

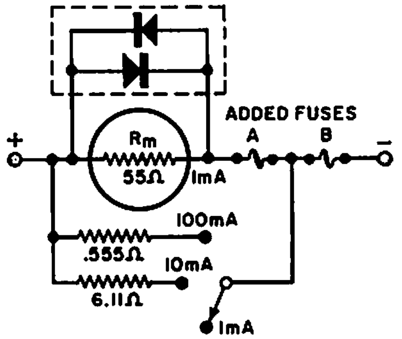
PROTECTOR DIODES FOR SIMPSON 260—Two Ohmite silicon diodes can be added to protect meter from current-range overloads. Bussmann AGX fast-blow 0.125-A instrument fuse can be added for extra protection, although 3,000-ohm resistor already in circuit will act as current limiter.—A. A. Mangieri, Diode Meter Protectors, *Electronics World*, Nov. 1966, p 56–57 and 76.


CIRCUIT BREAKER
T1
C3
0.05
μf
C2
0.05 μf
C1
0.05μf
T2
D2
GE6RS20SP4P4
24 A-C
10BD4A
D1
C4
450μf
R1
1N3193
1N3193
1N3193
1N3193
100

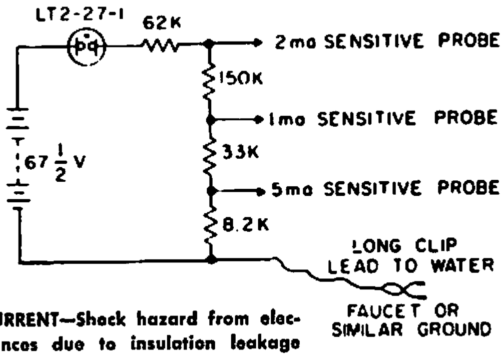
MIDNIGHT LINE SURGE CLIPPER—Protects refrigerators, freezers, and control equipment from damage by high line voltage surges that occur in late evening hours. Bridge rectifier and its load R1-C4, connected to a-c line filter, clips peaks of transients to keep voltage in filter at 117 V a-c.—L. E. Greenlee, Bridge Rectifier Clips Dangerous Voltages, *Electronics*, March 4, 1968, p 89–90.


+28V
-60V (UNREG)
LAMP
NE 2 NEON
+5V
0
R1 47k
Q1 2N718A
CR1 1N4245
R2 100k
Q2 2N1613

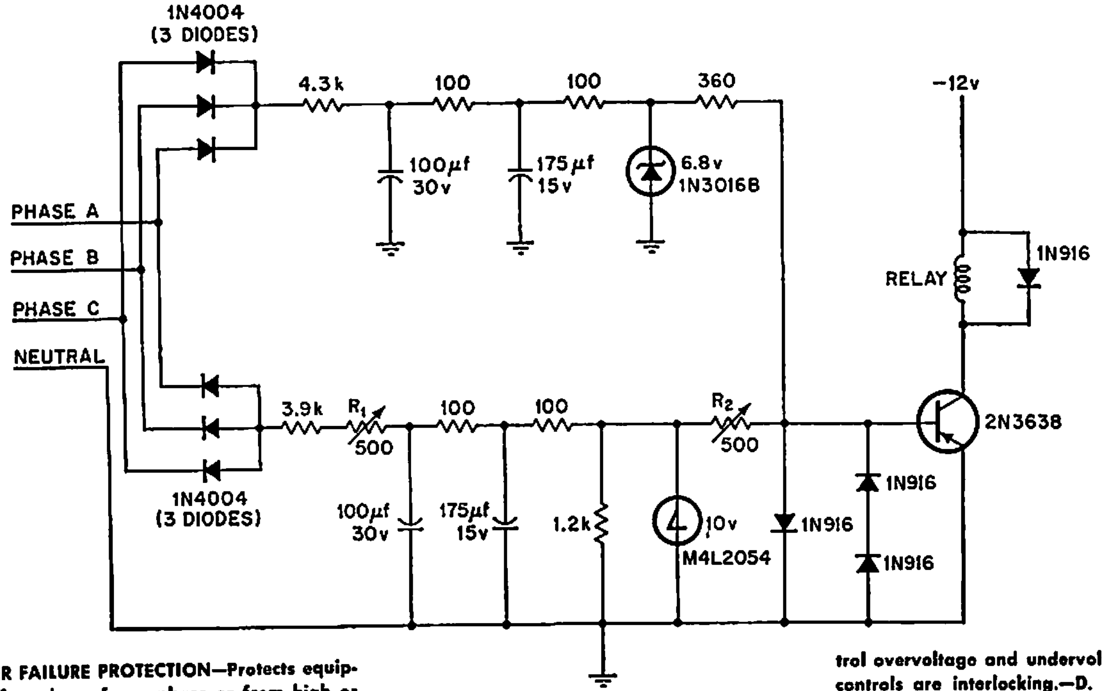
LAMP FAILURE—Provides reliable indication of failure of incandescent indicator lamp for critical information on instrument panel. Lamp being monitored is load for two-stage Darlington amplifier. Neon lamp connected across indicator glows only when incandescent lamp burns out.—D. A. Vaughan, Combination Lamp Driver and Failure Indicator, *EEE*, May 1969, p 117–118.


+
−
Rm
55Ω
ImA
ADDED FUSES
A
B
100mA
.555Ω
10mA
6.11Ω
ImA

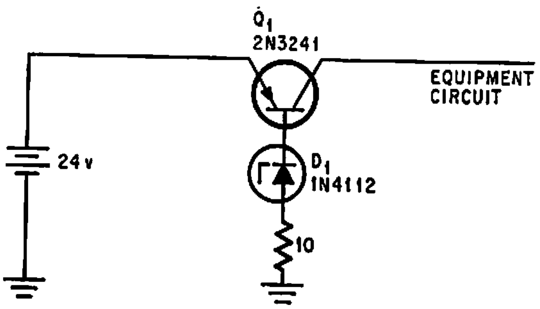
PROTECTING CURRENT RANGES OF VOM—Two Ohmite OMC7111 silicon diodes in parallel back-to-back provide protection against overloads of either polarity. Since diodes are connected directly between test leads, fuses must be added to protect against accidental overvoltage. Use ⅛-A fuses, which will break circuit in 1 s at 220 mA.—A. A. Mangieri, Diode Meter Protectors, *Electronics World*, Nov. 1966, p 56–57 and 76.


LT2-27-1
62K
2ma SENSITIVE PROBE
150K
1ma SENSITIVE PROBE
$67\frac{1}{2}$V
33K
5ma SENSITIVE PROBE
8.2K
LONG CLIP LEAD TO WATER
FAUCET OR SIMILAR GROUND

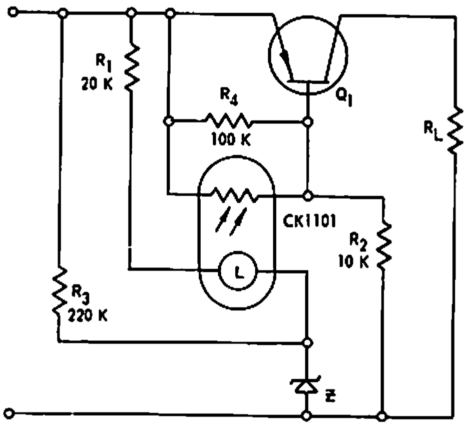
LEAKAGE CURRENT—Shock hazard from electrical appliances due to insulation leakage is determined by neon lamp indication. Anything above 5 mA is considered dangerous and makes neon glow.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 146.


1N4004 (3 DIODES)
4.3k
100
100
360
−12v
100μf 30v
175μf 15v
6.8v 1N3016B
PHASE A
PHASE B
PHASE C
NEUTRAL
RELAY
1N916
3.9k
R1
500
100
100
R2
500
2N3638
1N4004 (3 DIODES)
100μf 30v
175μf 15v
1.2k
10v
M4L2054
1N916
1N916
1N916

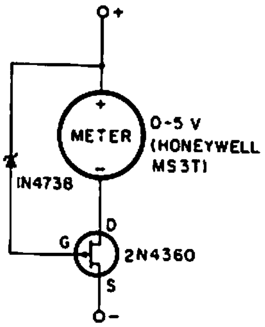
POWER FAILURE PROTECTION—Protects equipment from loss of one phase or from high or low line voltage. Compares sum of three-phase line voltages with regulated supply voltage and removes power from equipment when necessary. Settings of R1 and R2 control overvoltage and undervoltage trip points; controls are interlocking.—D. K. Smith, Monitor Guards Three Ways Against Power Failures, *Electronics*, Oct. 27, 1969, p 97–98.


Q1
2N3241
EQUIPMENT
CIRCUIT
24 v
D1
1N4112
10

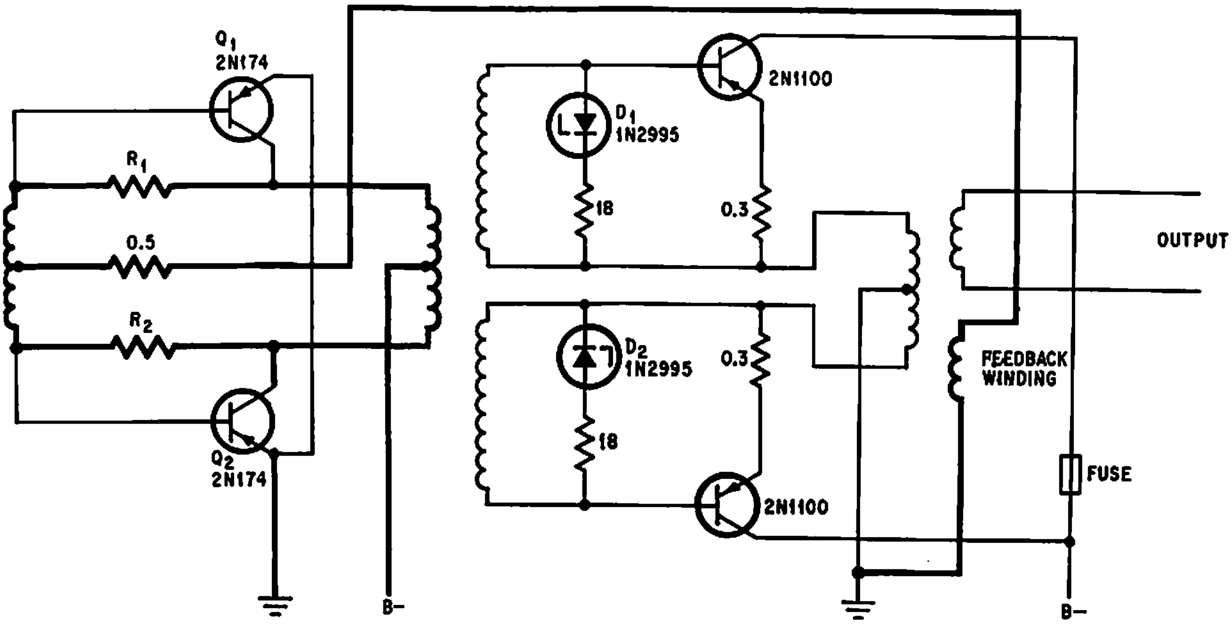
DEAD-BATTERY CUTOFF—Simple transistor arrangement with zener opens line between load and 24-V battery when battery discharges down to 18 V and affects accuracy of calibrating equipment. Particularly desirable for nickel-cadmium batteries because they can be destroyed if discharged below 30% of full capacity. For external indicator that comes on when line opens, place 24-V lamp between emitter and collector of Q1.—E. R. DeLoach, Transistor and Zener Monitor Calibration, *Electronics*, June 24, 1968, p 102.


R1
20 K
R4
100 K
Q1
RL
CK1101
R2
10 K
L
R3
220 K
Z

OVERVOLTAGE PROTECTION—At low voltage levels, transistor Q1 is saturated because photocell resistance of Raysistor acts as bias resistor. At overvoltage level determined by firing voltage of zener and neon in Raysistor, lamp fires and makes photocell resistance drop to low level, cutting off transistor and removing load voltage.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 27.

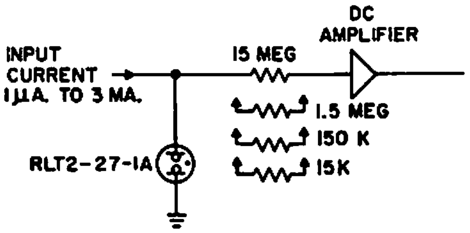

+
METER
+
-
0-5 V
(HONEYWELL
MS3T)
1N4738
D
G
2N4360
S
-

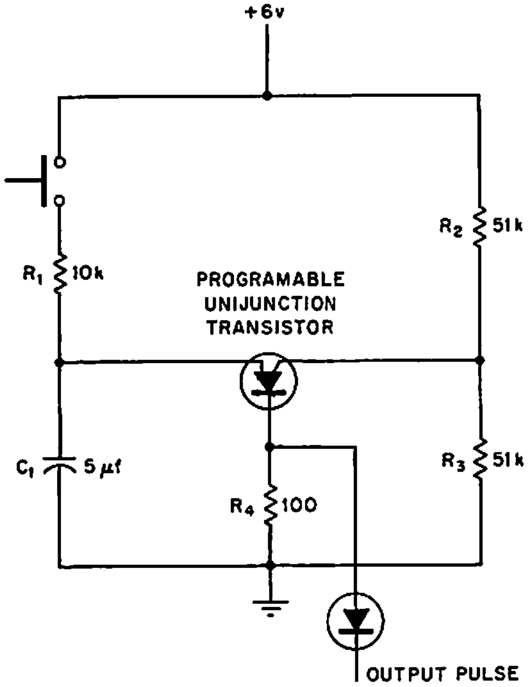
UJT-ZENER PROTECTION—Provides meter protection with only two components, without causing errors by loading external circuit. Developed for application where voltages measured were 2 to 3 V but with accidental overloads up to 14 V occasionally. Even with 16 V, voltage across meter is only 6.7 V. —R. L. Charnley, FET Provides Automatic Meter Protection, *EEE*, March 1969, p 128.

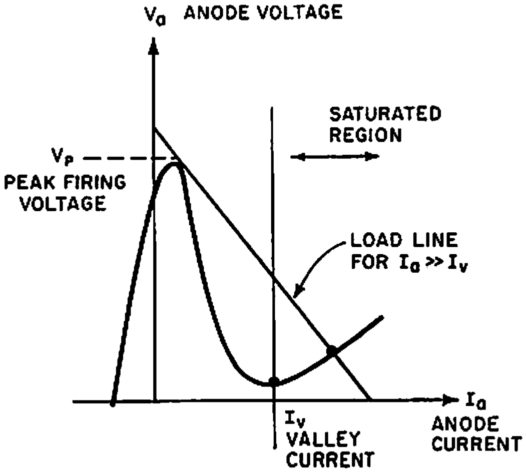

Q1
2N174
R1
0.5
R2
Q2
2N174
B-
D1
1N2995
18
0.3
2N1100
D2
1N2995
0.3
18
2N1100
OUTPUT
FEEDBACK
WINDING
FUSE
B-

PROTECTING POWER TRANSISTORS—Inductive feedback circuit shown in heavy line acts on driver stage of audio amplifier when output shorts or opens, to interrupt drive current and thereby protect output power transistors from breakdown or thermal runaway.—G. S. Lehston, Feedback Protects Amplifier During Load Failures, *Electronics*, Dec. 25, 1967, p 68–69.

IONIZATION GAGE—For aerospace sounding rocket, neon lamp with high breakdown voltage prevents d-c amplifier of cold-cathode ionization gage from being overloaded by abrupt rise in input current before external circuitry can switch in appropriate series resistor. Use of neon instead of zener diode maintains accuracy of gage readings.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 91.


DC AMPLIFIER
INPUT CURRENT
1µA. TO 3 MA.
15 MEG
1.5 MEG
150 K
15K
RLT2-27-1A


+6v
R1 10k
R2 51k
PROGRAMABLE UNIJUNCTION TRANSISTOR
C1 5µf
R3 51k
R4 100
OUTPUT PULSE



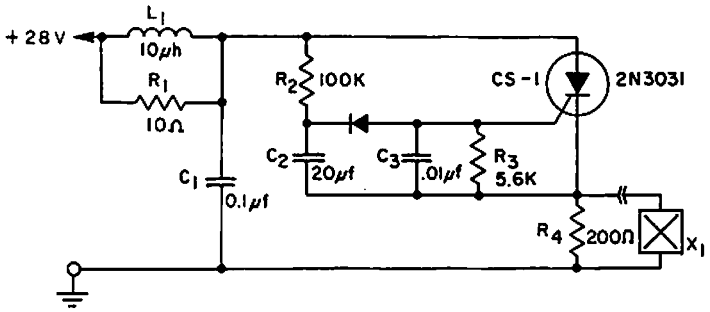
PROGRAMABLE UNIJUNCTION-TRANSISTOR CURVE

SWITCH BOUNCE ELIMINATOR—Programmable ujt generates clean pulses, free of switch contact bounce, over wide range of supply voltages. When switch is closed, C1 charges until it reaches peak firing voltage of ujt, then discharges through ujt to produce positive output voltage across R4. Circuit is immune to accidental triggering by transients or to contact bounce produced by switch.—C. Brogado, Unijunction Device Eliminates Contact Bounce, *Electronics*, April 13, 1970, p 106.

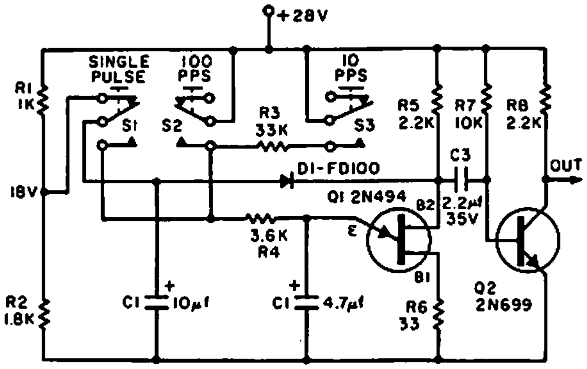
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 66

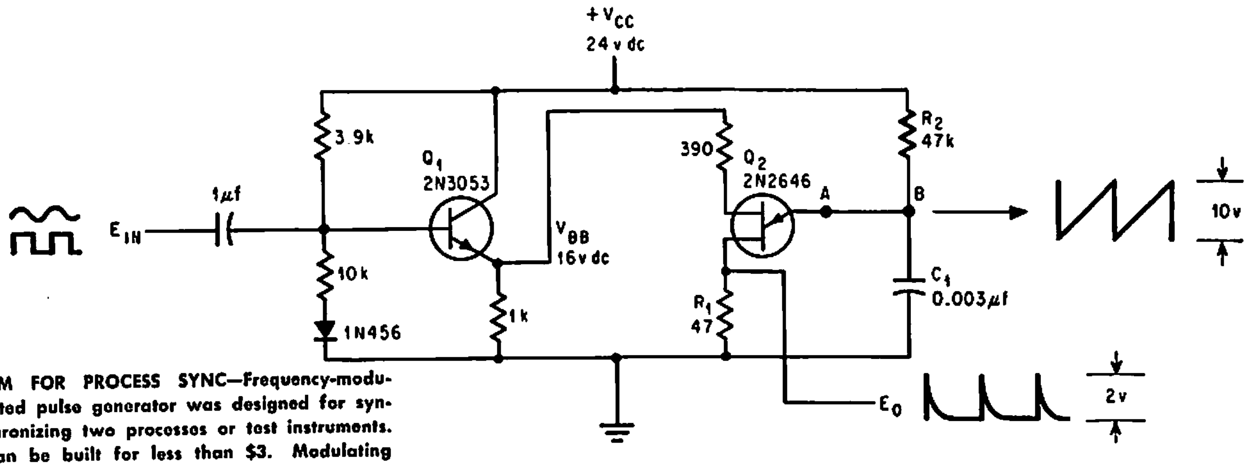
Pulse Generator Circuits


+28V
L1
10μh
R1
10Ω
C1
0.1μf
R2
100K
C2
20μf
C3
.01μf
R3
5.6K
CS-1
2N3031
R4
200Ω
X1

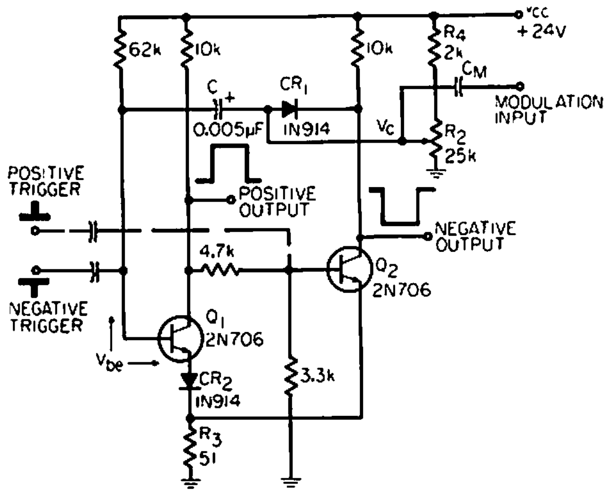
SQUIB FIRING—Energy for firing squib X1 is supplied through scr by 28-V d-c supply. To prevent scr from firing when anode voltage is applied rapidly, input network L1-R1-C1 limits rate of voltage rise. Time delay network R2-C2 and diode fire scr 1 s after circuit is armed by connecting to power supply.—High Reliability Squib Firing Circuits, Solid State Products, Salem, Mass., No. 3.


+28V
SINGLE PULSE
100 PPS
10 PPS
R1 1K
S1
S2
R3 33K
S3
R5 2.2K
R7 10K
R8 2.2K
18V
D1-FD100
C3
OUT
Q1 2N494
B2
2.2μf 35V
E
3.6K R4
B1
R2 1.8K
C1 10μf
C1 4.7μf
R6 33
Q2 2N699

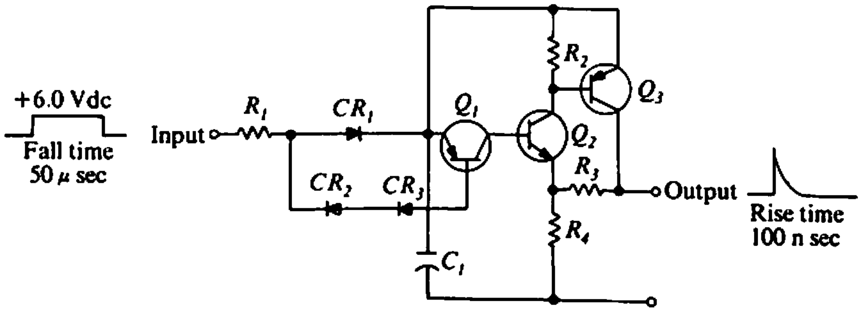
10 AND 100 PPS PLUS ONE-SHOT—Originally used as pulse source for stepping motors. Pulse width and repetition rate can be adjusted to any reasonable ratio, essentially independently; width is 850 μs for values shown.—G. E. Singleton, Pulse Generator Gives Low Frequency Otuput, *Electronic Design*, Jan. 20, 1964, p 79 and 81.


+Vcc
24 v dc
3.9k
Q1
2N3053
1μf
EIN
10k
1N456
1k
VBB
16v dc
390
Q2
2N2646
A
B
R2
47k
R1
47
C1
0.003μf
10v
E0
2v

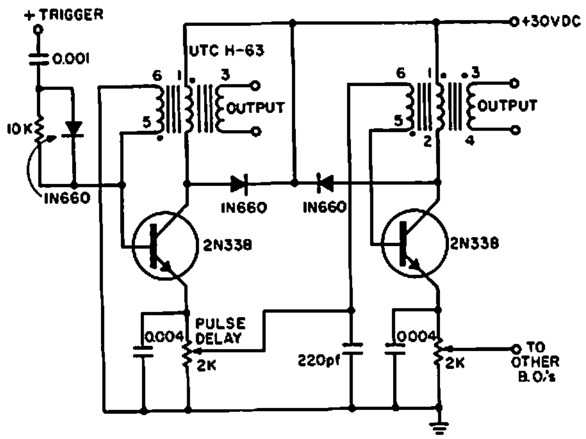
F-M FOR PROCESS SYNC—Frequency-modulated pulse generator was designed for synchronizing two processes or test instruments. Can be built for less than $3. Modulating input signal can be sinusoidal, square, or any other shape. Amplitude of input determines period of output, which is up to 0.0001 s for value shown, and frequency of input sets rate at which output changes. Increasing value of C1 increases period; above 10 μF, insert 1 ohm per μF between A and B to protect emitter of ujt Q2.—G. M. Nickus, Frequency-Modulated Output from Low-Cost Unijunction, *Electronics*, Nov. 14, 1966, p 122.


Vcc
+24V
62k
10k
10k
R4
2k
CM
C
+
CR1
0.005µF
IN914
Vc
MODULATION INPUT
R2
25k
POSITIVE TRIGGER
POSITIVE OUTPUT
NEGATIVE OUTPUT
4.7k
Q2
2N706
NEGATIVE TRIGGER
Q1
2N706
Vbe
CR2
IN914
3.3k
R3
51

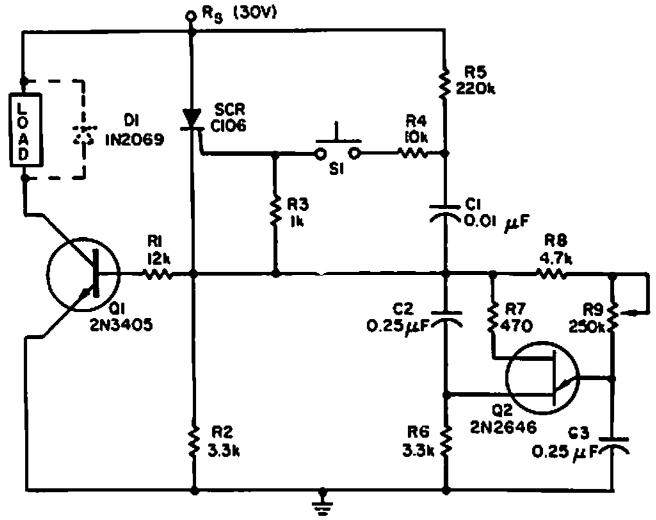
100:1 PWM—Modification of one-shot permits changing pulse width by means of R2, or externally with either d-c voltage or a-c modulation signal.—S. J. Erst, Improved Monostable Multivibrator Allows Wide Range of Pulse-Width Control, *EEE*, Jan. 1969, p 114–115.


+6.0 Vdc
Fall time
50 µ sec
Input
R1
CR1
Q1
R2
Q3
Q2
CR2
CR3
R3
Output
R4
C1
Rise time
100 n sec

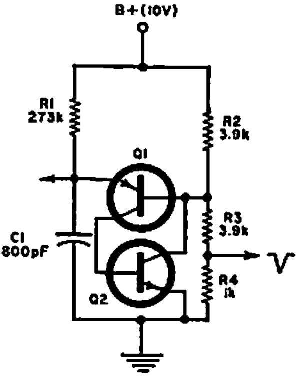
SELF-POWERED GENERATOR—Produces sharp output pulse, with rise time of 100 ns during 50-µs fall time of 6-V rectangular input signal. Q1 and Q3 are 2N2894; Q2 is 2N2369; all diodes are 1N4153; R1 and R4 100K; R2 3K; R3 10K; C1 0.1 µF.—"Selected Electronic Circuitry," NASA SP–5046, 1966, Government Printing Office, Washington, D.C., p 57.


+TRIGGER
0.001
10K
IN660
UTC H-63
6
1
3
5
OUTPUT
+30VDC
6
1
3
5
2
4
OUTPUT
IN660
IN660
2N338
2N338
0.004
PULSE DELAY
2K
220pf
0.004
2K
TO OTHER B.O.'s

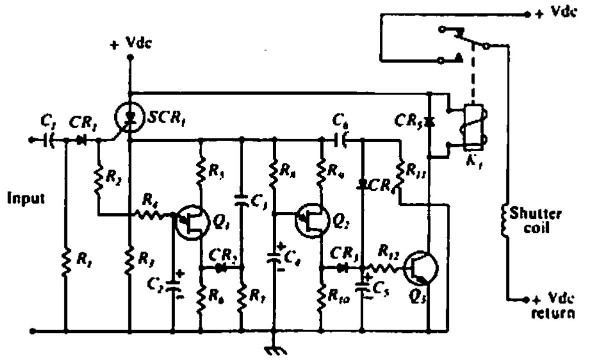
ADJUSTABLE PULSE TRAINS—Eight identical cascaded blocking oscillators generate pulse train in which spacing between pulses in adjacent oscillators is adjustable in range from 0.1 to 0.9 of previous pulse width. Pulse width is largely determined by values of R and C connected to emitter. Waveform at emitter is triangular, so potentiometer can adjust triggering time of next oscillator without affecting pulse width.—G. Mader, Blocking Oscillators Simplify Adjustable Interpulse Spacing, *Electronic Design*, July 6, 1964, p 52.


RS (30V)
LOAD
D1
IN2069
SCR
C106
R5
220k
R4
10k
S1
R3
1k
C1
0.01 µF
R1
12k
R8
4.7k
Q1
2N3405
C2
0.25µF
R7
470
R9
250k
Q2
2N2646
R2
3.3k
R6
3.3k
C3
0.25 µF

CONSTANT PULSE WIDTH—Random-duration closing of S1 produces fixed-duration output pulse with width adjustable by R9 from 2.5 to 100 ms. May be used as pulse stretcher, pulse shortener, and contact-bounce eliminator. Varying supply voltage from 15 V to 45 V produces less than 0.2-ms change in output pulse duration.—R. W. Murre, Any Switch Closure Produces a Fixed-Duration Output Pulse, *Electronic Design*, Feb. 1, 1969, p 72 and 74.

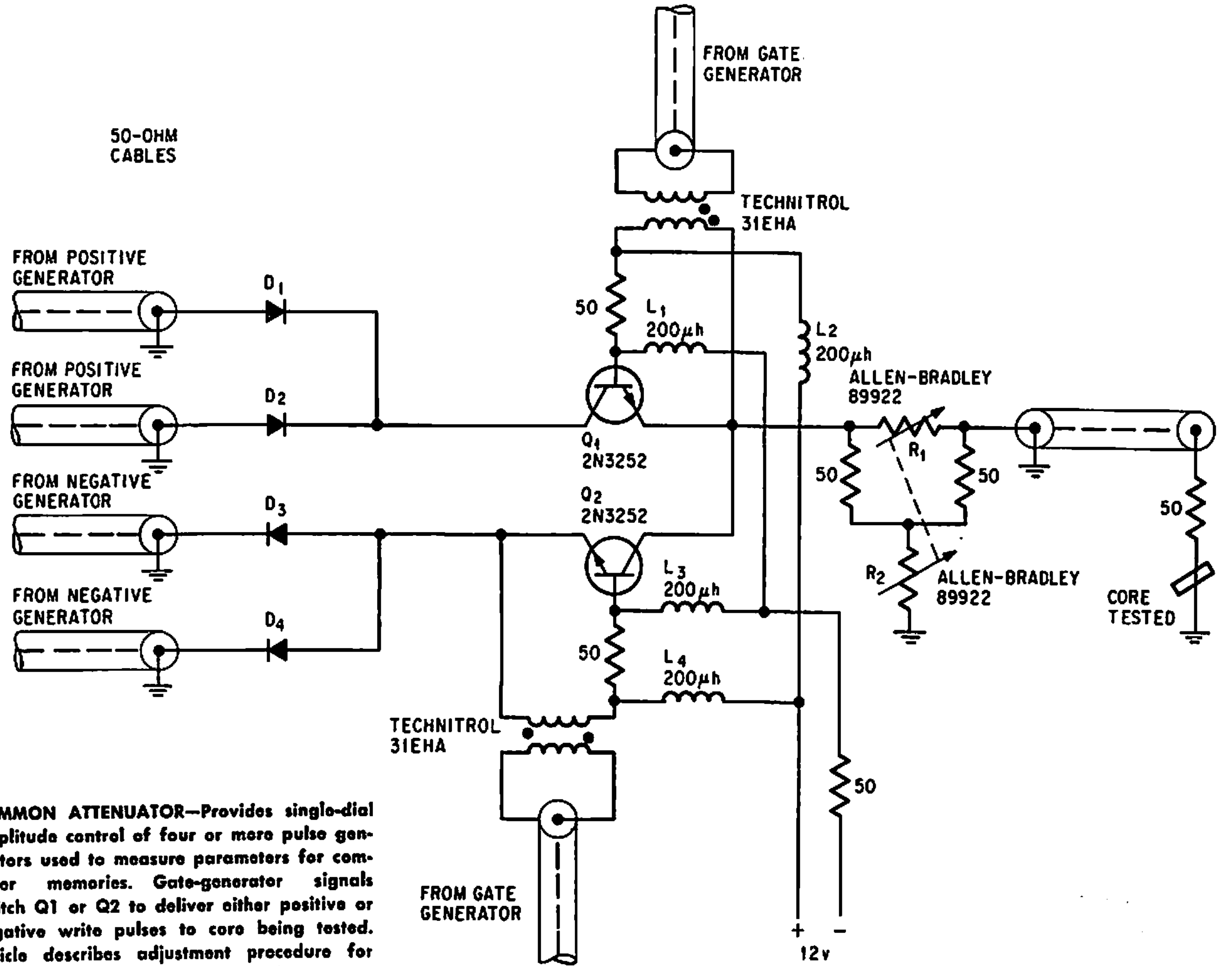

B+(10V)
R1
273k
R2
3.9k
Q1
R3
3.9k
C1
6800pF
V
R4
1k
Q2

TRANSISTOR RELAXATION OSCILLATOR—Two ordinary transistors connected as shown will equal performance of ujt relaxation oscillator. Component values are for 1 kHz.—W. A. Vincent, Using Transistors as Negative-Resistance Devices, *Electronics World*, June 1969, p 38–40 and 62.

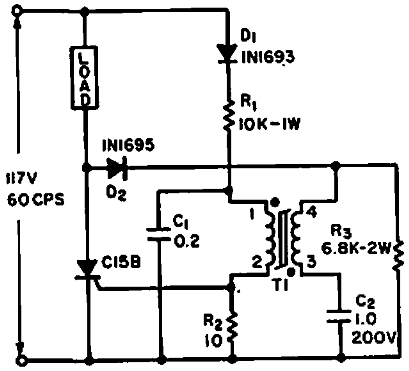

+ Vdc
+ Vdc
C_1
CR_1
SCR_1
C_6
CR_5
K_1
Input
R_2
R_5
R_8
R_9
CR_4
R_{11}
R_4
Q_1
C_3
Q_2
Shutter coil
R_1
R_3
CR_2
C_4
CR_3
R_{12}
C_2
R_6
R_7
R_{10}
C_5
Q_3
+ Vdc return

Supply	+ 20 Vdc
SCR_1	2N886
CR_1 through CR_5	1N645
K_1	BR5-1K
Q_1, Q_2	2N1671B
Q_3	2N930
C_1	0.01 μF
C_2, C_4	10 μF
C_3	0.1 μF
C_5	2.7 μF
C_6	1 μF
R_1	100K
R_2	2.2K
R_3	4.7K
R_4	68K
R_5, R_6, R_9, R_{10}	100 Ω
R_7	10K
R_8	33K
R_{11}	3.3K
R_{12}	27K

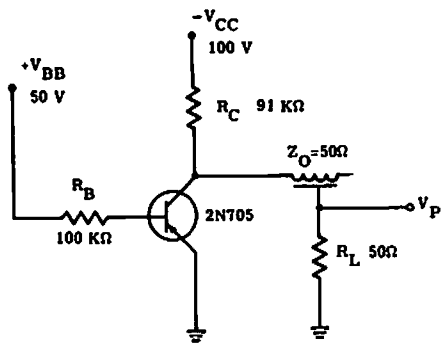
MULTIPULSE GENERATOR—Circuit was developed at Goddard Space Flight Center to generate pulses about 150 ms apart for operating shutter used to protect optical system from excessive light. Input trigger pulse turns on SCR1 to initiate capacitor-charging action for generating required pulses.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 24.


FROM GATE GENERATOR
50-OHM CABLES
TECHNITROL 31EHA
FROM POSITIVE GENERATOR
D1
50
L1
200μh
L2
200μh
FROM POSITIVE GENERATOR
D2
ALLEN-BRADLEY 89922
Q1
2N3252
R1
50
50
FROM NEGATIVE GENERATOR
D3
Q2
2N3252
50
FROM NEGATIVE GENERATOR
D4
L3
200μh
R2
ALLEN-BRADLEY 89922
CORE TESTED
50
L4
200μh
TECHNITROL 31EHA
50
FROM GATE GENERATOR
+
-
12v

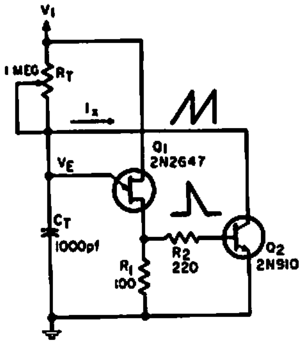
COMMON ATTENUATOR—Provides single-dial amplitude control of four or more pulse generators used to measure parameters for computer memories. Gate-generator signals switch Q1 or Q2 to deliver either positive or negative write pulses to core being tested. Article describes adjustment procedure for setup. Maximum output current of generator is 1 A into 50-ohm load. Repeatability of amplitude settings is limited only by attenuator backlash and generator stability.—W. M. Chu, Single Control Adjusts Outputs of Several Pulse Generators, *Electronics*, July 10, 1967, p 82–83.


LOAD
D1
1N1693
R1
10K-1W
1N1695
D2
117V
60CPS
C1
0.2
1
2
3
4
R3
6.8K-2W
C15B
T1
R2
10
C2
1.0
200V

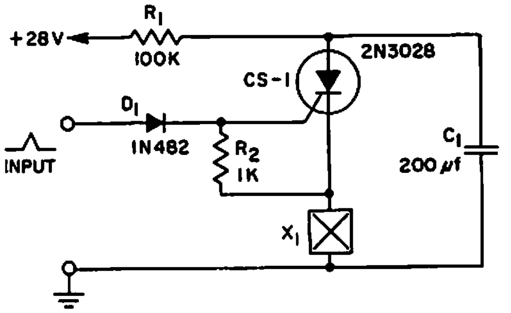
10-A PULSES AT 160 V—Scr with simple magnetic firing circuit switches half-cycles of line voltage to give high-power pulses for industrial control circuit application.—T. P. Sylvan, SCR Quarter-Wave Rectifier Forms High-Power Pulses, *Electronic Design*, April 27, 1964, p 95–97.


-VCC
100 V
+VBB
50 V
RC 91 KΩ
ZO=50Ω
RB
100 KΩ
2N705
VP
RL 50Ω

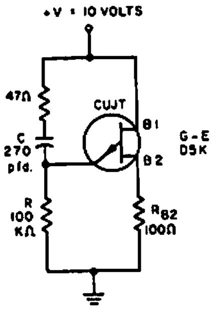
DELAY-LINE GENERATOR—Uses 50-ohm delay line Z with transistor operating in avalanche mode to generate positive or negative pulses with controllable amplitude and duration. To get negative pulses with circuit shown, load RL is placed in series with emitter-ground connection of transistor. VCC and RC affect repetition rate, but rate is primarily determined by value of line capacitance and therefore by pulse width. Pulse amplitude is changed by using different line impedance and transistor.—"High Speed Switching Transistor Handbook," Motorola, Phoenix, Ariz., 1969, p 295.


V1
1 MEG
RT
Ix
VE
Q1
2N2647
CT
1000pf
R1
100
R2
220
Q2
2N910

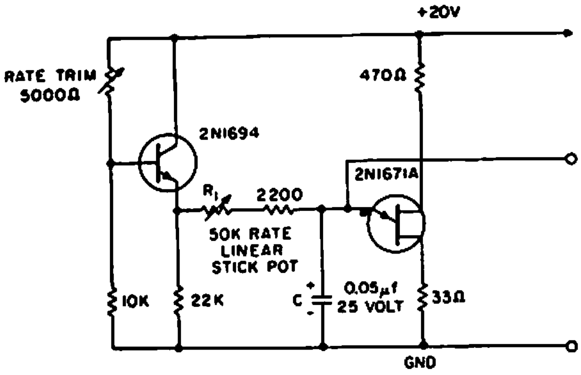
500-KHZ UJT RELAXATION—Single transistor and resistor extend frequency range of basic ujt.—M. Graminga, Modified Unijunction Oscillator Reaches 500 kHz, *EEE*, Sept. 1966, p 144.


+28V
R1
100K
2N3028
CS-1
D1
1N482
INPUT
R2
1K
C1
200µf
X1

FIRING EXPLOSIVE BOLT—C1 stores energy for firing squib X1. Positive 1-mA pulse fires scr, making C1 discharge through squib. Circuit resets automatically after test firing, allowing C1 to recharge. Can be used for detonation and for rocket engine ignition.—High Reliability Squib Firing Circuits, Solid State Products, Salem, Mass., No. 3.

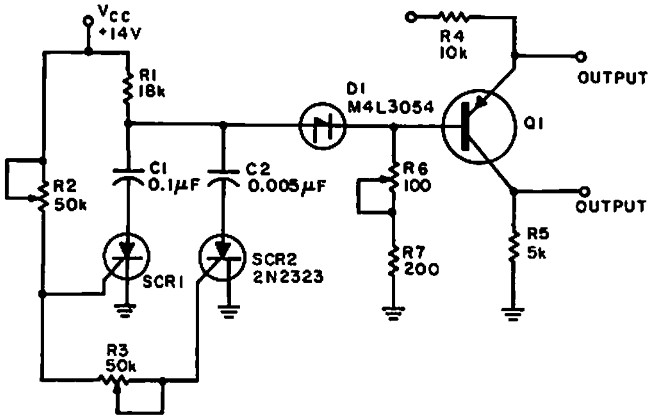

+V = 10 VOLTS
47Ω
CUJT
B1
G-E
D5K
C
270
pfd.
B2
R
100
KΩ
RB2
100Ω

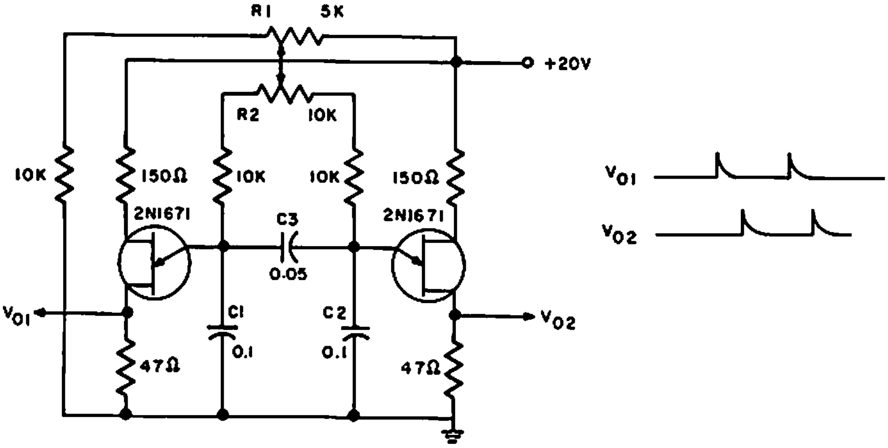
50-KHZ COMPLEMENTARY UJT—Operates as relaxation oscillator with good immunity to supply voltage changes.—W. R. Spofford, Jr., Complementary Unijunction Transistors, General Electric, Syracuse, N.Y., No. 90.72, 1968, p 10.


+20V
RATE TRIM
5000Ω
470Ω
2N1694
2N1671A
R1
2200
50K RATE
LINEAR
STICK POT
10K
22K
C
0.05µf
25 VOLT
33Ω
GND

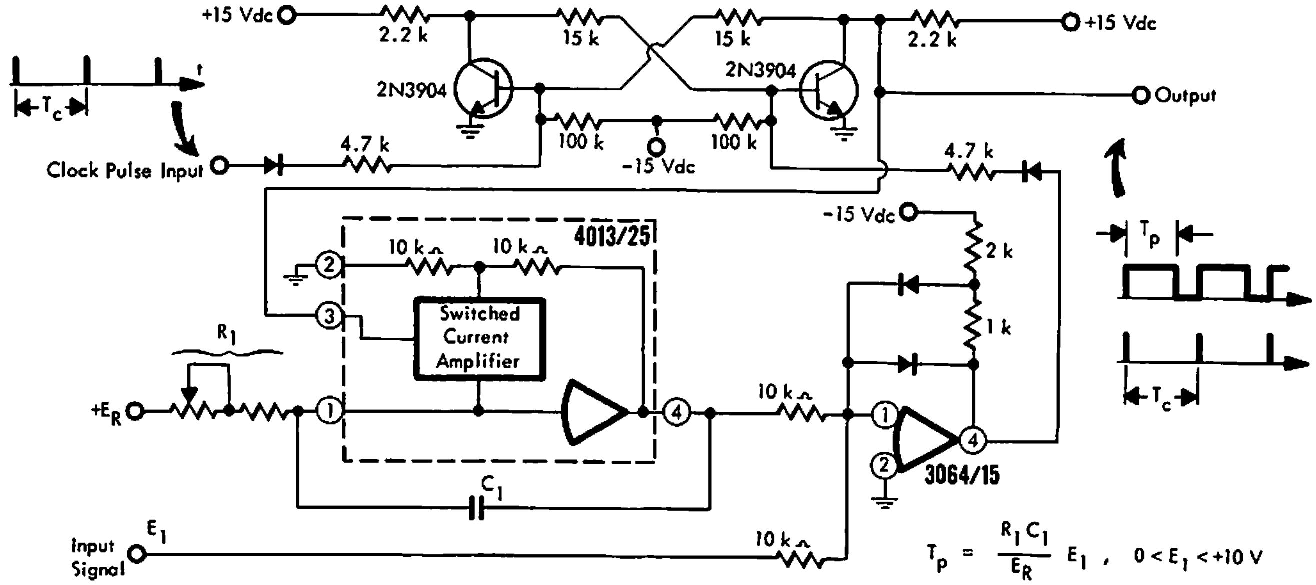
FREQUENCY-CALIBRATED POT IN UJT RELAXATION—High stability of ujt relaxation oscillator permits calibrating settings of potentiometers. Center frequency is approximately 1,000 Hz, with R1 providing at least one decade of variation and with trim control providing at least one octave of variation. Trim pot is independent of R1.—J. H. Phelps, Unijunction Oscillator Has Frequency Trim Control, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 177.

ONE, TWO, THREE, OR BURST—Versatile pulse generator costing about $20 delivers combinations of 5-V pulses in frequency range of 400 to 15,000 Hz. With R3 at maximum, R2 is adjusted to give single pulse when power is applied. R3 is then adjusted to give double- or triple-pulse groups or to give continuous burst of pulses. Q1 may be any transistor serving as inverter and isolation stage.—G. Lawson, A Four-Layer Diode Forms Double-Pulse Generator, *Electronic Design*, April 26, 1967, p 243.


Vcc
+14V
R1
18k
R2
50k
C1
0.1μF
C2
0.005μF
SCR1
SCR2
2N2323
R3
50k
D1
M4L3054
R4
10k
R6
100
R7
200
Q1
R5
5k
OUTPUT
OUTPUT


R1 5K
+20V
R2 10K
10K
150Ω
10K
10K
150Ω
2N1671
C3
0.05
2N1671
C1
0.1
C2
0.1
47Ω
47Ω
V01
V02
V01
V02

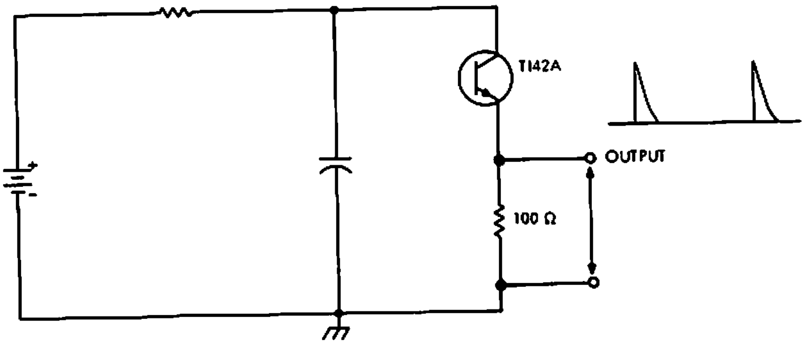
VARIABLE-PHASE DOUBLE-PULSE GENERATOR—Delivers high-power pulses alternately from two separate outputs, as required for such applications as firing an scr paralleled inverter having noninductive load. Circuit consists of two ujt relaxation oscillators, synchronized through C3, with R2 controlling the phase difference between outputs and R1 controlling frequency over range of 200 to 800 Hz. Output pulses are about 4 V peak and 10 μs wide.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 78.


+15 Vdc
2.2 k
15 k
15 k
2.2 k
+15 Vdc
2N3904
2N3904
Output
t
T_c
Clock Pulse Input
4.7 k
100 k
100 k
-15 Vdc
4.7 k
-15 Vdc
2 k
1 k
4013/25
10 k
10 k
Switched Current Amplifier
R_1
$+E_R$
10 k
3064/15
C_1
Input Signal
E_1
10 k
T_p
T_c

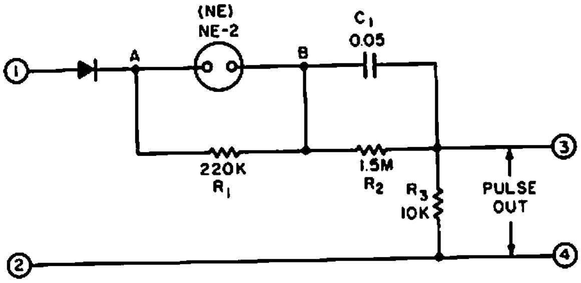
$$T_p = \frac{R_1 C_1}{E_R} E_1 , \quad 0 < E_1 < +10 \text{ V}$$

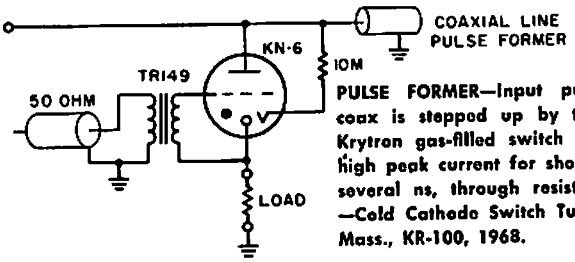
VOLTAGE TO PULSE WIDTH—With connections shown for Burr-Brown 4013/25 switched integrator, very linear and stable synchronized pulse-width modulator is obtained. Pulse train provides clocking signal to which output pulse train is synchronized. Pulse width of output is linear function of input signal voltage E1. Values of ER, C1, and R1 are chosen according to dynamic range and pulse repetition rate desired. If clock is 1 kHz and input voltage varies from 0.1 to 10 V, C1 can be 0.01 μF and R1 90K.—Sample/Hold Modules, Burr-Brown Research, Tucson, Ariz., PDS-211, 1969, p 10.

RELAXATION OSCILLATOR—Uses npn diffused silicon breakdown diode and minimum of other components to produce sharp output pulses. Breakdown voltage of T142A is in range of 28 to 36 V, so battery supply voltage must be enough for capacitor to charge through series resistor enough to exceed breakdown voltage and give desired repetition rate.—"Preferred Semiconductors and Components," Texas Instruments, Dallas, Texas, CC101, 1968, p 24108.

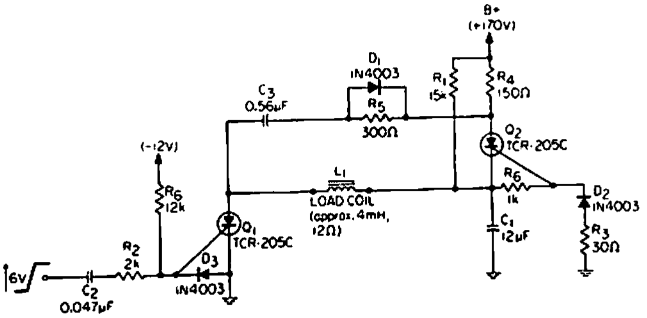

T142A
OUTPUT
100 Ω

NOISE-IMMUNE NEON ONE-SHOT—Switching of neon tube converts a-c voltage or long d-c gate into short 20-V output pulse having less than 1-μs rise time. Circuit locks out other signals as long as trigger signal is present, and is immune also to signals and noise for predetermined time after removal of trigger. Product of R2 and C1 determines lockout time.—A. M. Patlach, Neon Tube Circuit Forms One-Shot Pulse Generator, *Electronic Design*, June 7, 1965, p 38–39.

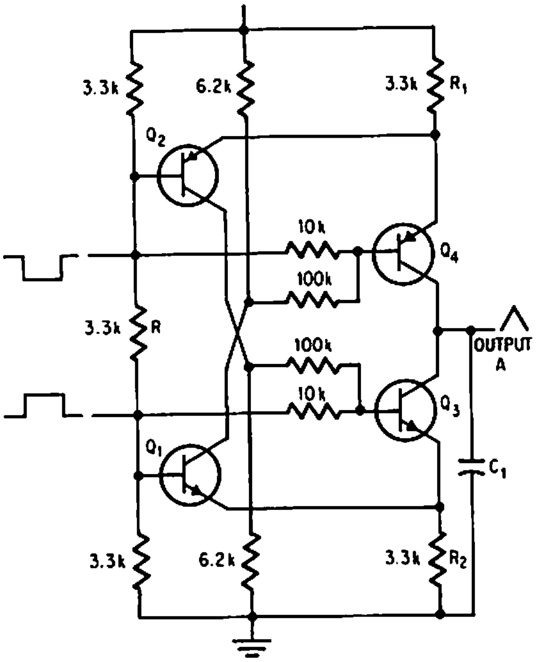

(NE)
NE-2
C₁
0.05
A
B
①
②
③
④
220K
R₁
1.5M
R₂
R₃
10K
PULSE
OUT


COAXIAL LINE
PULSE FORMER
KN-6
10M
TR149
50 OHM
LOAD

PULSE FORMER—Input pulse from 50-ohm coax is stepped up by transformer to trip Krytron gas-filled switch tube that produces high peak current for short duration, around several ns, through resistive load.—Krytrons—Cold Cathode Switch Tubes, EG&G, Boston, Mass., KR-100, 1968.


B+
(+170V)
D₁
1N4003
C₃
0.56μF
R₅
300Ω
R₁
15k
R₄
150Ω
Q₂
TCR-205C
(-12V)
R₆
12k
L₁
LOAD COIL
(approx. 4mH, 12Ω)
R₆
1k
D₂
1N4003
C₁
12μF
R₃
30Ω
Q₁
TCR-205C
R₂
2k
D₃
1N4003
6V
C₂
0.047μF

PRINT HAMMER DRIVE—Dual scr delay flop (monostable mvbr) delivers constant-energy pulses to solenoids of line printer hammers or paper tape punches, at repetition rates above 100 pps. Output is 170 V at 5 A. Circuit resets automatically.—S. W. Piccione, SCRs Simplify Monostable Coil-Driver, *EEE*, Nov. 1967, p 129–130.

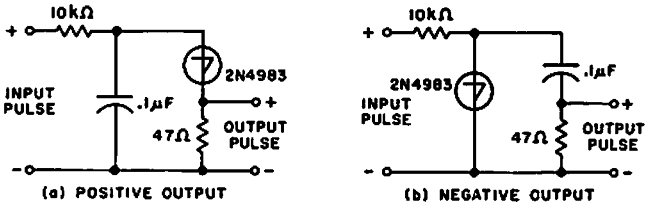

3.3k
6.2k
3.3k
R₁
Q₂
10k
Q₄
100k
3.3k
R
100k
OUTPUT
A
10k
Q₃
Q₁
C₁
3.3k
6.2k
3.3k
R₂

PWM—Arrangement shown requires only single capacitor on IC triangular-wave generator for pulse-width modulation in audio amplifiers. Also produces two square-wave outputs. Charging of C1 by collector current of Q4 forms leading edge of sawtooth.—O. Baade, One Capacitor Makes IC a Pulse-width Modulator, *Electronics*, Sept. 2, 1968, p 71.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

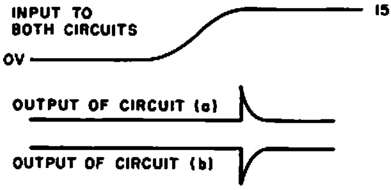
CHAPTER 67

Pulse Shaping Circuits



10kΩ
+
INPUT PULSE
-
.1μF
2N4983
47Ω
+
OUTPUT PULSE
-
10kΩ
+
2N4983
INPUT PULSE
-
.1μF
47Ω
+
OUTPUT PULSE
-

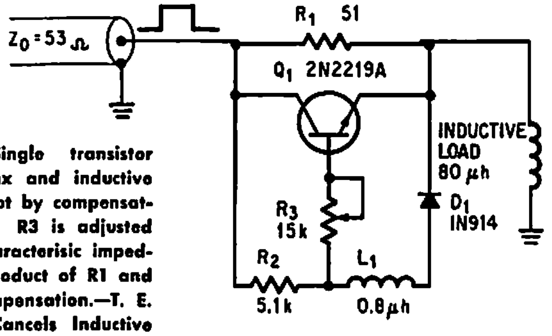
(a) POSITIVE OUTPUT (b) NEGATIVE OUTPUT



INPUT TO BOTH CIRCUITS
15V
0V
OUTPUT OF CIRCUIT (a)
OUTPUT OF CIRCUIT (b)

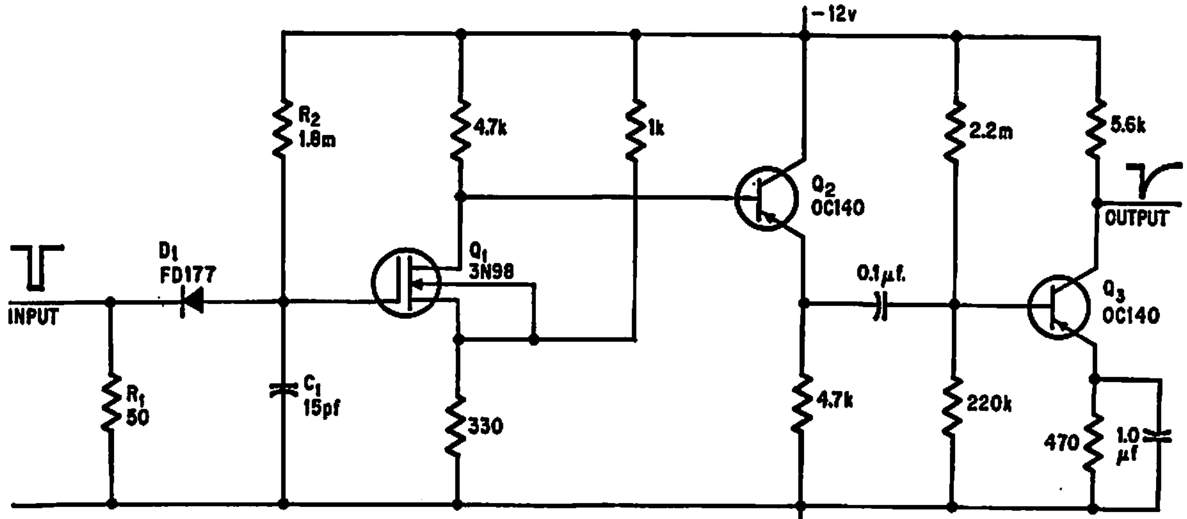
(c) TYPICAL WAVEFORMS

SUS PULSE SHARPENER—Simple 2N4983 (or 2N4987) silicon unilateral switch circuit uses energy stored in capacitor to generate rapid rise or fall time.—Silicon Unilateral Switch 2N4983/2N4986, General Electric, Syracuse, N.Y., No. 65.25, 1967.



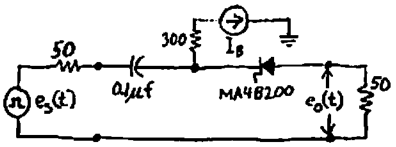
Z0=53Ω
R1 51
Q1 2N2219A
INDUCTIVE LOAD 80μh
D1 IN914
R3 15k
R2
5.1k
L1
0.8μh

INDUCTIVE OVERSHOOT—Single transistor stage inserted between coax and inductive load prevents pulse overshoot by compensating for inductive reactance. R3 is adjusted to terminate cable in its characterisic impedance. R2L1 should equal product of R1 and inductive load, for best compensation.—T. E. Skopal, Transistor Circuit Cancels Inductive Load Effects, *Electronics*, Dec. 9, 1968, p 83–84.

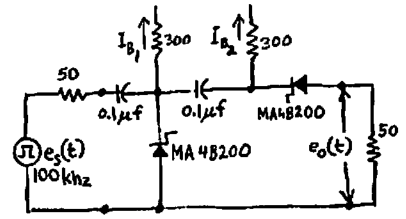


-12v
R2 1.8m
4.7k
1k
2.2m
5.6k
Q2 OC140
OUTPUT
INPUT
D1 FD177
Q1 3N98
0.1μf.
Q3 OC140
R1 50
C1 15pf
330
4.7k
220k
470
1.0 μf

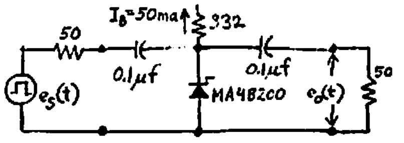
STRETCHING 2,000 TIMES—High impedance of mosfet transistor, in circuit for stretching narrow pulses by large factors, prevents loading of preceding stage. Circuit provides stretching factor of about 2,000 for 2.5-ns negative-going pulse having peak of at least 0.5 V.—J. Holland, MOS FET Prevents Loading By a Pulse Stretcher, *Electronics*, March 3, 1969, p 95.


50
300
I_B
0.1µf
MA4B200
e_s(t)
e_o(t)
50

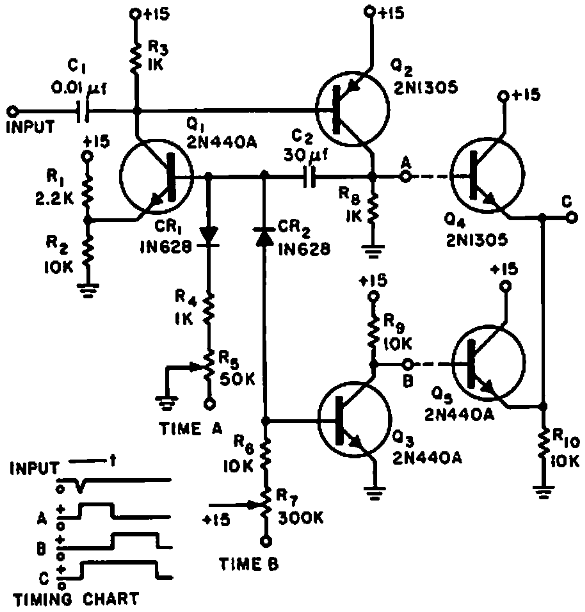
TRAILING-EDGE SHARPENER—Charge-controlled diode in series with load reduces output voltage until it switches into high-impedance state. For 5-ns fall time of input pulse, sharpening action reduces fall time of output pulse to less than 1 ns.—B. Siegal, Simpler Digital Circuits in a Snap, *Electronics*, June 9, 1969, p 105–108.


I_B1
300
I_B2
300
50
0.1µf
0.1µf
MA4B200
MA 4B200
e_s(t)
100khz
e_o(t)
50

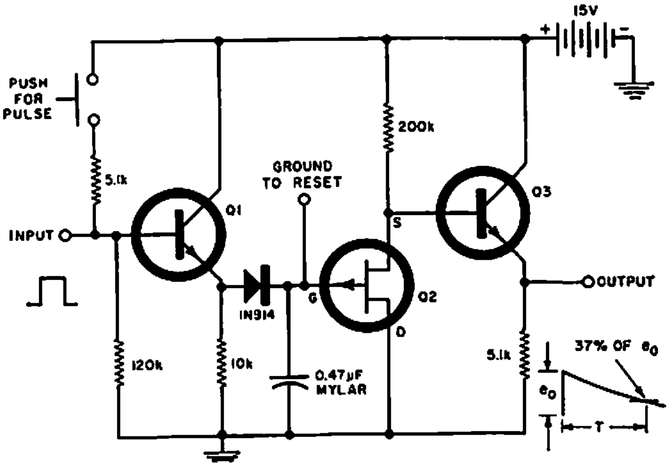
PULSE SQUARER—Combination of series and shunt charge-controlled diodes sharpens both leading and trailing edges of pulses in digital circuits. By varying bias currents, circuit will also serve for pulse position control and variable pulse width control.—B. Siegal, Simpler Digital Circuits in a Snap, *Electronics*, June 9, 1969, p 105–108.


I_B=50ma
332
50
0.1µf
0.1µf
MA4B200
e_s(t)
e_o(t)
50

LEADING-EDGE SHARPENER—Charge-controlled diode is connected across load to present low impedance that holds output voltage low until all its stored charge is removed, then switches to high-impedance state. Output pulse is narrower than input pulse by amount of delay time. With values shown, input rise time is about 12 ns, and output rise time is narrowed to less than 1 ns.—B. Siegal, Simpler Digital Circuits in a Snap, *Electronics*, June 9, 1969, p 105–108.


+15
R3 1K
C1 0.01µf
INPUT
Q1 2N440A
+15
R1 2.2K
R2 10K
CR1 1N628
R4 1K
R5 50K
TIME A
Q2 2N1305
C2 30µf
A
R8 1K
CR2 1N628
+15
Q4 2N1305
C
+15
R9 10K
B
Q5 2N440A
+15
Q3 2N440A
R6 10K
R7 300K
+15
TIME B
R10 10K
INPUT
t
A
B
C
TIMING CHART

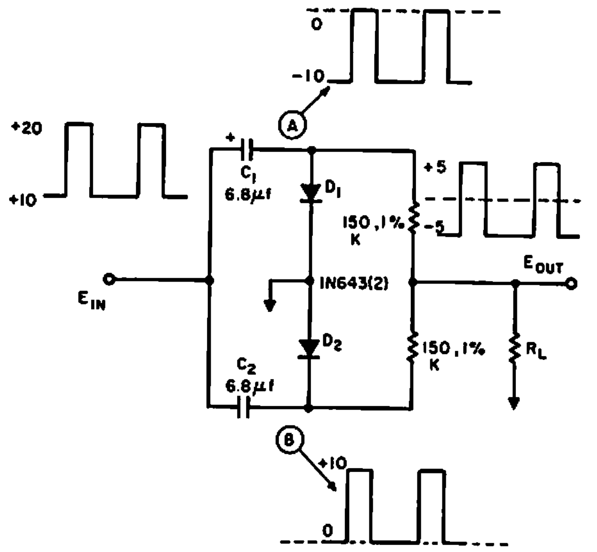
PULSE WIDENER—Modification of monostable mvbr gives equivalent of two standard mvbr circuits, for applications requiring elongated output pulse. For values shown, pulse width A can be adjusted from 0.05 to 1.8 s and B from 0.1 to 4.5 s. By adding OR gate Q4-Q5, width of output pulse at C becomes sum of times A and B. Circuit may also be used to provide timing function with zero recovery time and duty cycle approaching 100%.—R. W. Fergus, Modified Multivibrator Has Elongated Pulse Output, *Electronic Design*, March 15, 1965, p 59.


15V
PUSH FOR PULSE
5.1k
INPUT
Q1
1N914
GROUND TO RESET
G
S
D
Q2
200k
Q3
OUTPUT
120k
10k
0.47µF MYLAR
5.1k
37% OF e0
e0
T

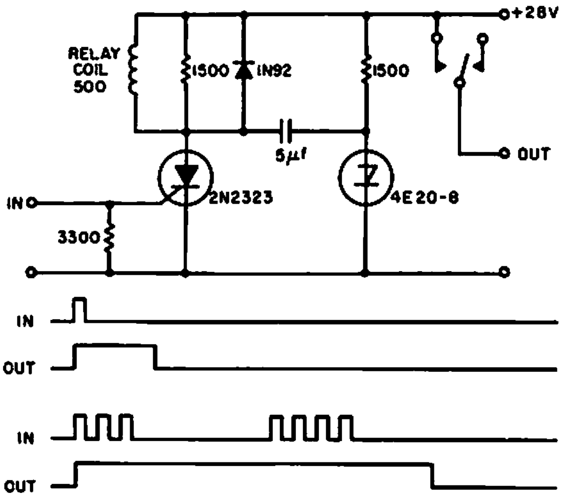
Q1 & Q3 ARE ANY OF THE FOLLOWING
2N3855
2N3391
2N3394

Q2 FET TYPE	T (MINUTES)
U-110	4
U-112	2.5
U-146	6
U-147	5

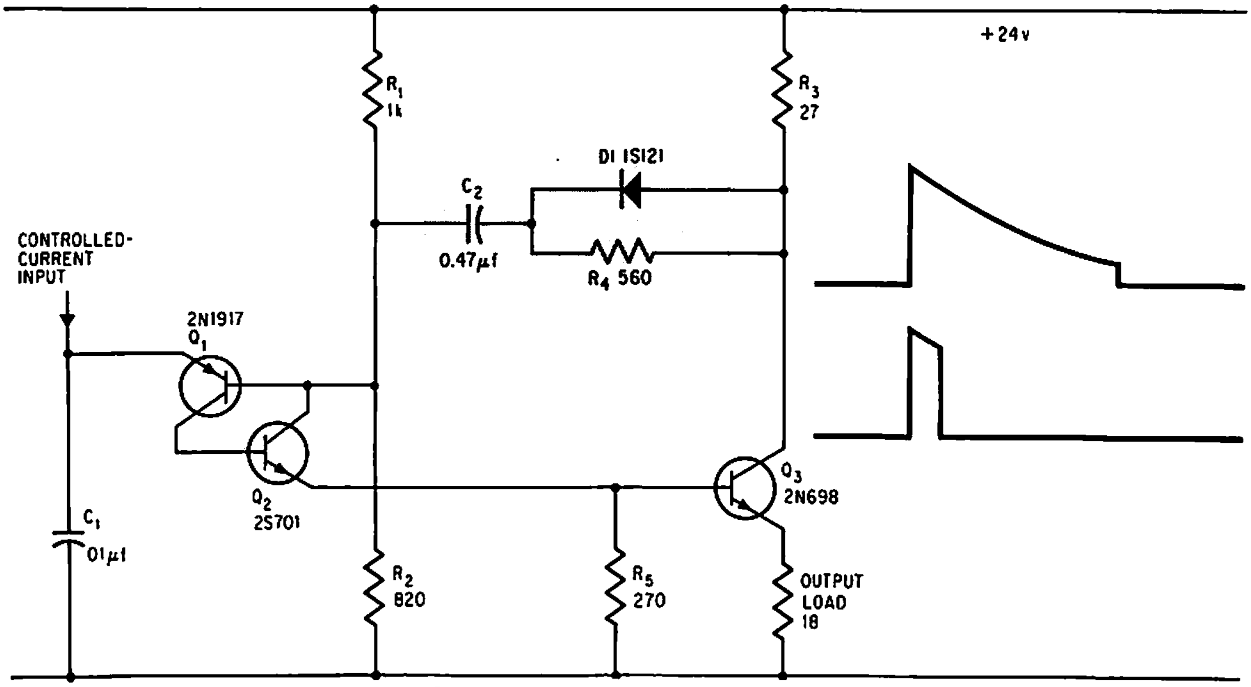
PULSE STRETCHER—Senses peak amplitude and holds this voltage level for much longer than width of pulse. External source can be used in place of pulse-initiating switch. Q1 and Q3 provide impedance transformation and isolate fet Q2 from source and load. Pulse can be stretched as long as 30 hours by using expensive fet with low gate leakage and selecting diode and capacitor with very low leakage.—J. H. Wujek, Jr., and M. E. McGee, Field-Effect Transistor Circuits, *Electronics World*, May 1967, p 32–33 and 75.


0
-10
A
+20
+10
+
C_1
6.8μf
D_1
150,1% K
+5
-5
E_{OUT}
E_{IN}
IN643(2)
D_2
150,1% K
R_L
C_2
6.8μf
B
+10
0

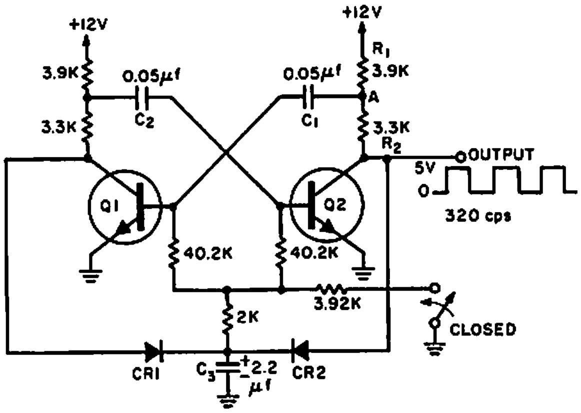
CENTERING WITH DIODES—Delivers output pulse having equal amplitudes above and below ground, when incoming pulse has variable amplitude and duty cycle. C1 and D1 provide positive clamping, so signal at A is reproduction of input shifted below d-c ground. Similarly, C2 and D2 provide negative clamp as at B. Resistor network acts as instantaneous adder to provide desired result. —T. B. Hooker, Circuit Provides Pulse Equally Centered About Ground, *Electronic Design*, Nov. 9, 1964, p 79.


+28V
RELAY COIL 500
1500
IN92
1500
OUT
5μf
IN
2N2323
4E20-8
3300
IN
OUT
IN
OUT

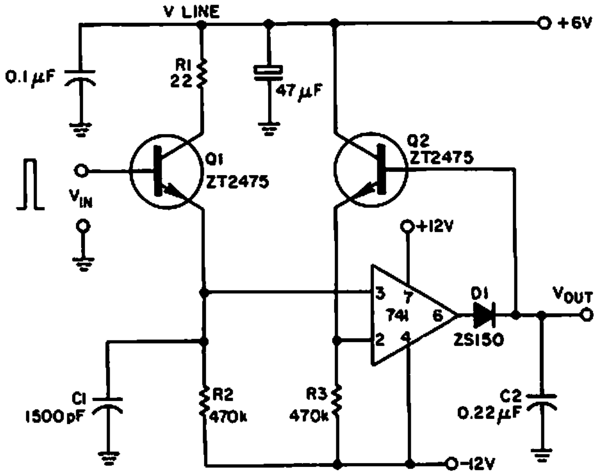
SCR PULSE STRETCHER—Will detect 3-V pulses as short as 20 μs, either singly or in trains, and stretch them as shown by waveforms. For values shown, relay is energized about 50 ms for single pulse. For repetition rates above 20 per second, relay remains energized during entire pulse train, but releases within 50 ms after last pulse in train.—A. Balint, SCR Pulse Stretcher Resets After Pulse Train, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 40.


R_1
1k
R_3
27
+24v
D1 1S121
C_2
0.47μf
R_4 560
CONTROLLED-CURRENT INPUT
2N1917
Q_1
Q_2
2S701
C_1
.01μf
R_2
820
R_5
270
Q_3
2N698
OUTPUT LOAD 18

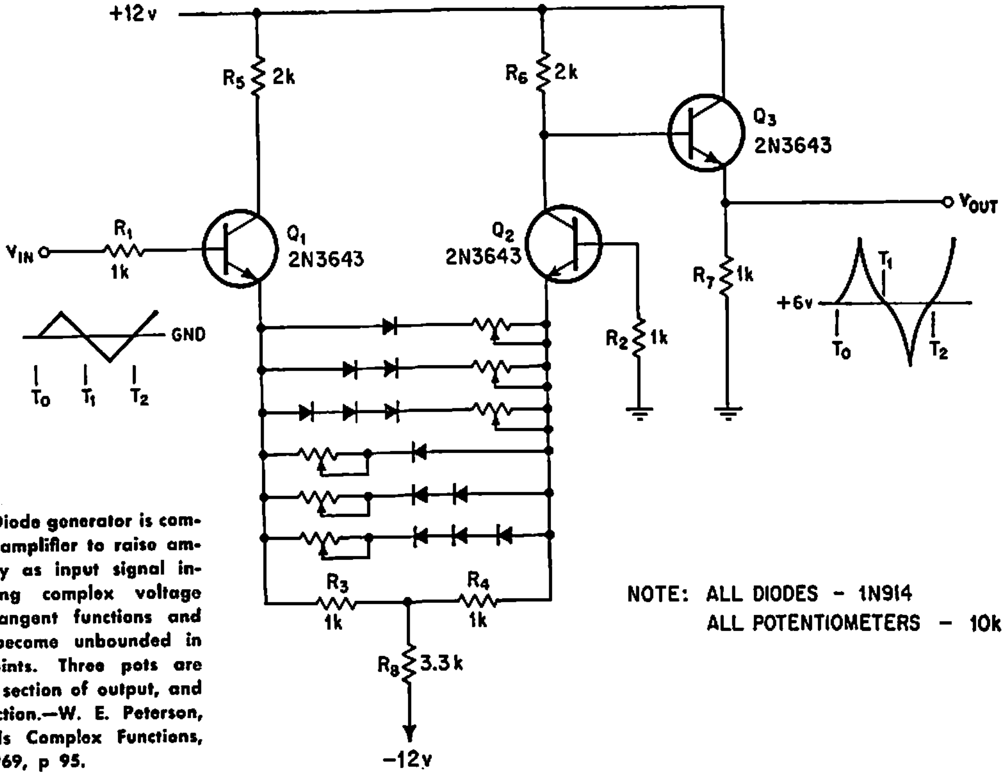
TRAILING-EDGE SHAPER—Feedback network is used between avalanche-switching input circuit and output stage of pulse generator to turn off Q1-Q2 sharply at desired interval after Q3 conducts, to shorten exponential decay time by factor of 10. The resulting sharper decay permits use of trailing edge of output pulse for triggering other circuits. With R5 as potentiometer, pulse width may be varied.—K. J. Foord, Simple Feedback Network Shapes Trailing Edges, *Electronics*, Oct. 2, 1967, p 96–97.


+12V
+12V
3.9K
0.05μf
C2
3.3K
0.05μf
C1
R1
3.9K
A
3.3K
R2
OUTPUT
5V
0
320 cps
Q1
Q2
40.2K
40.2K
2K
3.92K
CLOSED
CR1
C3
+2.2 μf
CR2

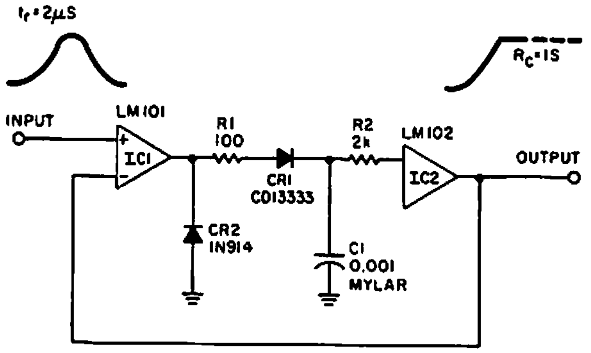
RISE-TIME BOOSTER—Rise time of conventional square-wave oscillator is greatly increased by connecting C1 and C2 to split collector loads of transistors. Circuit also provides clipping of output waveform.—P. D. Gargiulo, Fast Rise Times From Slow Circuits, *Electronic Design*, April 27, 1964, p 93–94.


V LINE
+6V
0.1μF
R1 22
47μF
Q1 ZT2475
Q2 ZT2475
VIN
+12V
3
7
741
6
2
4
D1
2S150
VOUT
C1 1500pF
R2 470k
R3 470k
C2 0.22μF
-12V

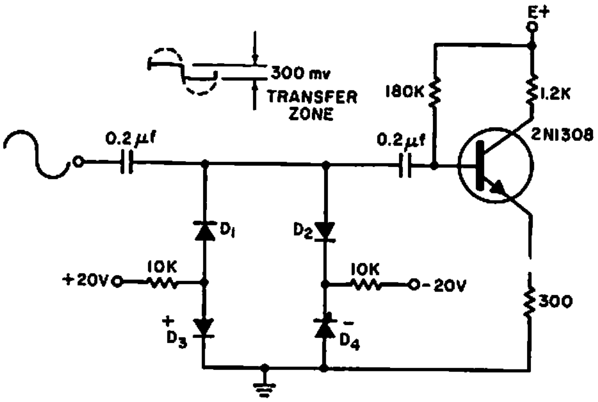
PEAK-HOLDING SPIKE STRETCHER—Will hold level of single pulse as narrow as 20 ns, with peak ranging from several hundred mV to 5 V, while increasing width of pulse up to 100,000,000 times.—I. D. Crawford, Pulse Stretcher Remembers Level of Narrow Spike, *Electronic Design*, June 7, 1970, p 96.


+12v
R5 2k
R6 2k
Q3 2N3643
VOUT
VIN
R1 1k
Q1 2N3643
Q2 2N3643
R7 1k
R2 1k
+6v
T0
T1
T2
GND
T0
T1
T2
R3 1k
R4 1k
R8 3.3k
−12v
NOTE: ALL DIODES - 1N914
ALL POTENTIOMETERS - 10k

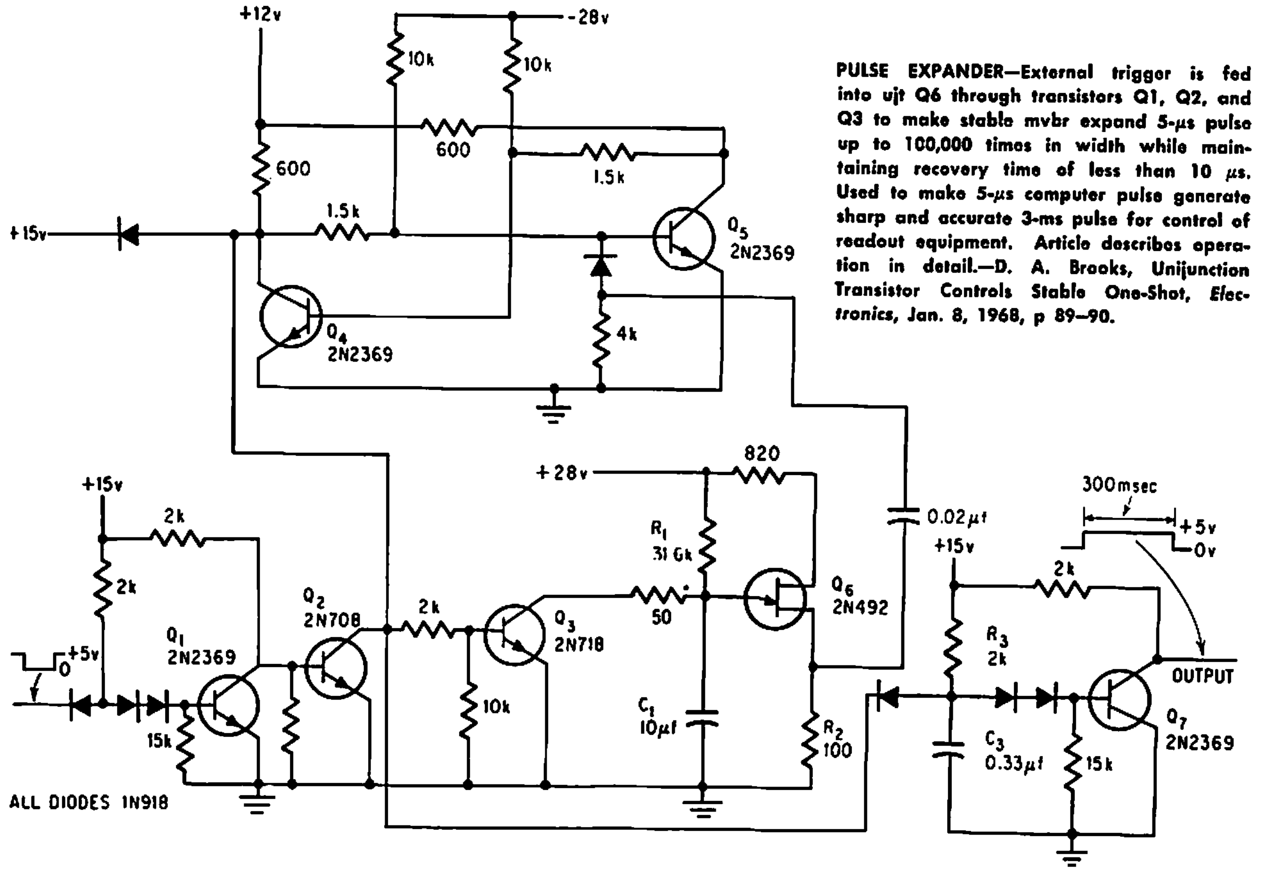
TANGENT FUNCTION—Diode generator is combined with differential amplifier to raise amplifier gain sequentially as input signal increases, for generating complex voltage waveforms such as tangent functions and other functions that become unbounded in magnitude at key points. Three pots are used to shape positive section of output, and three for negative section.—W. E. Peterson, Diode Generator Yields Complex Functions, *Electronics*, Oct. 13, 1969, p 95.


t_r = 2μS
R_C = 1S
INPUT
LM101
IC1
R1
100
CR1
C013333
CR2
1N914
R2
2k
LM102
IC2
C1
0.001
MYLAR
OUTPUT

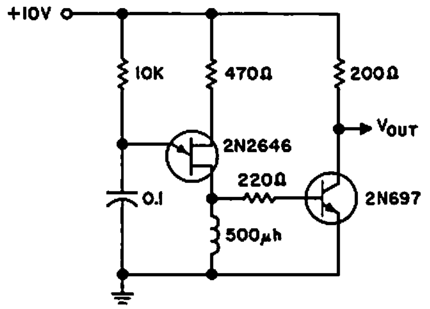
PULSE STRETCHER—Uses negative feedback for opamps to give unity gain. When positive pulse having rise time above 2 μs is fed to first opamp, positive output of opamp charges stretching capacitor C1 through R1 and CR1. When pulse dies away, CR1 becomes reverse-biased and C1 discharges with long time constant. Stretched output is thus obtained from second opamp serving as voltage follower. Typical pulse-stretching R-C time is 1 s for 3-V pulse. Dynamic range is over 200.—J. H. McQuaid, Linear Pulse Stretcher has Wide Dynamic Range, *Electronic Design*, July 5, 1969, p 80 and 82.


300 mv
TRANSFER
ZONE
E+
180K
1.2K
0.2μf
0.2μf
2N1308
D_1
D_2
+20V
10K
10K
-20V
+
D_3
-
D_4
300

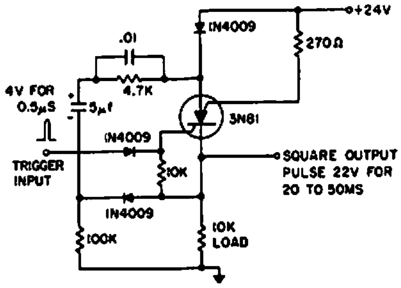
BIDIRECTIONAL CLIPPER—Symmetrically limits excursion of input signal about its average value. Transfer zone is only 300 mV. If all diodes are same type, allowed signal excursion will be nearly zero, because it is only as large as variations in diodes. For larger signals, use all silicon diodes, such as 1N459 for D1 and D2, and 1N456 for D3 and D4.—V. J. Kaneski, Simple Bidirectional Clipper Has Small Transfer Zone, *Electronic Design*, June 22, 1964, p 68–69.


+12v
-28v
10k
10k
600
600
1.5k
+15v
1.5k
Q_5
2N2369
Q_4
2N2369
4k
820
+28v
R_1
31.6k
0.02μf
+15v
2k
2k
Q_2
2N708
2k
Q_3
2N718
50
Q_6
2N492
+15v
2k
Q_1
2N2369
+5v
0
15k
10k
C_1
10μf
R_2
100
300msec
+5v
0v
2k
R_3
2k
OUTPUT
C_3
0.33μf
15k
Q_7
2N2369
ALL DIODES 1N918

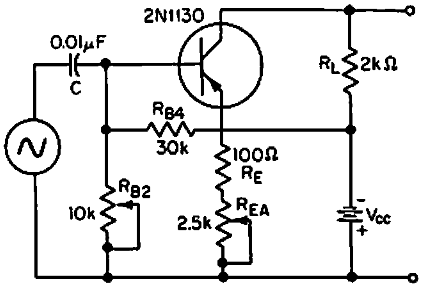
PULSE EXPANDER—External trigger is fed into ujt Q6 through transistors Q1, Q2, and Q3 to make stable mvbr expand 5-μs pulse up to 100,000 times in width while maintaining recovery time of less than 10 μs. Used to make 5-μs computer pulse generate sharp and accurate 3-ms pulse for control of readout equipment. Article describes operation in detail.—D. A. Brooks, Unijunction Transistor Controls Stable One-Shot, *Electronics*, Jan. 8, 1968, p 89–90.


+10V
10K
470Ω
200Ω
V_{OUT}
2N2646
0.1
220Ω
2N697
500μh

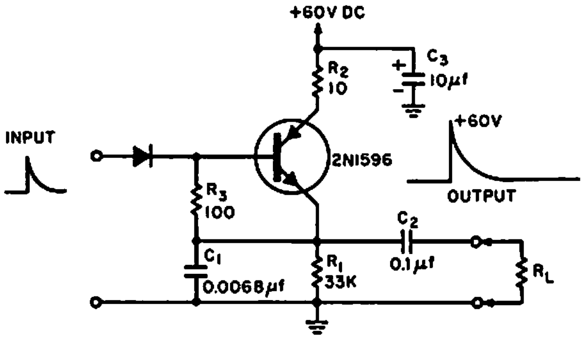
UJT SHAPER—Use of inductance in ujt relaxation oscillator cuts rise and fall times to 0.3 μs for 12-μs pulse width. With 47-ohm resistor in place of inductance, rise time is same, but fall time goes up to 3 μs.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 1.


+24V
IN4009
270Ω
.01
4.7K
4V FOR 0.5μS
5μf
3N81
IN4009
TRIGGER INPUT
10K
SQUARE OUTPUT PULSE 22V FOR 20 TO 50MS
IN4009
100K
10K LOAD

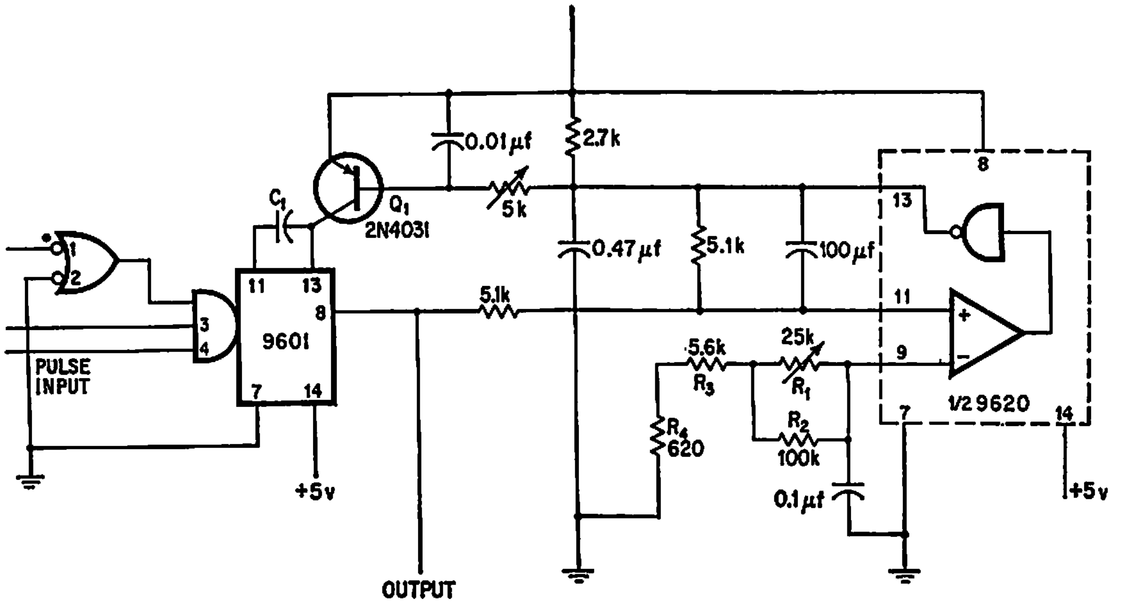
STRETCHER—Provides both amplification and widening of 4-V 0.5-μs trigger input pulse, with 5-μF capacitor and 4.7K resistor determining stretch interval and same capacitor with 100K resistor determining circuit recovery time. Gives square-wave output of 20 to 50 ms at 22 V.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


2N1130
0.01μF
C
R_L 2kΩ
R_{B4}
30k
100Ω
R_E
R_{B2}
10k
R_{EA}
2.5k
V_{cc}

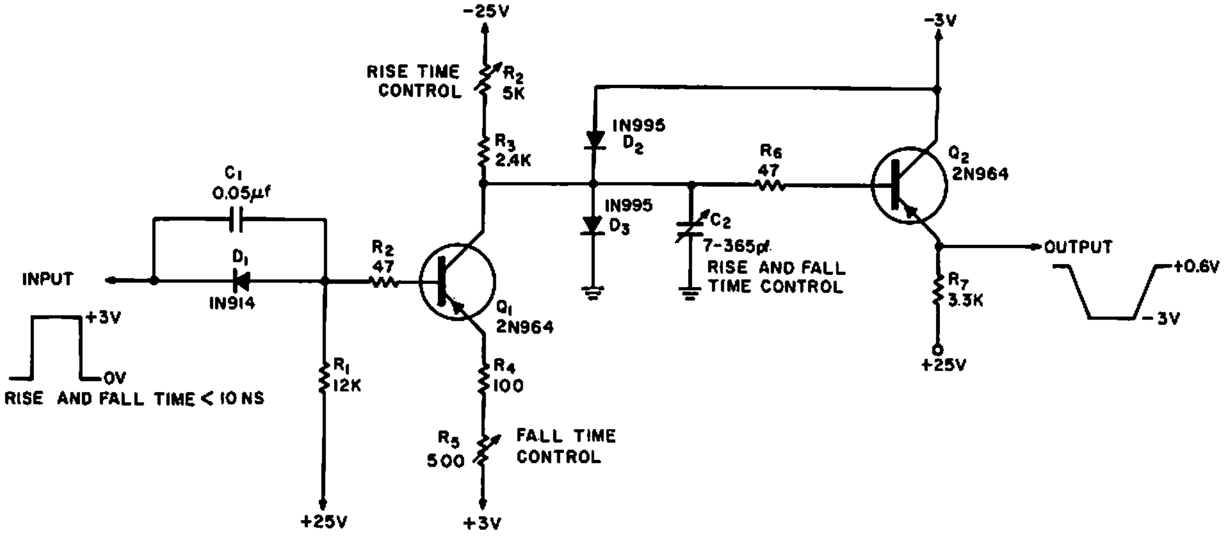
SINE-DRIVEN TRAPEZOIDAL—Gives trapezoidal output waveform for sine-wave input voltage large enough to drive transistor alternately into saturation and into cutoff. Typical value for battery is 10 V. Output is produced by clipping of input.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 278.


+60V DC
R_2 10
C_3 10μf
INPUT
2N1596
+60V
OUTPUT
R_3 100
C_2
C_1 0.0068μf
R_1 33K
0.1μf
R_L

SCR AMPLIFIES ONLY LEADING EDGE—2N1596 scr acts as low-impedance pulse amplifier, eliminating need for shut-off for circuit requiring only leading edge of pulse. Pulse period of 8 ms is determined by C1, R1, C2, and load. Article gives operating details.—A. J. Fishman, Shut-Off is Not Required in SCR Pulse Amplifier, *Electronic Design*, March 16, 1964, p 107–108.


+12v
0.01μf
2.7k
8
C_1
Q_1
2N4031
5k
13
1
2
0.47μf
5.1k
100μf
3
4
11
13
8
9601
5.1k
11
PULSE INPUT
7
14
5.6k
R_3
25k
R_1
9
R_4 620
R_2 100k
0.1μf
7
1/2 9620
14
+5v
+5v
OUTPUT

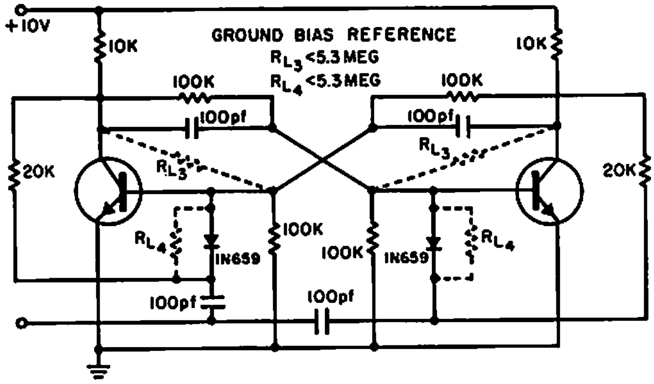
CONSTANT DUTY CYCLE—Single-shot mvbr coupled to integrator delivers output pulse train with constant duty cycle while matching output frequency to changing input frequency. Circuit permits varying frequency of pulse generator over wide range without simultaneously adjusting pulse width control. Duty cycle can be set anywhere from 7% to 93% over frequency range of 100 to 1,000 kHz if C1 is 500 pF.—W. Ross, Pulse Train Frequency Varied as Duty Cycle Stays Constant, *Electronics*, July 21, 1969, p 84.


-25V
RISE TIME CONTROL
R2 5K
R3 2.4K
IN995 D2
R6 47
-3V
Q2 2N964
C1 0.05μf
IN995 D3
C2 7-365pf
RISE AND FALL TIME CONTROL
D1
IN914
INPUT
R2 47
Q1 2N964
+3V
0V
RISE AND FALL TIME < 10 NS
R1 12K
R4 100
R5 500
FALL TIME CONTROL
+25V
+3V
OUTPUT
+0.6V
-3V
R7 3.3K
+25V

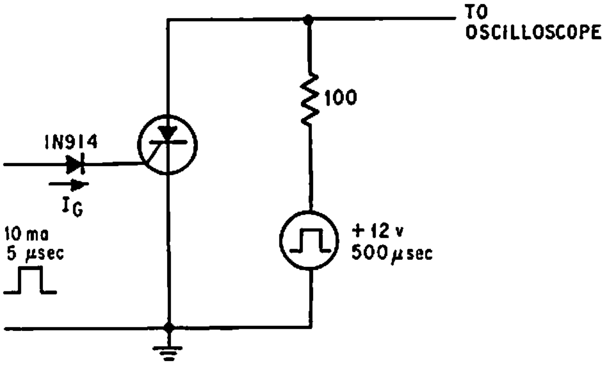
SQUARE TO TRAPEZOIDAL—Converts positive square waves into negative pulses having adjustable linear rise and fall times. With controls R2 and R5 set at minimum, C2 will vary output rise and fall times over range of 10 to 200 ns. Rise time only is affected by R2, while R5 changes both rise and fall times. With larger values for these adjustable components, rise and fall times can be increased to ms range.—D. N. Lee, Trapezoidal Generator Forms Variable Linear Ramps, *Electronic Design*, Dec. 7, 1964, p 66–67.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

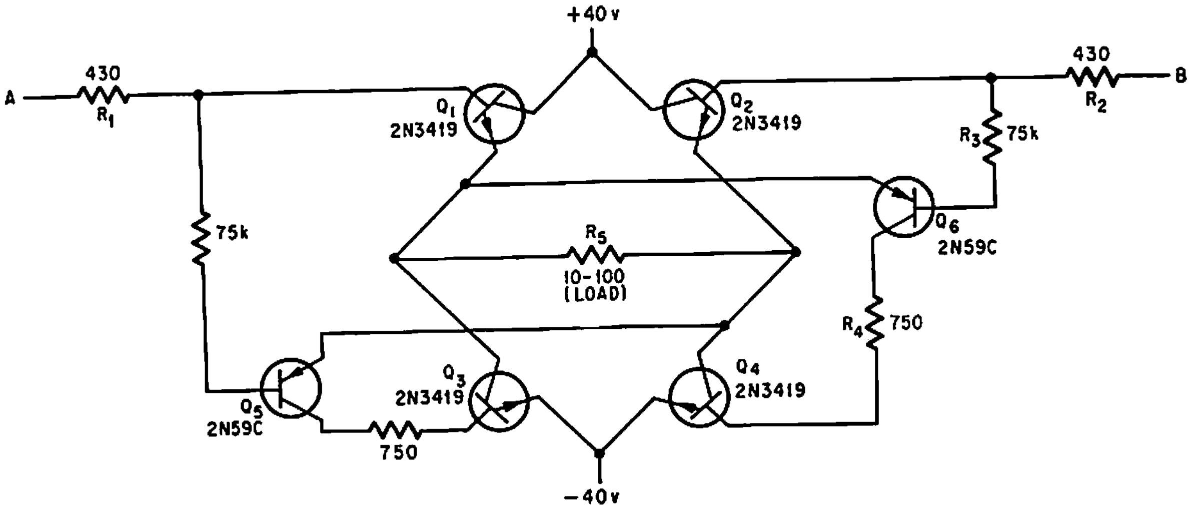
CHAPTER 68
Radiation Circuits


+10V
10K
GROUND BIAS REFERENCE
R_L3<5.3MEG
R_L4<5.3MEG
10K
100K
100K
100pf
100pf
R_L3
R_L3
20K
20K
R_L4
R_L4
IN659
IN659
100K
100K
100pf
100pf

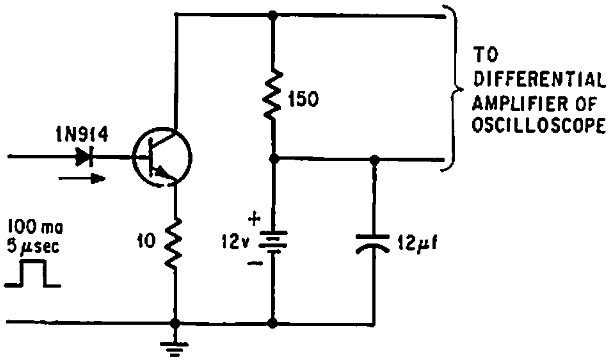
UNHARDENED—Even with special transistors, flip-flop shown is sensitive to radiation because its relatively low base-collector off-current makes it vulnerable to being turned off by transient pulse. Article discusses techniques for hardening such circuits for military equipment. Dashed lines show resistance paths that can carry radiation-induced leakage currents.—Designing Hardened Equipment: Several Methods Are Useful, *Electronic Design*, June 8, 1964, p 46 and 48–51.


TO OSCILLOSCOPE
100
IN914
I_G
10 ma
5 μsec
+12 v
500 μsec

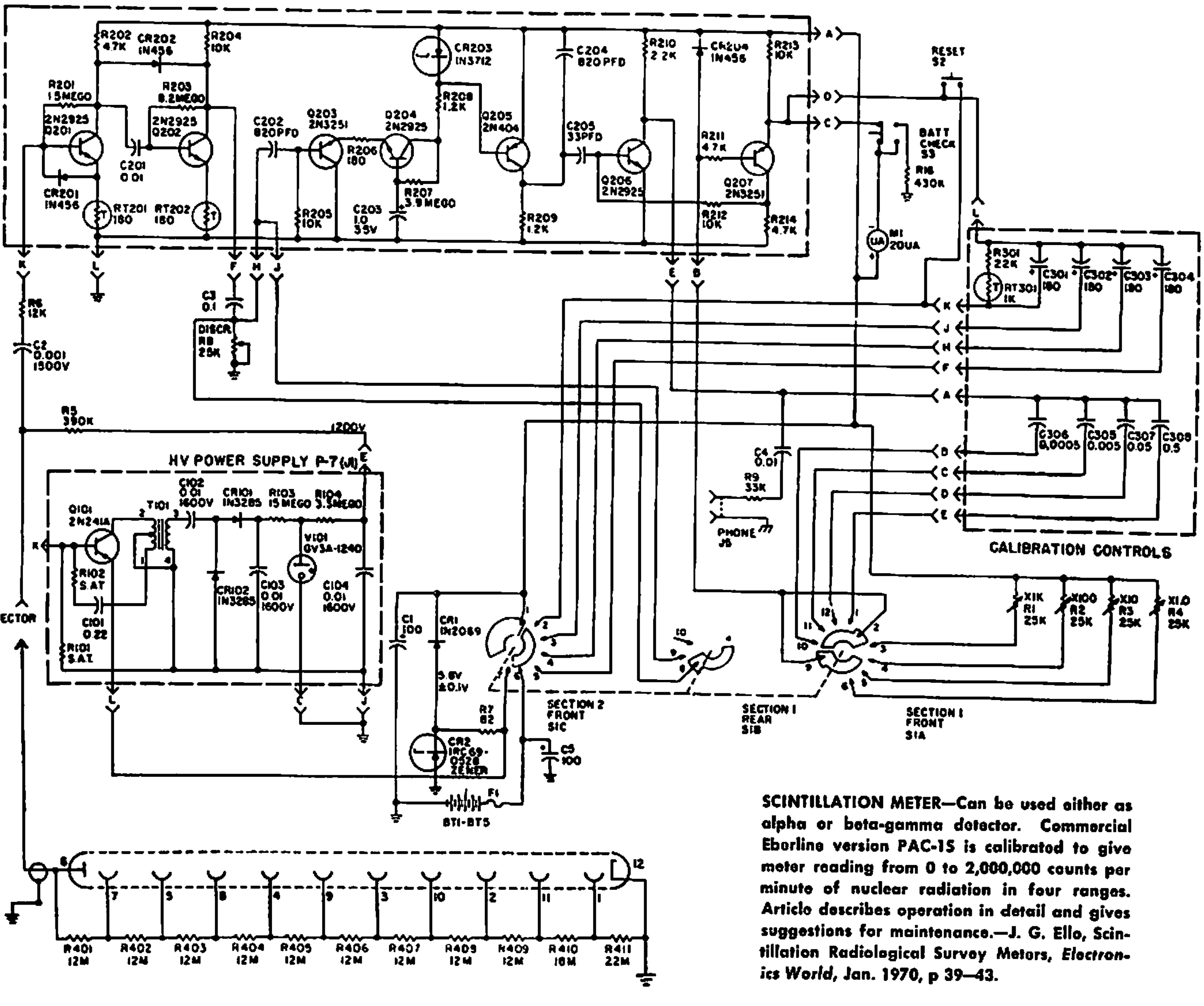
HARDENED SCR SWITCHING TIME—Article gives equations into which measured parameters of components without radiation can be inserted for predicting response under radiation. Circuit shown is used to display on cro, in manner suitable for photographing, switching time of scr under test. Pulses are simultaneously applied to gate and anode. When anode pulse disappears, scr turns off until next gate and anode pulses arrive. Equation then gives performance under radiation.—J. T. Finnell, Jr. and F. W. Karpowich, Skipping the Hard Part of Radiation Hardening, *Electronics*, March 4, 1968, p 122–127.


+40 v
A
430
R1
Q1
2N3419
Q2
2N3419
430
R2
B
R3
75k
Q6
2N59C
75k
R5
10-100
(LOAD)
R4
750
Q3
2N3419
Q4
2N3419
Q5
2N59C
750
−40 v

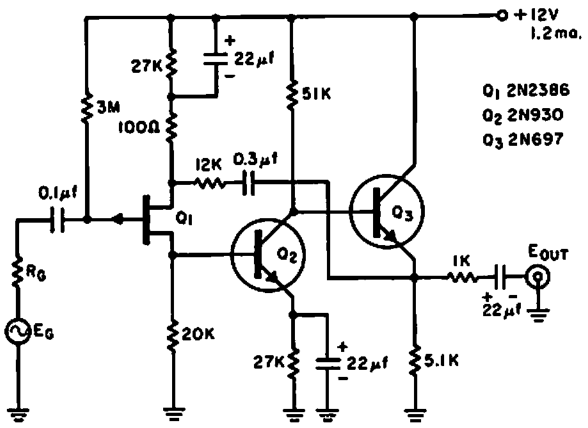
REACTOR ROD DRIVE—Bridge amplifier controls 100-W d-c motor for positioning control rods in nuclear reactor. Q5 and Q6 provide isolation between input and output and ensure class B operation. Load current is proportional to difference between voltages A and B.—M. A. Hassan and T. A. Greinevitch, Bridge Amplifier Provides Isolation, *Electronics*, Sept. 30, 1968, p 83.


1N914
100 ma
5 μsec
10
150
12v
12μf
TO DIFFERENTIAL AMPLIFIER OF OSCILLOSCOPE

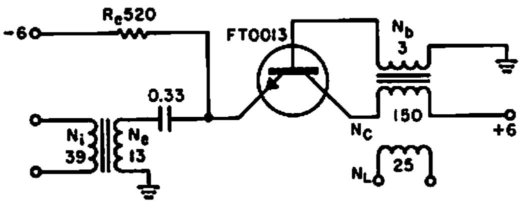
HARDENED TRANSISTOR STORAGE TIME—Article gives equations into which measured parameters of components without radiation can be inserted for predicting response under radiation. Circuit shown is used with cro to measure time required for transistor under test to recover after being driven into saturation by leading edge of pulse. Values are for 2N2222 transistor, which gave saturation or storage time of 3 μs. Equation gives storage time under gamma dose rate of 0.1 terarad/s as 4 μs, as compared to 3.8 μs measured under actual radiation.—J. T. Finnell, Jr. and F. W. Karpowich, Skipping the Hard Part of Radiation Hardening, *Electronics*, March 4, 1968, p 122–127.


R202 4.7K
CR202 IN456
R204 10K
R201 15MEGO
R203 8.2MEGO
2N2925 Q201
2N2925 Q202
C201 0.01
CR201 IN456
RT201 180
RT202 180
C202 820PFD
Q203 2N3251
Q204 2N2925
R206 180
R205 10K
C203 1.0 35V
R207 3.9MEGO
CR203 IN3712
R208 1.2K
Q205 2N404
R209 1.2K
C204 820PFD
C205 33PFD
Q206 2N2925
R210 2.2K
CR204 IN456
R211 4.7K
Q207 2N3251
R212 10K
R213 10K
R214 4.7K
A
D
C
K
L
F
H
J
E
B
R6 12K
C2 0.001 1500V
C3 0.1
DISCR R8 25K
R5 390K
1200V
HV POWER SUPPLY P-7(J1)
Q101 2N241A
T101
C102 0.01 1600V
CR101 IN3285
R103 15MEGO
R104 3.5MEGO
R102 S.A.T
C101 0.22
R101 S.A.T.
CR102 IN3285
C103 0.01 1600V
V101 GV3A-1240
C104 0.01 1600V
DETECTOR J4
C1 100
CR1 IN2069
5.6V ±0.1V
R7 82
CR2 IRC69-0528 ZENER
C5 100
F1
BT1-BT5
SECTION 2 FRONT S1C
RESET S2
BATT CHECK S3
R16 430K
M1 20UA
C4 0.01
R9 33K
PHONE J8
R301 22K
RT301 1K
C301 180
C302 180
C303 180
C304 180
C306 0.0005
C305 0.005
C307 0.05
C308 0.5
CALIBRATION CONTROLS
X1K R1 25K
X100 R2 25K
X10 R3 25K
X1.0 R4 25K
SECTION 1 REAR S1B
SECTION 1 FRONT S1A
R401 12M
R402 12M
R403 12M
R404 12M
R405 12M
R406 12M
R407 12M
R408 12M
R409 12M
R410 16M
R411 22M

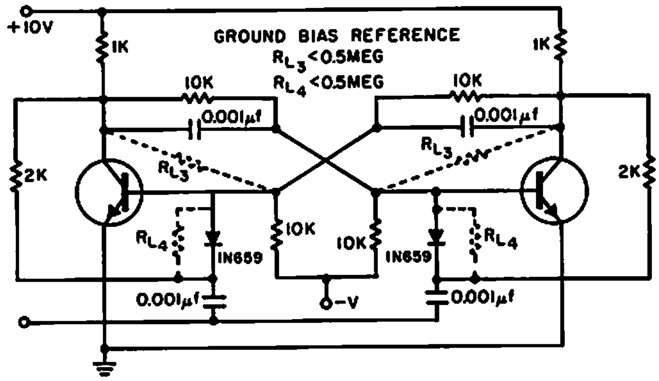
SCINTILLATION METER—Can be used either as alpha or beta-gamma detector. Commercial Eberline version PAC-1S is calibrated to give meter reading from 0 to 2,000,000 counts per minute of nuclear radiation in four ranges. Article describes operation in detail and gives suggestions for maintenance.—J. G. Ello, Scintillation Radiological Survey Meters, *Electronics World*, Jan. 1970, p 39–43.


+12V
1.2ma.
27K
22μf
3M
100Ω
51K
Q1 2N2386
Q2 2N930
Q3 2N697
12K
0.3μf
0.1μf
Q1
Q2
Q3
RG
EG
1K
EOUT
22μf
20K
27K
22μf
5.1K

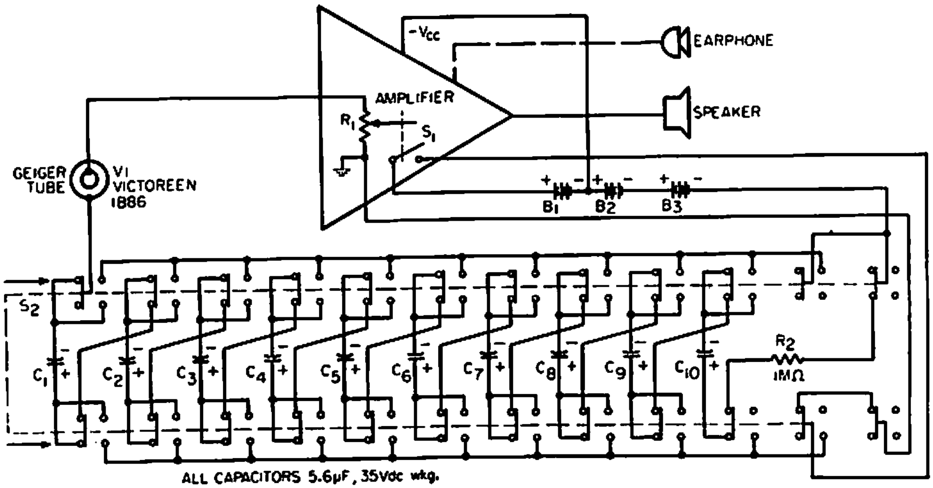
LOW NOISE FOR RADIATION DETECTOR—Silicon fet input stage has high input impedance and low noise level, to provide maximum signal transfer from high-impedance photovoltaic radiation detector. Amplifier stages Q2 and Q3 have direct coupling, with over-all a-c feedback loop to give desired frequency response. Over-all voltage gain is 115 at 1 kHz.—C. R. Seashore, Field-Effect Input Stage Gives Low-Noise Preamp, *Electronic Design*, May 25, 1964, p 70–71.


Re520
-6
FT0013
Nb
3
0.33
Ni
39
Ne
13
NC
150
+6
NL
25

HARDENED—Common-base preamp, using special high-frequency small-signal transistor having short carrier transit time, loses only 3 dB of gain in high-radiation environment. Has stabilized voltage gain, with input impedance increased by negative feedback to base. Requires exact input and output power matching. Article gives circuit hardening techniques.—Designing Hardened Equipment: Several Methods Are Useful, *Electronic Design*, June 8, 1964, p 46 and 48–51.


+10V
1K
GROUND BIAS REFERENCE
RL3<0.5MEG
RL4<0.5MEG
1K
10K
10K
0.001μf
0.001μf
RL3
RL3
2K
2K
RL4
1N659
10K
10K
1N659
RL4
0.001μf
-V
0.001μf

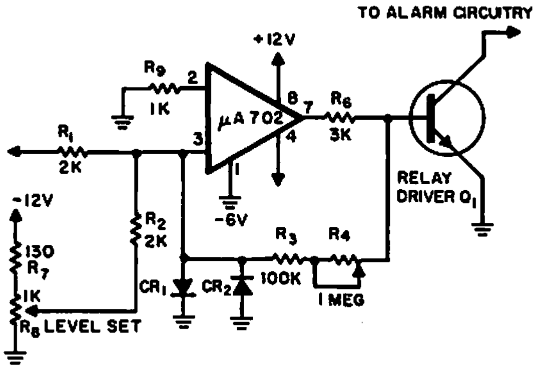
HARDENED FLIP-FLOP—Circuit is designed for reliable operation in high neutron fluxes, as required in military equipment. Base bias circuitry is designed to prevent turn-off by transient pulse. Dashed lines show resistance paths that can carry radiation-induced leakage currents. Special transistors are used. Article discusses circuit hardening techniques. —Designing Hardened Equipment: Several Methods Are Useful, *Electronic Design*, June 8, 1964, p 46 and 48–51.


-Vcc
EARPHONE
AMPLIFIER
SPEAKER
R1
S1
GEIGER TUBE
V1
VICTOREEN
1B86
B1
B2
B3
S2
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
R2
1MΩ

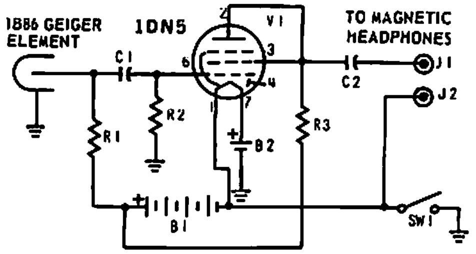
ALL CAPACITORS 5.6μF, 35Vdc wkg.

SWITCHED-CAPACITOR GEIGER—Printed-circuit switch charges capacitors in parallel to 27 V, then connects all capacitors in series with battery to give 300 V d-c required for Geiger tube. Counter will operate over 30 min on single charge of capacitors. Uses three small 9-V batteries in series.—D. J. Pistulka, Passive D-C Converter for Geiger Counter, *EEE*, June 1967, p 137.

BISTABLE NUCLEAR-REACTOR TRIP-ALARM DRIVER—Uses Fairchild IC opamp, with radiation-monitoring transducer fed through R1 to noninverting input. Since 0–10 V range of sensor is outside input limits of IC, level-set pot is returned to −12 V to shift input signal level to zero. Once adjusted, increase of a few mV above this threshold makes IC switch on and operate relay driver and alarm. Triggering repeatability is order of magnitude better than can be obtained with more expensive discrete-component circuits.—K. A. Zimmerman, The Integrated Operational Amplifier: A Versatile and Economical Circuit, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 189–194.



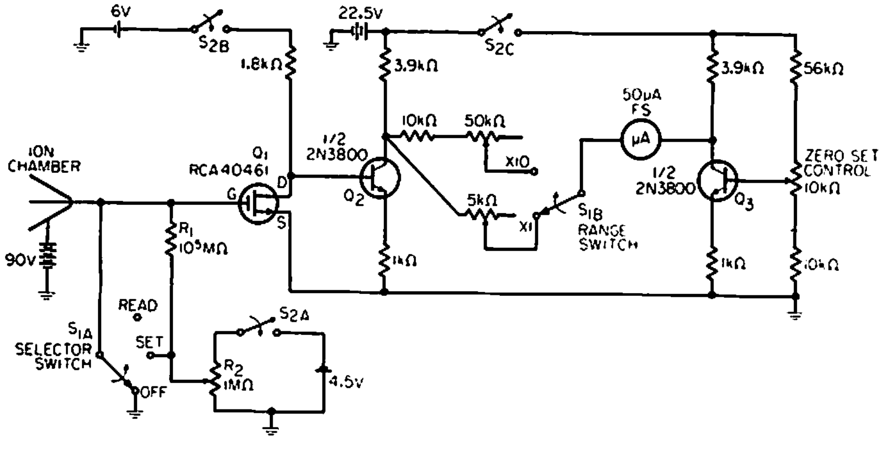
TO ALARM CIRCUITRY
+12V
R9
1K
2
μA 702
8
7
R6
3K
4
3
1
-6V
R1
2K
-12V
R2
2K
130
R7
1K
R8 LEVEL SET
CR1
CR2
R3
100K
R4
1 MEG
RELAY
DRIVER Q1



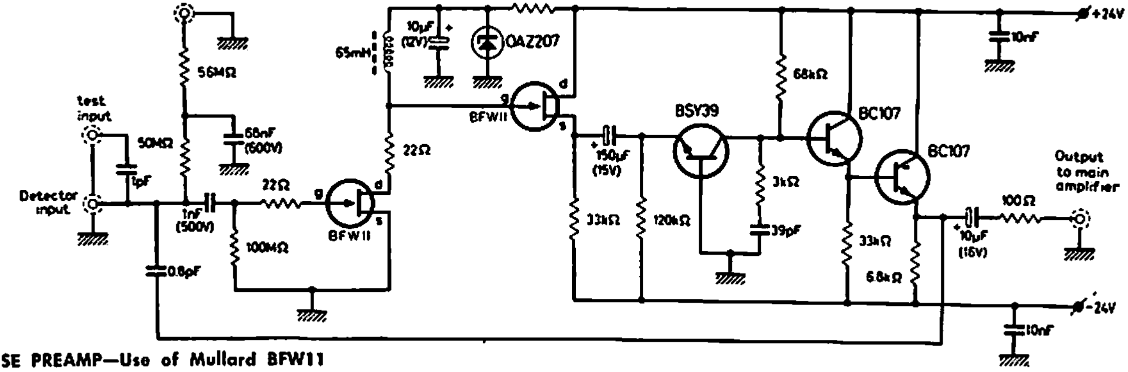
1B86 GEIGER ELEMENT
1DN5
V1
C1
R1
R2
B2
R3
B1
TO MAGNETIC HEADPHONES
C2
J1
J2
SW1

GEIGER COUNTER—Operates from 1.25-V cell B2 and 300-V battery B1, using Victoreen 1B86 Geiger element. Values are: C1-C2 0.025 μF; R1-R2 4.8 meg; R3 1.2 meg. Some clicking is always heard, due to normal background radiation on earth. Increase in clicking indicates strong source of radiation, such as lost shipment of uranium or radium. —R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 122.

MOSFET SURVEY METER—Mosfet Q1 serves in place of conventional electrometer tube in providing input impedance of 100 teraohms. Eliminates tube warm-up time, reduces weight and cost, and extends battery life. Range is 50 mR/hr full-scale at setting X1 of range switch, and ten times that at other settings. —R. L. Brayden, Radiation Meter Uses MOSFET, *EEE*, July 1967, p 129–130.



6V
S2B
1.8kΩ
22.5V
S2C
3.9kΩ
3.9kΩ
56kΩ
ION CHAMBER
Q1
RCA40461
G
D
S
1/2 2N3800
Q2
10kΩ
50kΩ
X10
5kΩ
X1
S1B
RANGE SWITCH
50μA FS
μA
1/2 2N3800
Q3
ZERO SET CONTROL
10kΩ
1kΩ
1kΩ
10kΩ
90V
R1
10⁵MΩ
READ
SET
S1A
SELECTOR SWITCH
OFF
S2A
R2
1MΩ
4.5V



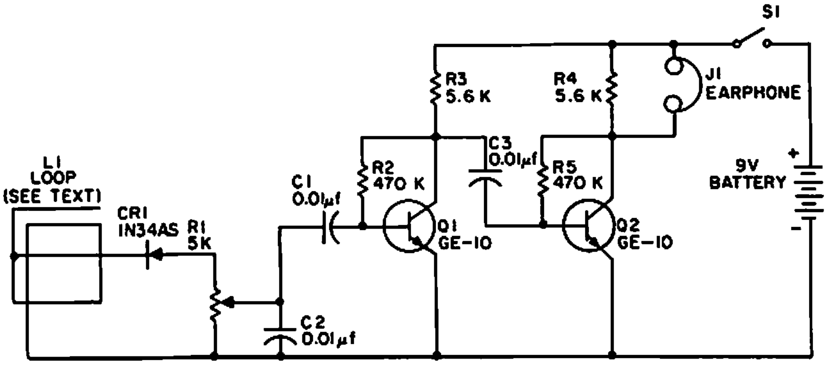
+Bias
56MΩ
test input
50MΩ
68nF (600V)
1pF
Detector input
1nF (500V)
22Ω
100MΩ
0.8pF
g
d
s
BFW11
65mH
10μF (12V)
OAZ207
680Ω
22Ω
g
d
s
BFW11
150μF (15V)
33kΩ
120kΩ
BSY39
3kΩ
39pF
68kΩ
BC107
BC107
33kΩ
6.8kΩ
10μF (15V)
100Ω
Output to main amplifier
10nF
+24V
-24V
10nF

LOW-NOISE PREAMP—Use of Mullard BFW11 fet's significantly reduces noise as compared to that with conventional bipolar transistors when used with high-impedance radiation sensor.—Reduce Pre-Amplifier Noise in Solid State Radiation Detector, Sasco *Electronic News*, England, Sept. 1969, p 2.

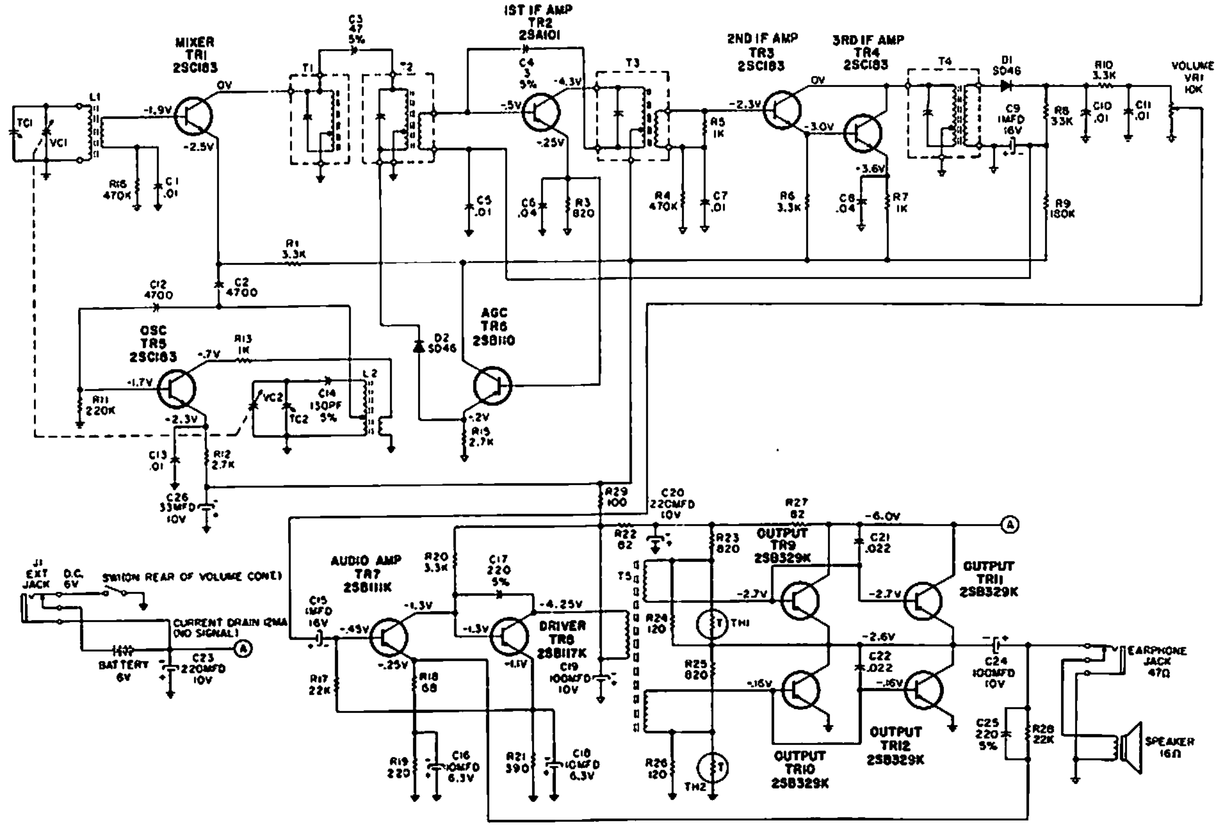
CHAPTER 69

Receiver Circuits

IN-FLIGHT AIRCRAFT RECEIVER—Nonradiating pocket-size receiver using diode detector and two audio stages permits listening to 110–135 MHz pilot-ground transmission while flying, or control-tower transmissions while visiting airport. Range is about 500 ft from transmitter. Signals are picked up with three-turn loop antenna wound around base of plastic pillbox containing entire receiver. —"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 74.



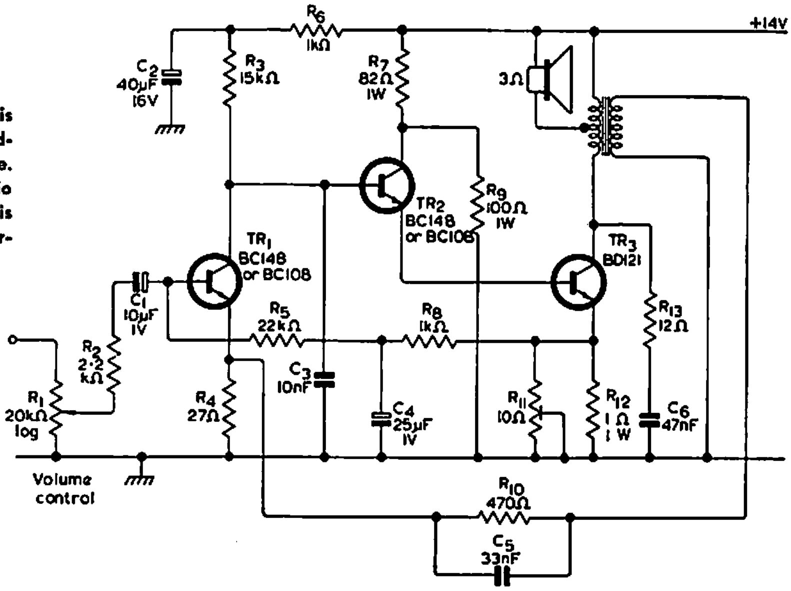
S1
R3 5.6 K
R4 5.6 K
J1 EARPHONE
C3 0.01μf
L1 LOOP (SEE TEXT)
C1 0.01μf
R2 470 K
R5 470 K
9V BATTERY
+
-
CR1 IN34AS
R1 5K
Q1 GE-10
Q2 GE-10
C2 0.01μf

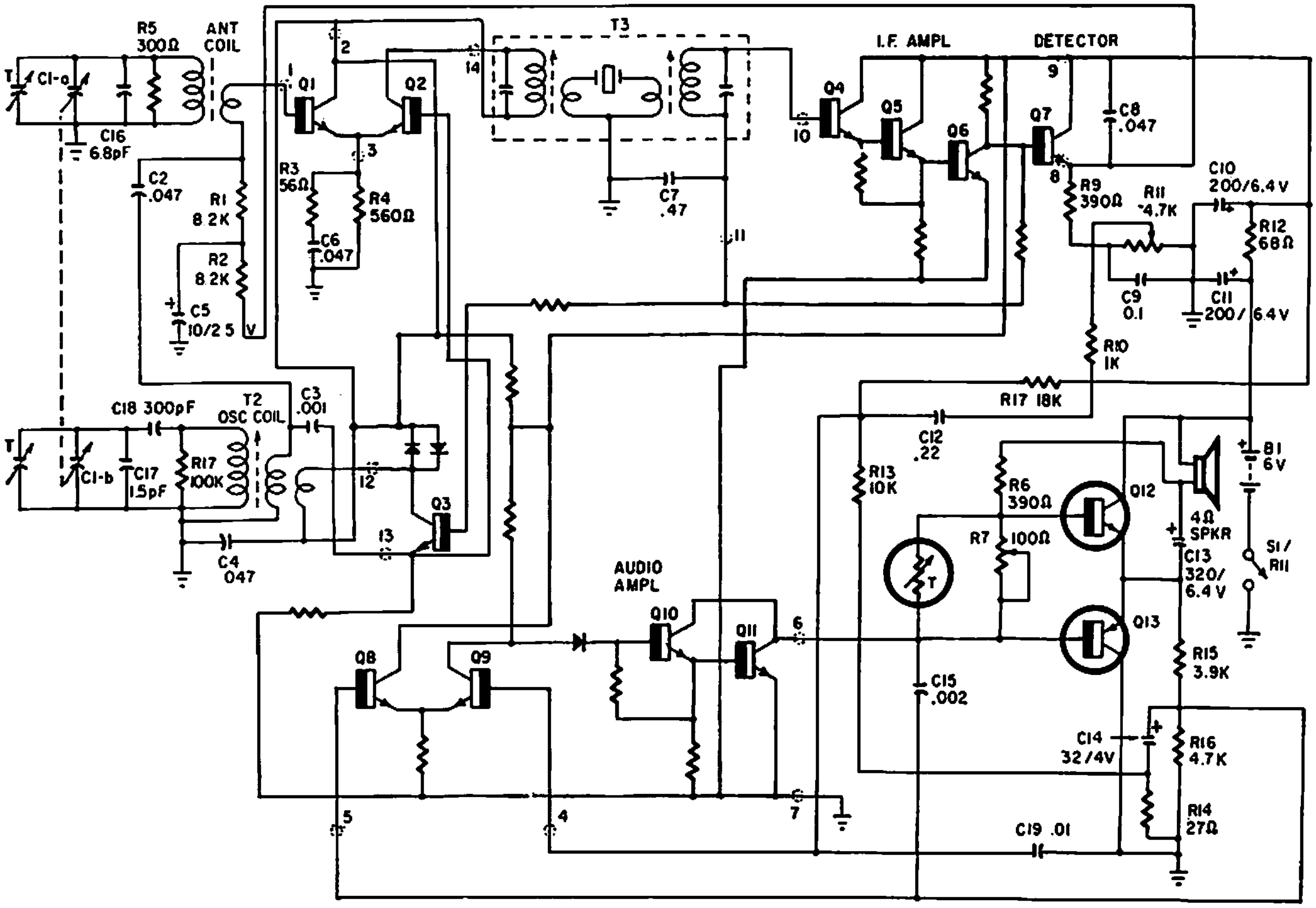


MIXER TR1 2SC183
C3 47 5%
1ST IF AMP TR2 2SA101
T1
T2
T3
C4 3 5%
2ND IF AMP TR3 2SC183
3RD IF AMP TR4 2SC183
T4
D1 SO46
R10 3.3K
VOLUME VR1 10K
L1
TC1
VC1
0V
-1.9V
-2.5V
-5V
-4.3V
-.25V
-2.3V
-3.0V
+3.6V
R16 470K
C1 .01
C5 .01
C6 .04
R3 820
R5 1K
R4 470K
C7 .01
R6 3.3K
C8 .04
R7 1K
C9 1MFD 16V
R8 33K
C10 .01
C11 .01
R9 180K
R1 3.3K
C12 4700
C2 4700
OSC TR5 2SC183
-.7V
R13 1K
L2
-1.7V
R11 220K
VC2
TC2
C14 130PF 5%
-2.3V
D2 SO46
AGC TR6 2SB110
-.2V
R15 2.7K
C13 .01
R12 2.7K
C26 33MFD 10V
R29 100
C20 220MFD 10V
R27 82
-6.0V
A
R22 82
R23 820
OUTPUT TR9 2SB329K
C21 .022
OUTPUT TR11 2SB329K
J1 EXT JACK
D.C. 6V
SW1(ON REAR OF VOLUME CONT)
CURRENT DRAIN 12MA (NO SIGNAL)
BATTERY 6V
C23 220MFD 10V
A
AUDIO AMP TR7 2SB111K
R20 3.3K
C17 220 5%
C15 1MFD 16V
-.45V
-1.3V
-1.3V
-4.25V
DRIVER TR8 2SB117K
-.25V
-1.1V
C19 100MFD 10V
T5
R24 120
TH1
-2.7V
-2.7V
-2.6V
R17 22K
R18 68
R25 820
-.16V
C22 .022
-.16V
C24 100MFD 10V
EARPHONE JACK 47Ω
C25 220 5%
R28 22K
SPEAKER 16Ω
R19 220
C16 10MFD 6.3V
R21 390
C18 10MFD 6.3V
R26 120
TH2
OUTPUT TR10 2SB329K
OUTPUT TR12 2SB329K

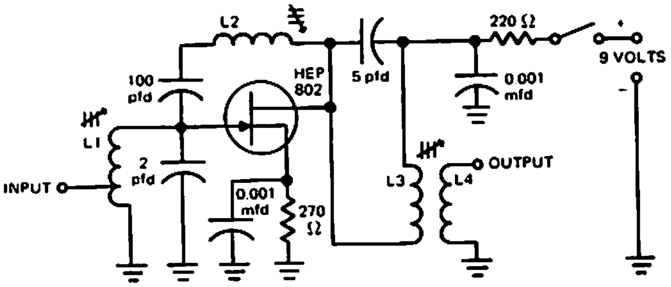
12-TRANSISTOR A-M PORTABLE—Operates from four 1.5-V Eveready 1015 AA cells or equivalent or from separate 6-V d-c adaptor for a-c line. All capacitors with values less than 1 are in μF, and greater than 1 in pF. No-signal battery drain is 12 mA. Covers 535–1605 kHz.—1R1005 AM Portable Radio, Magnavox Service Manual 1439, 1969.

5-W CAR RADIO AMPLIFIER—Loudspeaker is driven by center-tap choke having small winding that provides feedback to first stage. Choke inductance is 30 mH and voltage ratio of choke to secondary is 13:1. Operation is class A.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 90.

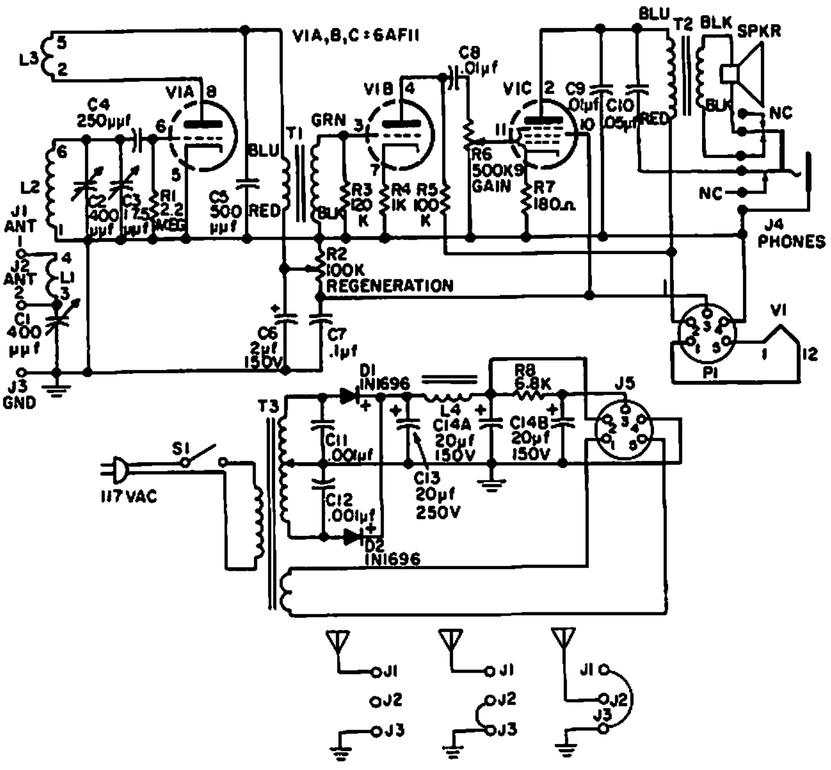

R6 1kΩ
+14V
C2 40µF 16V
R3 15kΩ
R7 82Ω 1W
3Ω
TR2 BC148 or BC108
R9 100Ω 1W
TR1 BC148 or BC108
TR3 BD121
C1 10µF 1V
R5 22kΩ
R8 1kΩ
R13 12Ω
R2 2.2kΩ
R1 20kΩ log
C3 10nF
R4 27Ω
C4 25µF 1V
R11 10Ω
R12 1Ω 1W
C6 47nF
Volume control
R10 470Ω
C5 33nF


R5 300Ω
ANT COIL
T
C1-a
C16 6.8pF
1
Q1
2
Q2
14
T3
I.F. AMPL
DETECTOR
9
Q4
Q5
Q6
Q7
C8 .047
10
3
R3 56Ω
R4 560Ω
C6 .047
C2 .047
R1 8.2K
R2 8.2K
C5 10/2.5 V
C7 .47
11
8
R9 390Ω
R11 4.7K
C10 200/6.4 V
R12 68Ω
C9 0.1
C11 200/6.4 V
R10 1K
R17 18K
C12 .22
R13 10K
C18 300pF
T2 OSC COIL
C3 .001
C1-b
C17 1.5pF
R17 100K
12
Q3
13
C4 .047
R6 390Ω
R7 100Ω
Q12
T
B1 6V
4Ω SPKR
C13 320/6.4 V
S1/R11
Q13
AUDIO AMPL
Q10
Q11
6
Q8
Q9
C15 .002
R15 3.9K
C14 32/4V
R16 4.7K
R14 27Ω
5
4
7
C19 .01

PORTABLE A-M RADIO—Single Amperex TAD-100 IC (shaded area) includes all active stages for driving earphone, and requires only two additional transistors for speaker (Q12 is 2N4105 and Q13 is 2N4106). Output power is then 1.5 W into 4-ohm speaker. T3 is Amperex 822-410-42010 ceramic i-f filter. C1 is 280-pF two-section tuning capacitor. Article gives construction details.—L. Auer and H. Thanos, Experiment With One-IC Radio, *Radio-Electronics*, Nov. 1969, p 49–51.

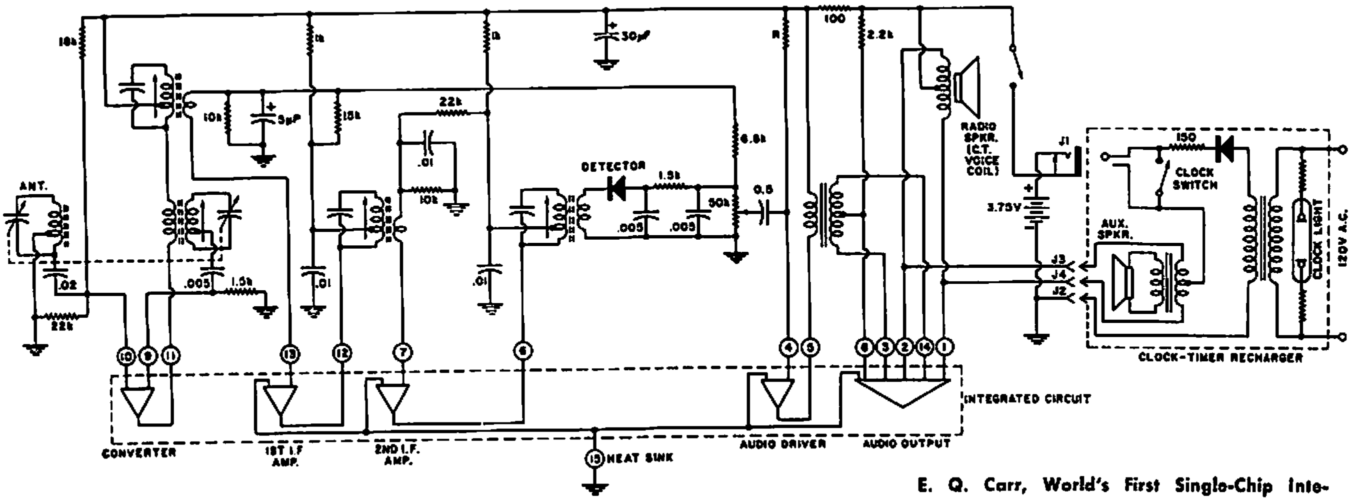

L2
100 pfd
HEP 802
5 pfd
220 Ω
+
9 VOLTS
-
0.001 mfd
L1
2 pfd
INPUT
0.001 mfd
270 Ω
L3
L4
OUTPUT

150-MHz FET—Battery-operated circuit gives 14-dB gain with low noise for 2-meter receiver. Coils L1, L2, L3, and L4 are respectively 5¼ turns tapped at 1¼ turns No. 26, 9½ turns No. 34, 5 turns No. 26, and 1¼ turns No. 26 at low end of L3, all wound on brass-slug ceramic forms.—"Tips on Using FET's," HMA-33, Motorola, Phoenix, Ariz., 1969.

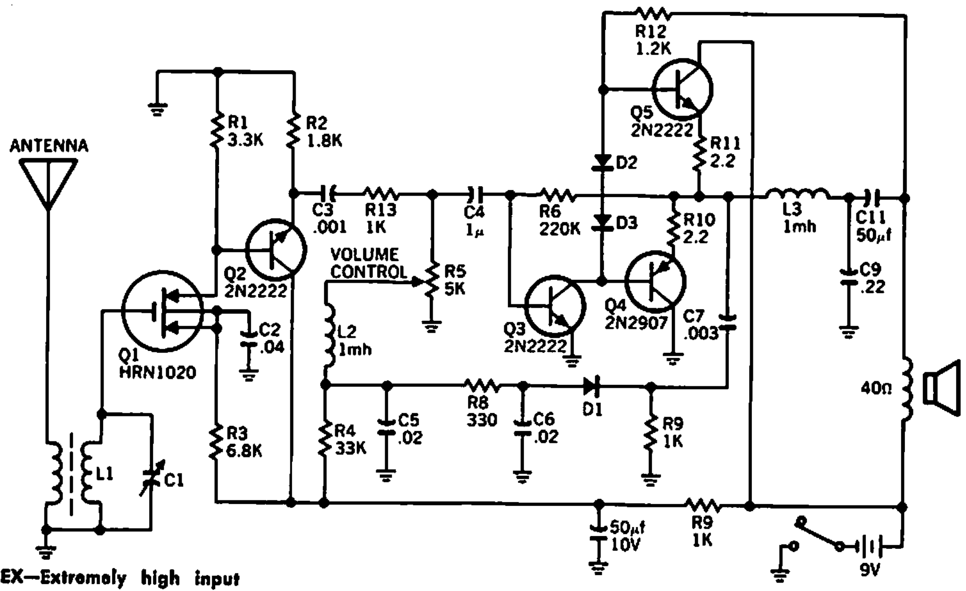

VIA,B,C = 6AF11
L3
C4 250μμf
VIA
L2
J1 ANT
J2 ANT
L1
C1 400 μμf
J3 GND
C2 400 μμf
C3 17.5 μμf
R1 2.2 MEG
C5 500 μμf
BLU
RED
T1
GRN
VIB
BLK
R3 120 K
R4 1K
R5 100 K
R2 100K REGENERATION
C6 2μf 150V
C7 .1μf
C8 .01μf
VIC
R6 500K GAIN
R7 180Ω
C9 .01μf
C10 .05μf
RED
BLU
T2
BLK
SPKR
NC
NC
J4 PHONES
P1
V1
12
D1 1N1696
L4
R8 6.8K
J5
T3
S1
117 VAC
C11 .001μf
C12 .001μf
C13 20μf 250V
C14A 20μf 150V
C14B 20μf 150V
D2 1N1696
J1
J2
J3

1-COMPACTRON S-W RECEIVER—Covers 250 kHz to 16 MHz with plug-in coils. Uses triode regenerative detector, triode audio voltage amplifier, and pentode power amplifier. Choice of antenna connections is provided to increase selectivity and tune out dead spots. Can serve as backup in case larger receiver breaks down. Article gives construction details and coil-winding data.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 108.

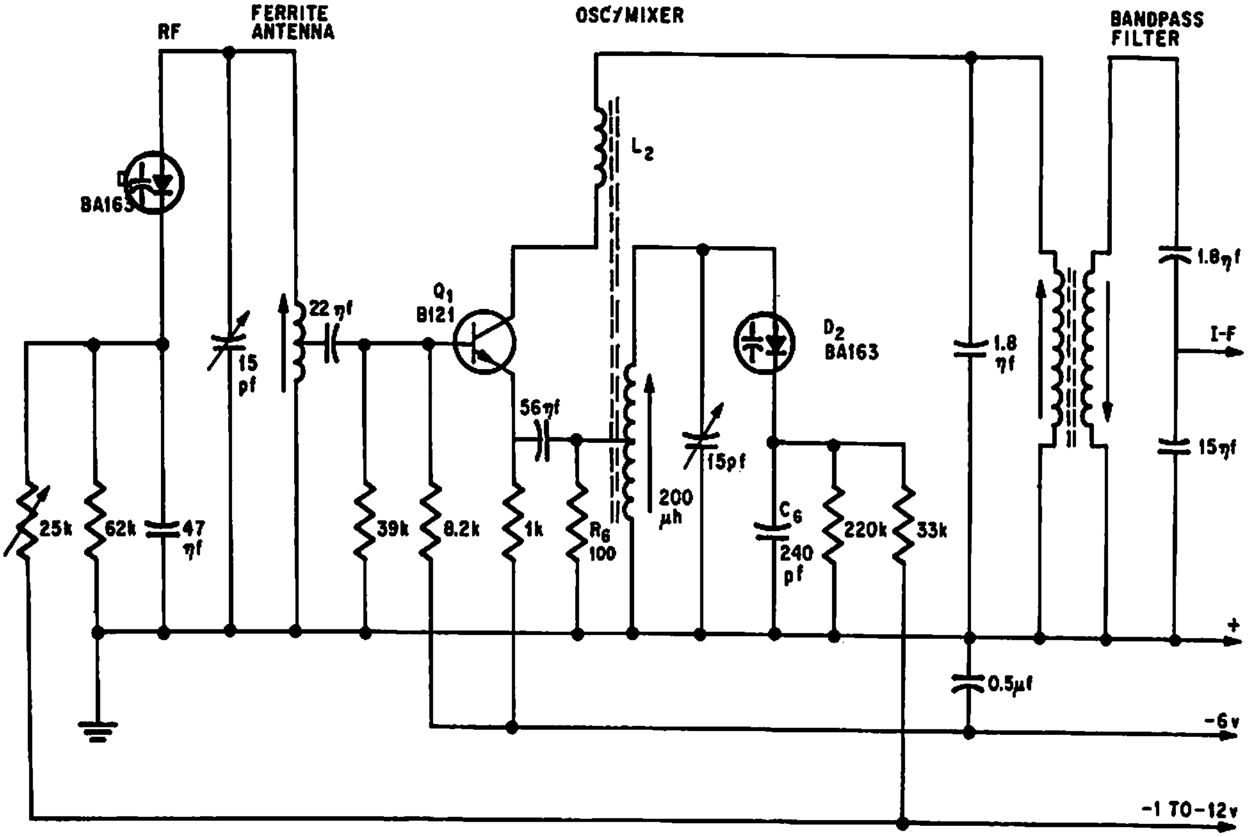
THREE POSSIBLE ANTENNA CONNECTIONS


ANT.
18k
1k
1k
30μf
R
100
2.2k
10k
3μf
15k
22k
.01
10k
DETECTOR
1.5k
.005
.003
50k
0.5
6.8k
.02
22k
.005
1.5k
.01
.01
RADIO SPKR. (C.T. VOICE COIL)
J1
3.75V
J3
J4
J2
150
CLOCK SWITCH
AUX. SPKR.
CLOCK LIGHT
120V A.C.
CLOCK-TIMER RECHARGER
INTEGRATED CIRCUIT
CONVERTER
1ST I.F. AMP.
2ND I.F. AMP.
AUDIO DRIVER
AUDIO OUTPUT
15 HEAT SINK
10
9
11
13
12
7
6
4
5
8
3
2
14
1

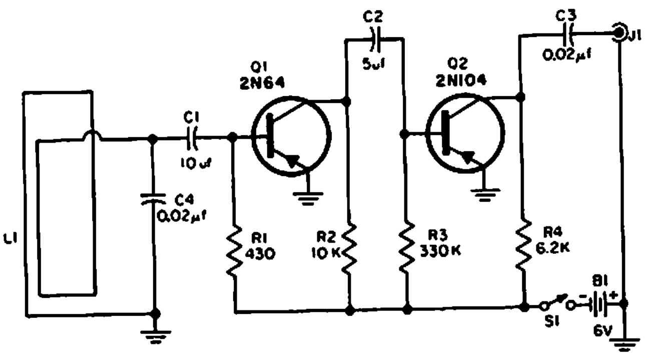
IC RADIO—G-E Model P1740 radio uses single 15-lead integrated circuit for all active components. External components include battery charger in clock-timer.—J. R. Cacciola and E. Q. Carr, World's First Single-Chip Integrated-Circuit Radio, *Electronics World*, Nov. 1966, p 44–46.


ANTENNA
R1 3.3K
R2 1.8K
R12 1.2K
Q5 2N2222
R11 2.2
D2
C3 .001
R13 1K
C4 1µ
R6 220K
D3
R10 2.2
L3 1mh
C11 50µf
Q2 2N2222
VOLUME CONTROL
R5 5K
C9 .22
Q1 HRN1020
C2 .04
L2 1mh
Q3 2N2222
Q4 2N2907
C7 .003
40Ω
R8 330
D1
L1
C1
R3 6.8K
R4 33K
C5 .02
C6 .02
R9 1K
50µf 10V
R9 1K
9V

MOSFET A-M REFLEX—Extremely high input impedance of mosfet makes input tank circuit determine selectivity. Q2 buffers signal into low-impedance input of reflex amplifier Q3-Q4-Q5 that amplifies both r-f and audio signals. R-f output signal is filtered and fed to peak detector formed by R9, D1, C6, R8, C5, and L2. Resulting audio signal is fed through volume control R5 back into amplifier and filtered into speaker.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 39.

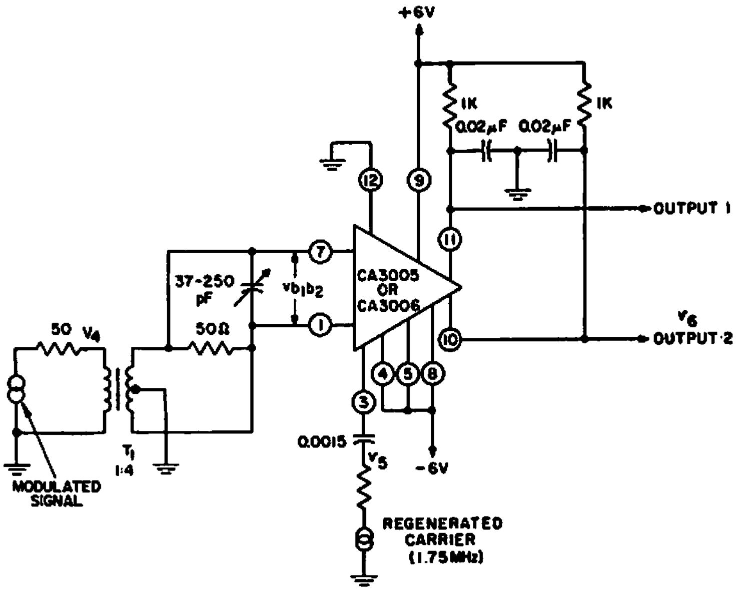

RF
FERRITE ANTENNA
OSC/MIXER
BANDPASS FILTER
D1
BA163
L2
Q1
BF121
22ηf
15 pf
56ηf
200 µh
15pf
D2
BA163
1.8 ηf
1.8ηf
I-F
15ηf
25k
62k
47 ηf
39k
8.2k
1k
R6 100
C6 240 pf
220k
33k
+
0.5µf
-6v
-1 TO-12v

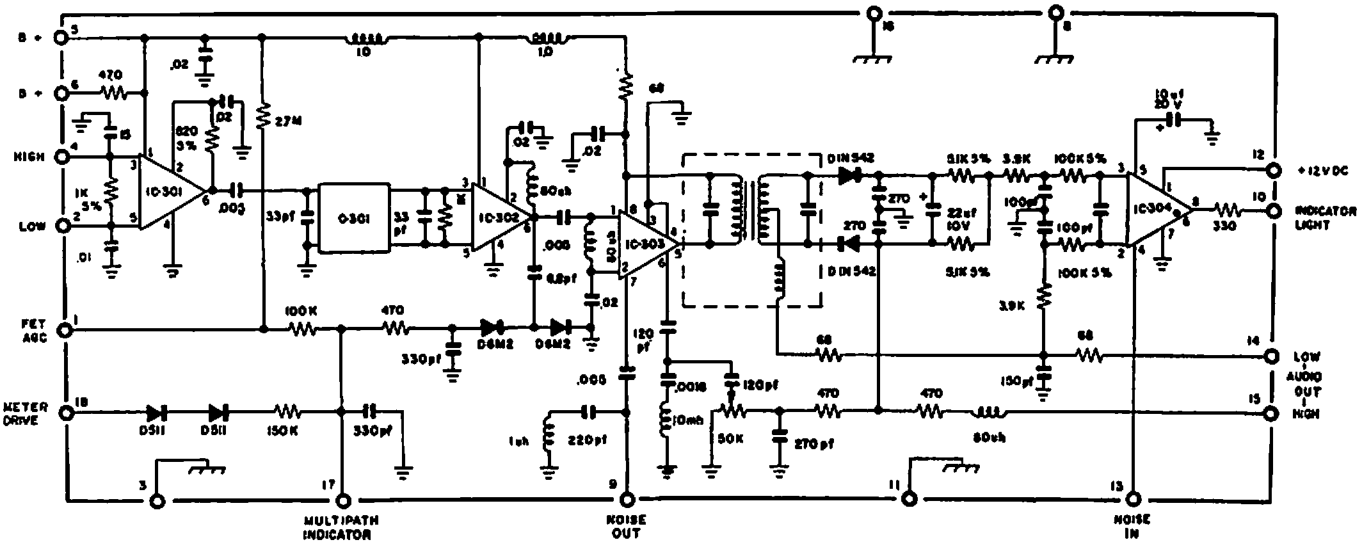
A-M VARACTOR-DIODE TUNER—Developed in Europe for covering 510–1,610 kHz broadcast band. Provides tuning accuracy and stability needed for pushbutton tuning. Self-oscillating mixer transistor Q1 operates in common-base mode. Maximum voltage required for tuning across band is 12 V. Varactor diodes should be matched.—H. Keller, Overcoming Design Problems in Varactor-Diode Tuners, *Electronics*, Jan. 6, 1969, p 88–92.


C2
5µf
C3
0.02µf
J1
Q1
2N64
Q2
2N104
C1
10µf
C4
0.02µf
L1
R1
430
R2
10K
R3
330K
R4
6.2K
B1
S1
6V

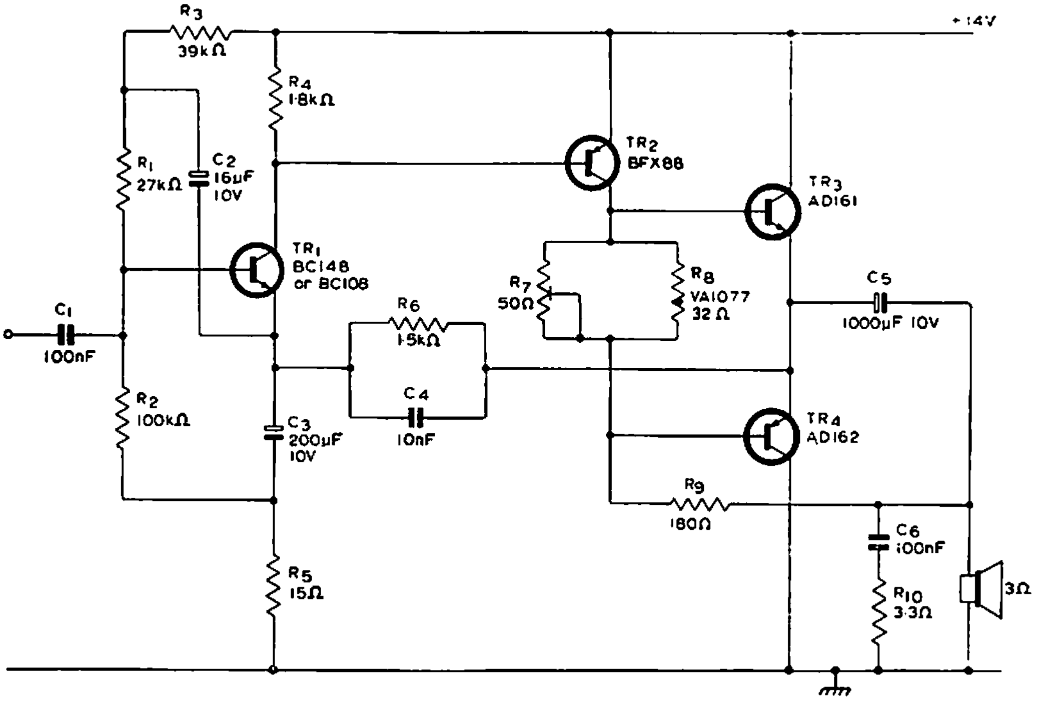
VLF WHISTLER RECEIVER—Covers vlf portion of r-f spectrum, from 4 to 16 kHz, for listening to whistlers (descending-frequency whistles caused by lightning), chirping and clicking sounds at sunrise known as dawn chorus, and sounds associated with launching of spacecraft and firing of nuclear explosions. Navy code broadcasts on 14.8 kHz may also be heard. Loop antenna is 200 turns of No. 25 enameled wire wound on frame consisting of two 4-ft pieces of wood formed into X by notching. Rotate loop to point where power-line hum is minimum. J1 should go to high-impedance input of hi-fi amplifier.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 43.

IC PRODUCT DETECTOR—IC r-f amplifier is connected to provide double-ended out-of-phase output when driven through 50-ohm adjustable feed by double-sideband signal from separate suppressed-carrier modulator. —"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 230.

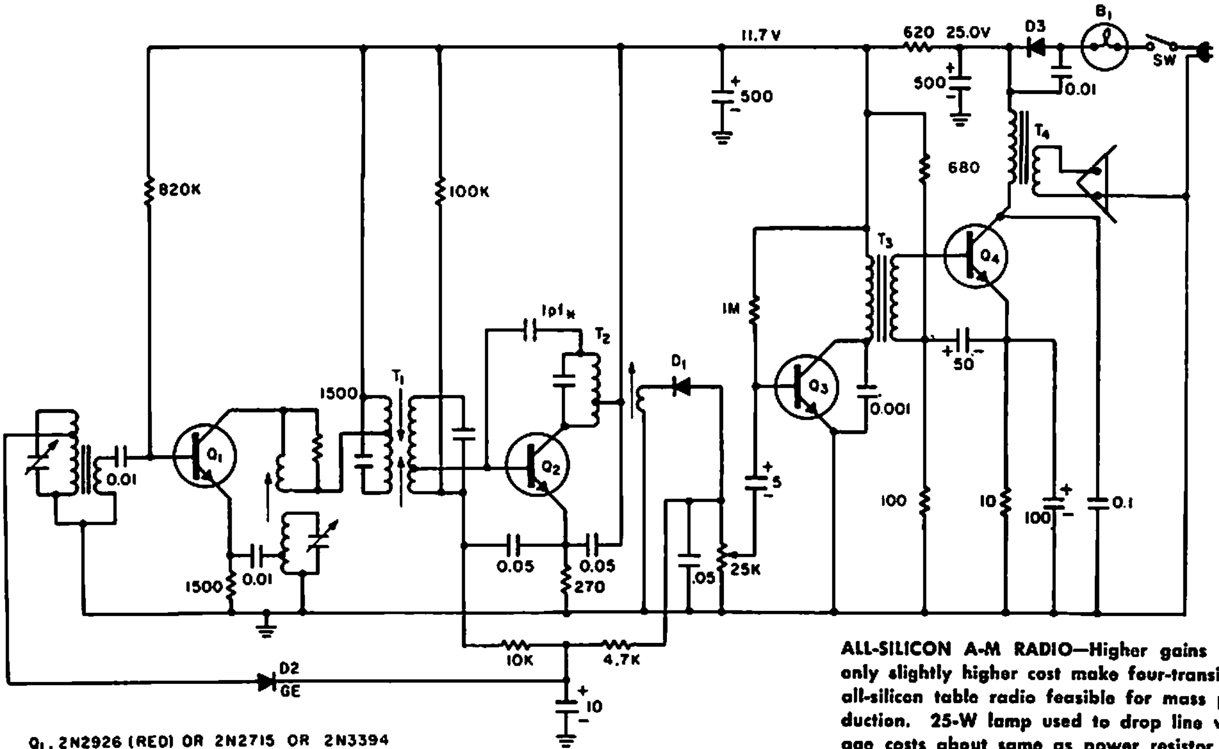

+6V
1K
1K
0.02µF
0.02µF
12
9
11
OUTPUT 1
7
1
37-250 pF
vb1b2
50Ω
CA3005 OR CA3006
50
V4
V6
10
OUTPUT 2
4
5
8
3
T1
1:4
MODULATED SIGNAL
0.0015
V5
-6V
REGENERATED CARRIER (1.75MHz)


B+
5
B+
6
470
HIGH
4
15
LOW
2
1K 5%
.01
IC-301
820 3%
.02
.003
27M
.02
1.0
1.0
33pf
C-301
33 pf
IC-302
.02
80uh
.005
6.8pf
68
.02
IC-303
80uh
.02
120 pf
.005
.0018
10mh
120pf
50K
1uh
220pf
FET AGC
1
100K
470
330pf
D6M2
D6M2
METER DRIVE
18
D511
D511
150K
330pf
3
17
MULTIPATH INDICATOR
9
NOISE OUT
16
8
D1N542
D1N542
270
270
22uf 10V
5.1K 5%
5.1K 5%
3.9K
3.9K
100K 5%
100K 5%
100pf
100pf
150pf
68
68
470
470
270 pf
80uh
10uf 20V
IC304
330
12
+12VDC
10
INDICATOR LIGHT
14
LOW
AUDIO OUT
15
HIGH
11
13
NOISE IN

HI-FI I-F WITH IC—Uses integrated circuits designed for H. H. Scott f-m receivers by Motorola, with quartz crystal filter (C-301) between first two IC's to improve phase linearity over entire bandwidth. Output terminal 10 drives "Perfect Tune" lamp to show exact tuning of stereo signal.—L. W. Fish, Jr., and K. J. Peter, New Concepts in Hi-Fi Receiver Design, *Electronics World*, Feb. 1969, p 32–34 and 69–70.


R3
39kΩ
+14V
R4
1·8kΩ
TR2
BFX88
TR3
AD161
R1
27kΩ
C2
16μF
10V
TR1
BC148
or BC108
R7
50Ω
R8
VA1077
32Ω
C5
1000μF 10V
C1
100nF
R6
1·5kΩ
C4
10nF
R2
100kΩ
C3
200μF
10V
TR4
AD162
R9
180Ω
C6
100nF
R5
15Ω
R10
3·3Ω
3Ω

6-W CLASS B AMPLIFIER—Designed for use in car radio. Circuit is conventional except that decoupling capacitor C2 in input stage is returned to emitter of TR1 instead of to chassis; this reduces effect of ripple in supply and increases input resistance by bootstrapping base resistor.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 92.

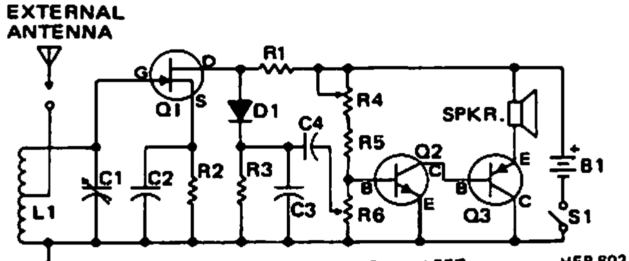

11.7V
620
25.0V
D3
B1
SW
500
500
0.01
T4
680
820K
100K
T3
Q4
1M
1pf*
T2
D1
50
T1
1500
Q3
0.001
Q1
Q2
0.01
5
100
10
100
0.1
1500
0.01
0.05
0.05
270
.05
25K
10K
4.7K
D2
GE
10

Q1, 2N2926 (RED) OR 2N2715 OR 2N3394
Q2,Q3, 2N2926 (ORANGE) OR 2N2716 OR 2N3393
Q4, 2N2196 OR 2N2107 (ATTACH TO HEATSINK)
D1 SI DIODE IN4009
D2 GE DIODE IN60
D3 IN1692.

B1-110V, 25W LIGHT BULB
T1 EX-5168 (4K/IK)
T2 13964 (IK/IK)
T3 35K/100
T4 250/8

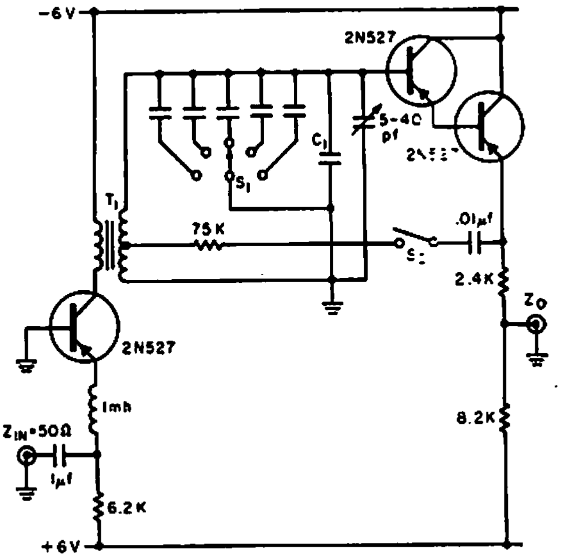
ALL-SILICON A-M RADIO—Higher gains and only slightly higher cost make four-transistor all-silicon table radio feasible for mass production. 25-W lamp used to drop line voltage costs about same as power resistor but also performs regulating function.—The 20¢ Transistor, *Electronic Design*, Oct. 12, 1964, p 40–42.

* USE 1.0pf WITH 2N2926 AND 2N3391 SERIES TRANSISTORS, 0.5pf WITH 2N2715 SERIES.

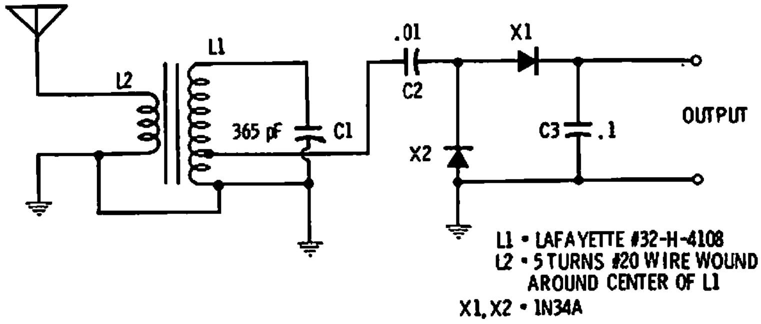

EXTERNAL ANTENNA
G
D
S
Q1
R1
D1
C4
R4
SPKR.
R5
Q2
B
C
E
B
E
C
Q3
B1
S1
C1
C2
R2
R3
C3
R6
L1
EXTERNAL GROUND

Q1	N Channel FET	HEP 802
Q2	NPN Transistor	
Q3	PNP Power Transistor (Germanium)	
D1	Signal Diode	
C1	365 PFD Variable Capacitor	
C2	0.01 μF Disc. Ceramic	
C3	0.02 μF Disc. Ceramic	
C4	0.1 μF Disc. Ceramic	
L1	Ferrite Antenna Coil (Variable)	
R1,R2	4,700 Ω Resistor ¼ Watt 10%	
R3	1 MEG Ω Resistor ½ Watt 10%	
R4	500,000 Ω Trim Potentiometer	
R5	100,000 Ω Resistor ½ Watt 10%	
R6	50,000 Ω Potentiometer	
S1	Switch Part of R6	

3-TRANSISTOR A-M RADIO—Use of fet as r-f amplifier contributes to selectivity and gain of trf circuit feeding diode detector and two-transistor audio amplifier driving small speaker. Requires 12 V, obtained from eight 1.5-V cells in series. R6 is volume control, and R4 is bias adjustment.—Calectro Handbook, GC Electronics, Rockford, Ill., FR-69-C, p 41.

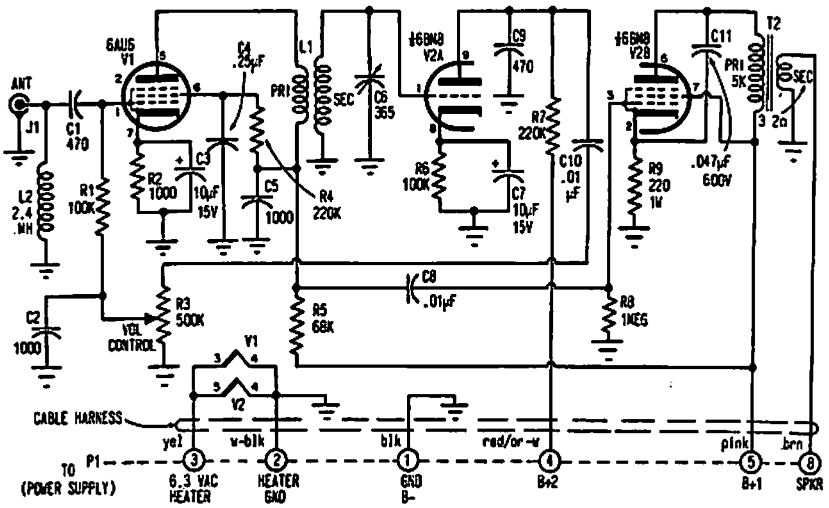

-6V
2N527
5-40 pf
2N527
C1
S1
T1
75K
S2
.01μf
2.4K
Zo
2N527
1mh
ZIN=50Ω
1μf
8.2K
6.2K
+6V

VLF RECEIVER—Uses Darlington circuit as Q-multiplier to give good selectivity over entire vlf band. T1 has 1:15 turns ratio. All transistors are 2N527. Output can be fed to ordinary R-C amplifiers to give desired output level.—R. W. Couch, Simple VLF Receiver Uses Single Tuned Stage, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 33.

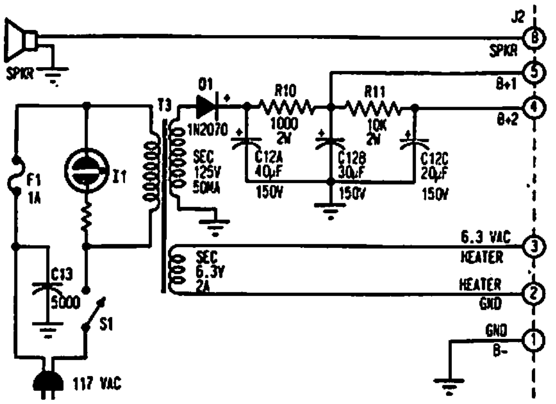

L1
L2
365 pF
C1
.01
C2
X1
X2
C3
.1
OUTPUT

L1 • LAFAYETTE #32-H-4108
L2 • 5 TURNS #20 WIRE WOUND AROUND CENTER OF L1
X1, X2 • 1N34A

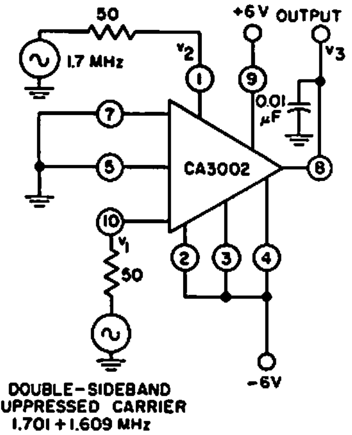
VOLTAGE-DOUBLER CRYSTAL SET—Gives best performance with crystal headphones or when connected to high-impedance input of audio amplifier. The longer the antenna, the louder the signal.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 64.


ANT
J1
C1 470
6AU5 V1
C4 .25μF
L1
PRI
SEC
C6 365
½6BN8 V2A
C9 470
½6BN8 V2B
C11
T2
PRI 5K
SEC 2Ω
L2 2.4 MH
R1 100K
R2 1000
C3 10μF 15V
C5 1000
R4 220K
R6 100K
C7 10μF 15V
R7 220K
C10 .01 μF
R9 220 1W
.047μF 600V
C2 1000
R3 500K VOL CONTROL
C8 .01μF
R5 68K
R8 1MEG
V1
V2
CABLE HARNESS
yel
v-blk
blk
red/or-v
pink
brn
TO P1 (POWER SUPPLY)
6.3 VAC HEATER
HEATER GND
GND B-
B+2
B+1
SPKR

TWO-TUBE BROADCAST-BAND REFLEX—First tube, V1, serves as r-f amplifier and then as a-f amplifier, to minimize number of components required. Article gives construction details, including those for a-c power supply required.—C. Green, Build Twofer-Flex, *Radio-TV Experimenter*, June—July 1969, p 37—41.

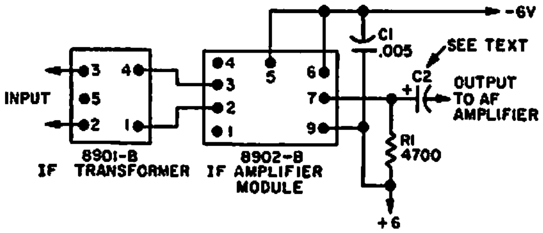

J2
SPKR
SPKR
8
5
B+1
4
B+2
D1
1N2070
R10
1000
2W
R11
10K
2W
T3
SEC
125V
50MA
C12A
40µF
150V
C12B
30µF
150V
C12C
20µF
150V
F1
1A
I1
6.3 VAC
HEATER
3
SEC
6.3V
2A
HEATER
GND
2
C13
5000
S1
GND
B-
1
117 VAC

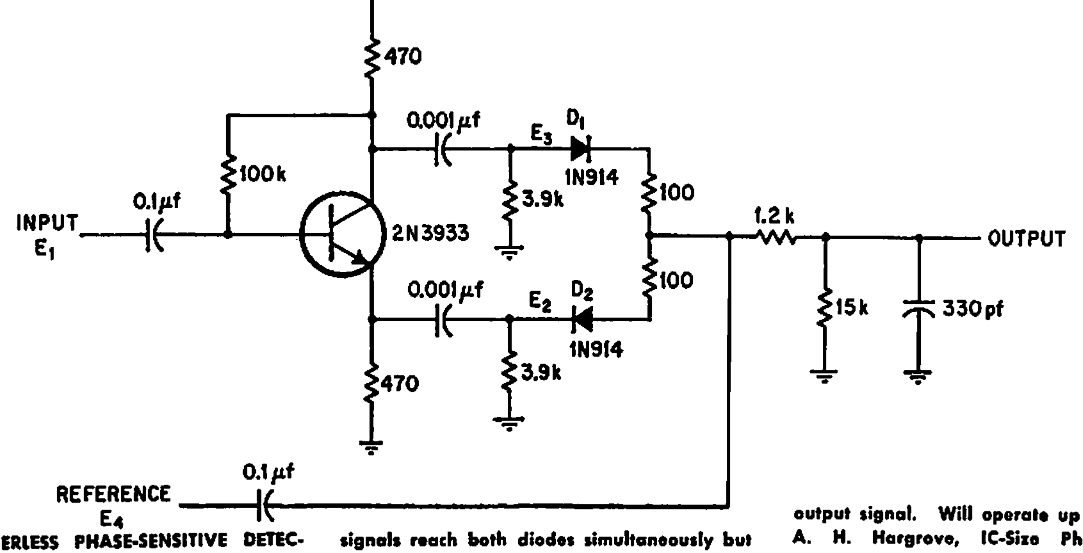
REFLEX-RECEIVER SUPPLY—Output terminals are numbered to correspond to those of two-tube broadcast-band reflex receiver shown in this chapter. Article gives construction details. I1 is NE-51H neon lamp.—C. Green, Build Twofer-Flex, *Radio-TV Experimenter*, June–July 1969, p 37–41.


50
1.7 MHz
V2
1
+6V
9
OUTPUT
V3
0.01
µF
7
5
CA3002
8
10
V1
50
2
3
4
-6V
DOUBLE-SIDEBAND
SUPPRESSED CARRIER
1.701+1.609 MHz

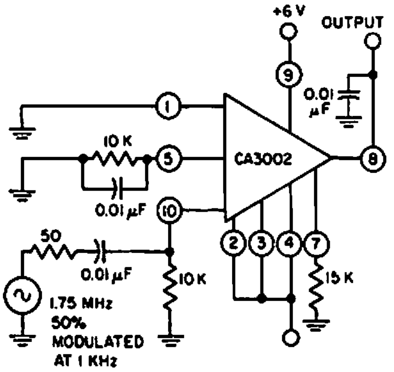
PRODUCT DETECTOR—Uses IC i-f amplifier with only three external components for handling suppressed-carrier signals. Output capacitor provides filtering for high-frequency components of oscillator signal at output. Gain is maximum for oscillator voltage range of 1 to 2 V.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 158.

IMPROVING SHORT-WAVE RECEIVER SELECTIVITY—Insertion of Miller 8902-B IC i-f strip, including detector, ahead of audio in budget-priced short-wave receiver boosts gain 100X (40 dB) and gives additional 18 dB of selectivity at 10 kHz. Receiver must have 455-kHz i-f. Will operate with either positive or negative grounds. Selectivity is greatly improved by using Miller 8901-B i-f transformer ahead of module. Article gives construction details and instructions for connecting to set. C2 is 0.01 µF.—H. Friedman, The 100Xer, *Elementary Electronics*, Mar.–Apr. 1970, p 43–48.

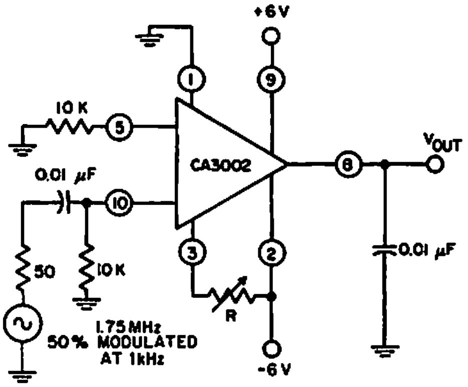

-6V
C1
.005
SEE TEXT
INPUT
3
4
5
2
1
4
3
2
1
5
6
7
9
C2
+
OUTPUT
TO AF
AMPLIFIER
R1
4700
8901-B
IF TRANSFORMER
8902-B
IF AMPLIFIER
MODULE
+6


+20v
470
100k
0.001µf
E3
D1
1N914
3.9k
100
INPUT
E1
0.1µf
2N3933
1.2k
OUTPUT
0.001µf
E2
D2
1N914
100
15k
330pf
3.9k
470
0.1µf
REFERENCE
E4

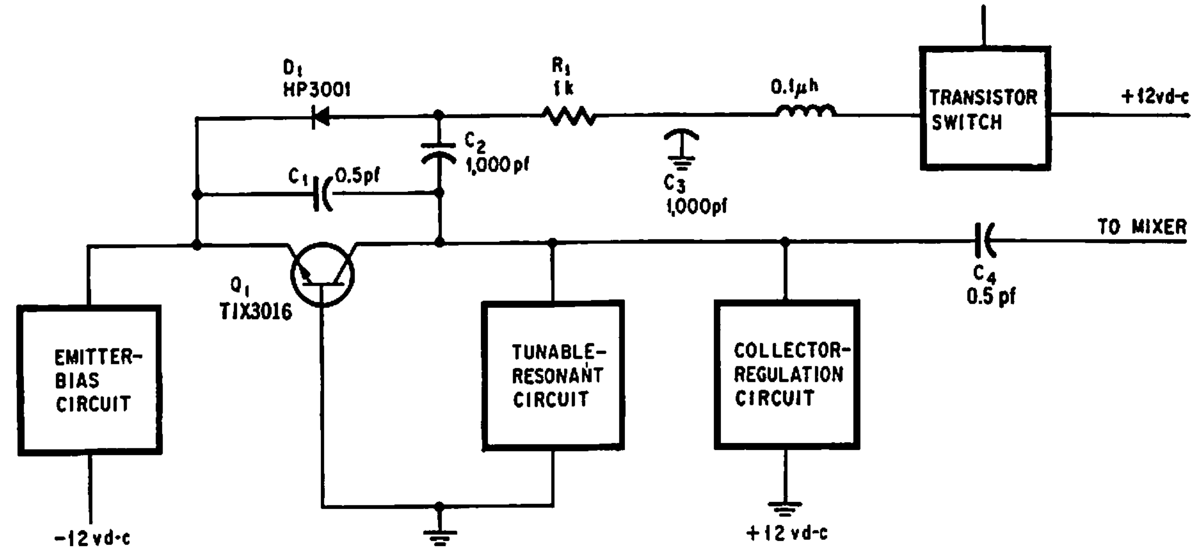
TRANSFORMERLESS PHASE-SENSITIVE DETECTOR—Extracts phase and amplitude modulation data from 20-MHz i-f signals. Incoming signals reach both diodes simultaneously but out of phase. Reference voltage combines with diode outputs by vector addition to give output signal. Will operate up to 30 MHz.—A. H. Hargrove, IC-Size Phase Detector Doesn't Need Any Inductors, *Electronics*, Aug. 4, 1969, p 91–92.


+6 V
OUTPUT
9
0.01 μF
1
10 K
5
CA3002
8
0.01 μF
10
50
0.01 μF
2
3
4
7
10 K
15 K
1.75 MHz
50%
MODULATED
AT 1 KHz

ENVELOPE DETECTOR—Uses IC i-f amplifier with fixed 15K resistor connected externally to reduce emitter current of output transistor, to give operating point providing required nonlinearity for detection of audio modulation signal. Distortion is below 3% for input signals from 12 to 60 mV.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 156.


+6V
1
9
10 K
5
CA3002
8
V_{OUT}
0.01 μF
10
3
2
50
10K
0.01 μF
R
1.75MHz
50% MODULATED
AT 1kHz
-6V

ENVELOPE DETECTOR—Operation of IC i-f amplifier with external connections shown gives envelope detector with distortion below 3% for input signals from 10 to 100 mV. Filter capacitor across output removes r-f signal from detected audio output.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 156.


D_1
HP3001
R_1
1k
0.1μh
TRANSISTOR SWITCH
+12vd-c
C_2
1,000pf
C_1
0.5pf
C_3
1,000pf
TO MIXER
C_4
0.5 pf
Q_1
TIX3016
EMITTER-BIAS CIRCUIT
TUNABLE-RESONANT CIRCUIT
COLLECTOR-REGULATION CIRCUIT
-12vd-c
+12 vd-c

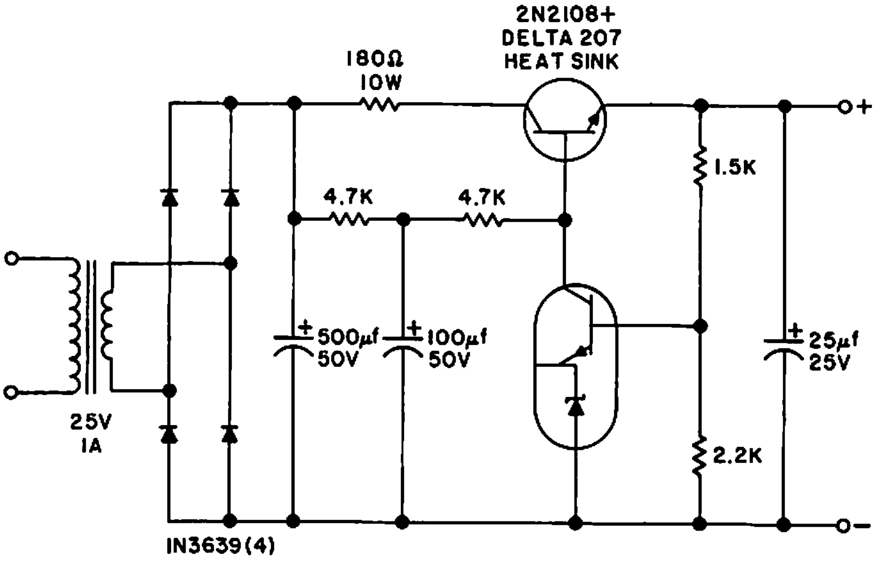
FAST-ON OSCILLATORS—Tunable oscillators in wide-spectrum communication equipment are kept in oscillation continuously to prevent transistor warmup delay, with p-i-n diode D1 shunting out signal until receiver is tuned to that band. When signal is desired, command signal is applied to transistor switch, restoring naturally high resistance of diode and providing oscillations within 50 ms.—A. Barone, P-I-N Diodes Turn On Microwave Bands Faster, *Electronics*, April 29, 1968, p 67.

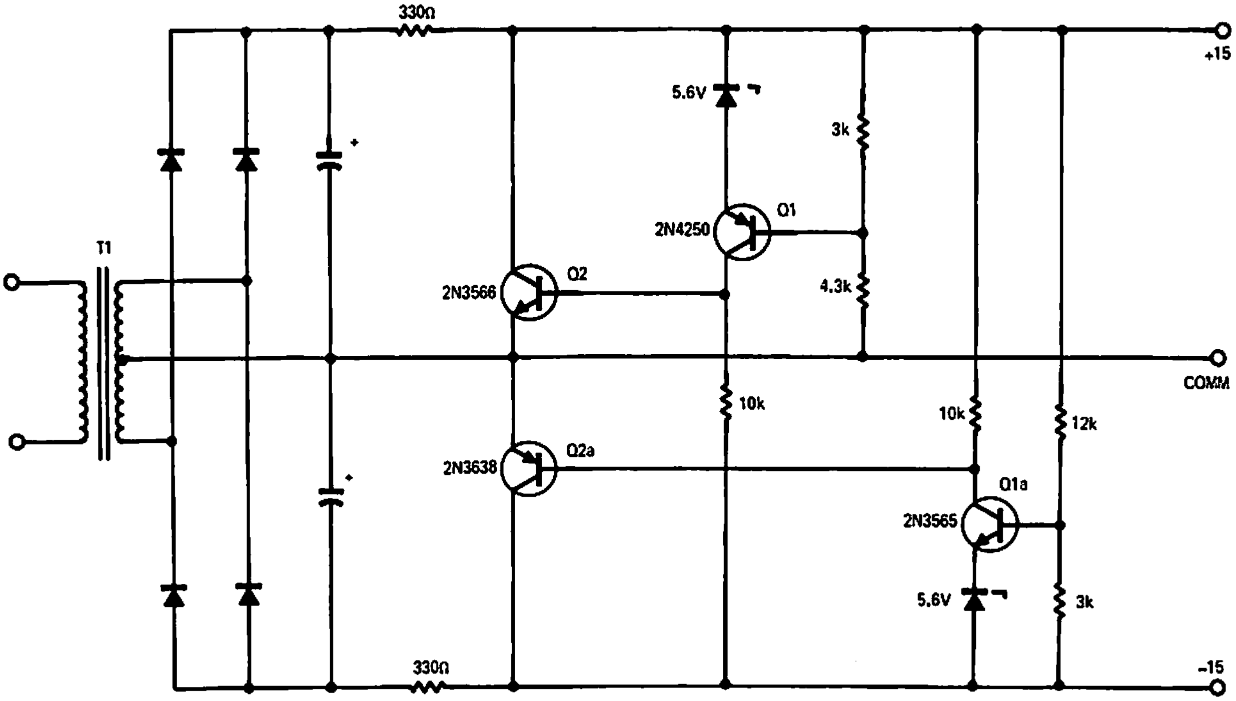
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 70

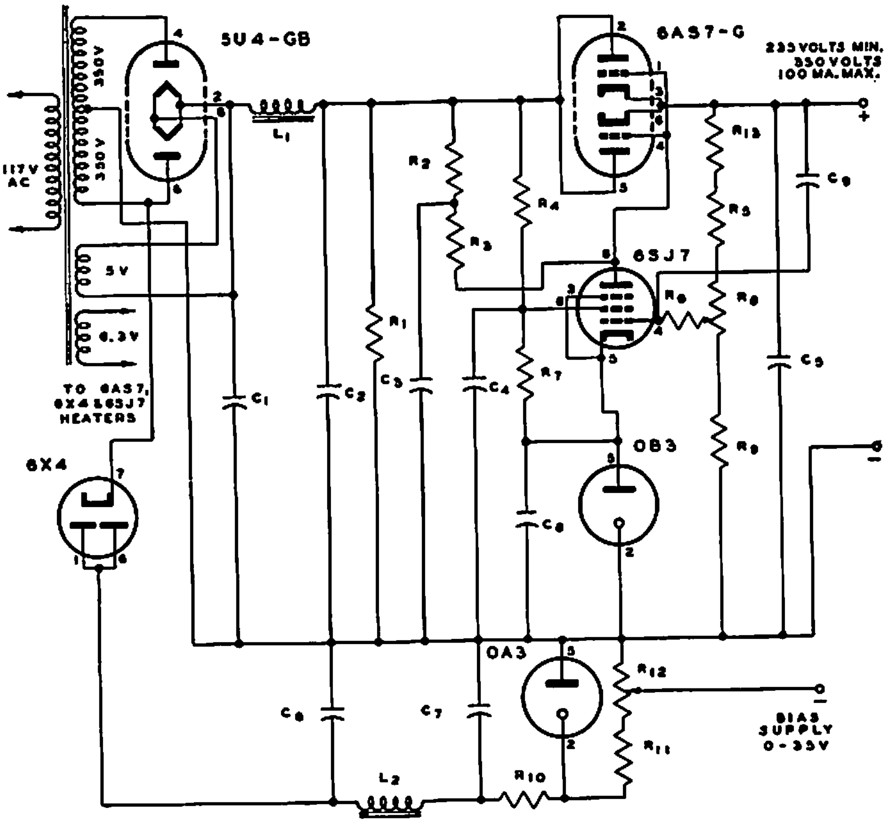
Regulated Power Supply Circuits

12 V AT 100 MA WITH REFERENCE AMPLIFIER—Uses zener and npn silicon transistor packaged together, such as RA-1 to RA-3B, to perform functions of voltage reference and error voltage amplifier for precision power supply. Output voltage regulation is better than 0.3% for line voltage variations of 10%. Output is 12 V at 100 mA.—T. P. Sylvan, An Integrated Reference Amplifier For Precision Power Supplies, General Electric, Syracuse, N.Y., No. 90.15, 1963.


2N2108+
DELTA 207
HEAT SINK
180Ω
10W
4.7K
4.7K
1.5K
500µf
50V
100µf
50V
25µf
25V
2.2K
25V
1A
IN3639(4)
+
−


330Ω
+15
5.6V
3k
2N4250
Q1
2N3566
Q2
4.3k
T1
COMM
10k
10k
12k
2N3638
Q2a
Q1a
2N3565
5.6V
3k
330Ω
-15

BIPOLAR 15 V—Provides sufficient power for up to four average-size IC's, delivering up to 25 mA with only 1-mV p-p ripple. Voltage regulation is within 0.2% for loads from 600 ohms to infinity and a-c line voltage changes from 105 to 125 V. Uses high-beta shunt regulator driven by current source Q1.—R. W. Forsberg, Shunt Regulator Has Optimized Gain, *EDN*, May 15, 1970, p 53.

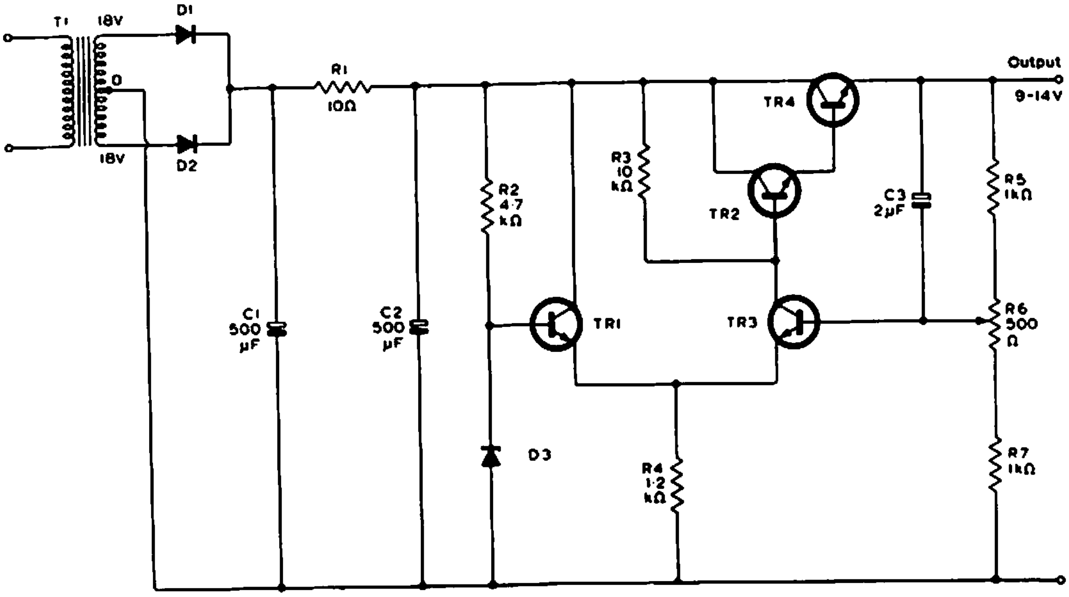

5U4-GB
6AS7-G
235 VOLTS MIN.
350 VOLTS
100 MA. MAX.
+
117V
AC
350V
350V
5V
6.3V
TO 6AS7,
6X4 & 6SJ7
HEATERS
L1
R2
R3
R4
R13
R5
R6
R8
R1
R7
R9
C1
C2
C3
C4
C5
C8
C9
6SJ7
0B3
6X4
0A3
R12
R11
R10
L2
C6
C7
BIAS
SUPPLY
0-35V
−

C_1 C_2—16 µf 600V
C_3 C_8—1 µf 600V
C_4—8 µf 450V
C_5—4 µf 600V
C_6 C_7—40 µf 450V
C_9—0.1 µf 600V

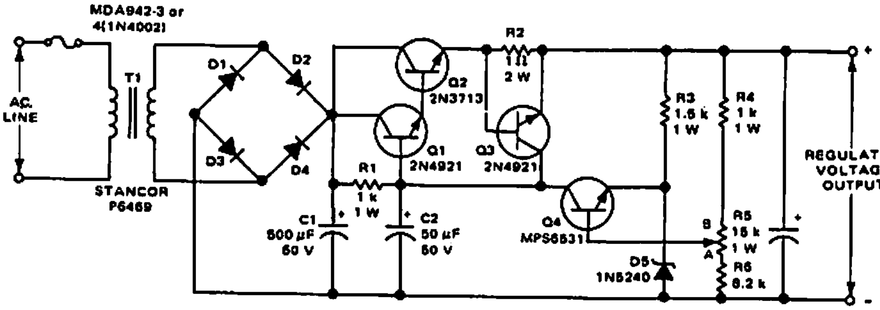
L_1—15 H 200 Ma
L_2—15 H 60 Ma
R_1—470 K
R_2 R_9 R_{13}—330 K
R_3—100 K
R_4—20 K 10 Watt

R_5 R_6—1 Meg
R_7—10 K 10 Watt
R_8—500 K Pot.
R_{10}—20 K 5 Watt
R_{11}—5 K 5 Watt
R_{12}—5 K Pot. 5 Watt

350 V AT 100 MA PLUS BIAS—All-tube version of series regulator uses separate diode for adjustable 0–35 V negative bias supply.—"Essential Characteristics," General Electric, Owensboro, Ky., 1969, p 348.

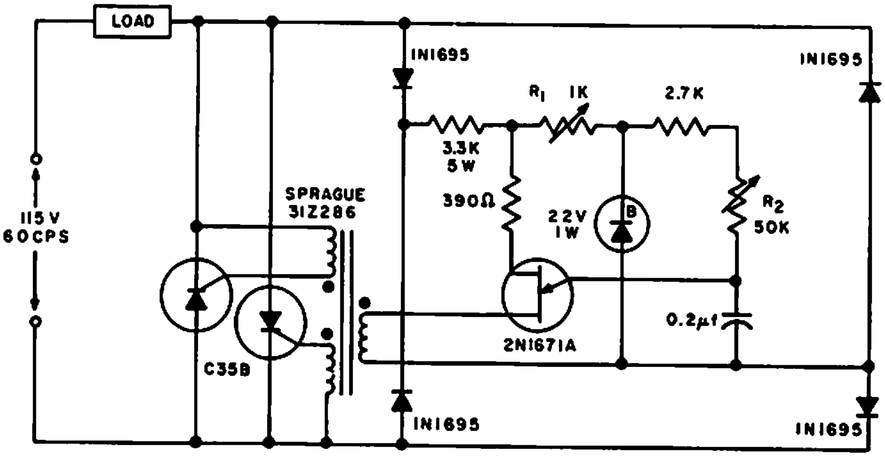

T1
18V
0
18V
D1
D2
R1
10Ω
C1
500
µF
C2
500
µF
R2
4·7
kΩ
D3
TR1
R3
10
kΩ
R4
1·2
kΩ
TR2
TR3
TR4
C3
2µF
R5
1kΩ
R6
500
Ω
R7
1kΩ
Output
9-14V

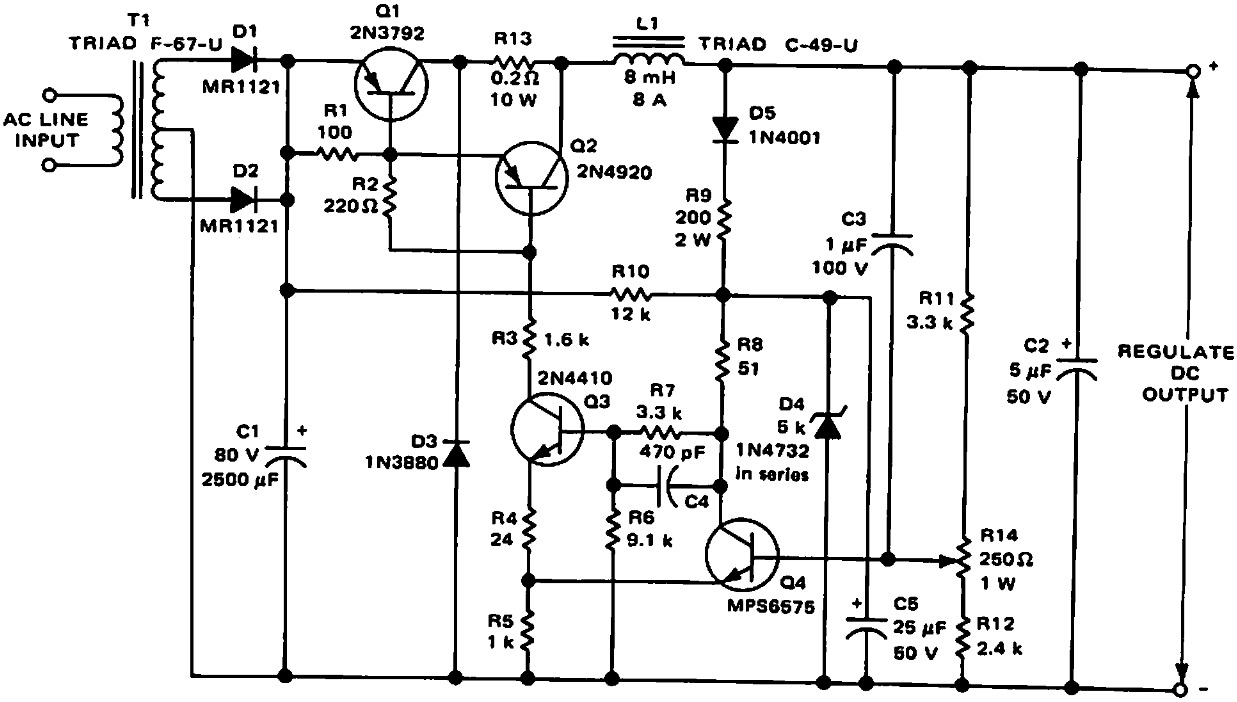
14 V WITH LONG-TAILED PAIR—Two of four BFY52 transistors are arranged as long-tailed-pair differential amplifier giving higher gain and better regulation than conventional three-transistor regulator. Changes in output current do not affect current or voltage of zener D3. Regulation is 1.5% over output voltage range of 9 to 14 V, with load currents up to 250 mA.—Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


MDA942-3 or 4(1N4002)
AC LINE
T1
STANCOR P6469
D1
D2
D3
D4
Q2 2N3713
Q1 2N4921
Q3 2N4921
R2 1Ω 2 W
R1 1 k 1 W
C1 500 µF 60 V
C2 50 µF 50 V
Q4 MPS6531
D5 1N5240
R3 1.5 k 1 W
R4 1 k 1 W
B
A
R5 15 k 1 W
R6 8.2 k
REGULATED VOLTAGE OUTPUT
+
-

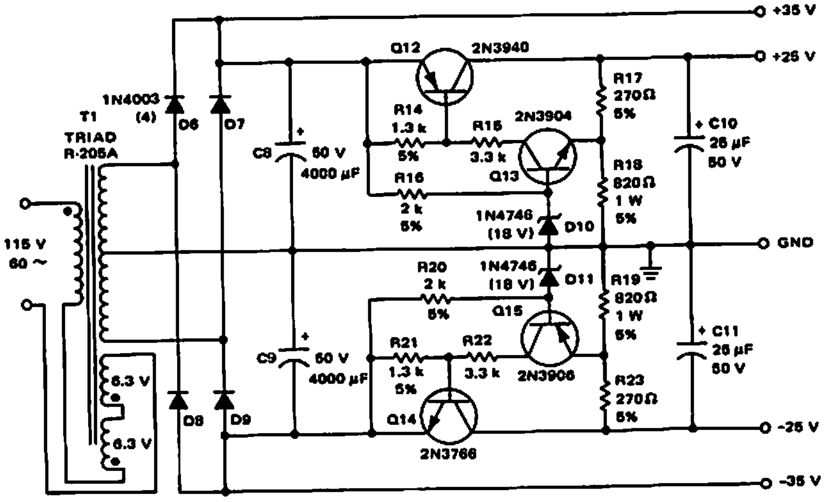
11–32 V D-C AT 700 MA—Use of series-pass regulators provides extremely good regulation, low ripple, and low output impedance, with excellent dynamic response. Can readily be adapted for remote voltage sensing, remote programming, and current-regulating or current-limiting applications. Overcurrent protection is provided by R2 and Q3.—G. V. Fay, Series-Pass Regulators, *Electronics World*, March 1969, p 48 and 78.

HIGH-POWER REGULATED A-C SUPPLY—Output current depends on ratings of scr's, and for those shown is 32 A (3.7 kW). Uses a-c phase control, with regulation for changes in line voltage. R1 makes peak voltage increase as line voltage increases, thereby retarding firing angle of scr's and reducing voltage applied to load. R1 can be adjusted to hold load voltage constant for given variation in line voltage. R2 determines output voltage. Size and cost are only one-tenth of comparable constant-voltage transformer and Variac.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 79.

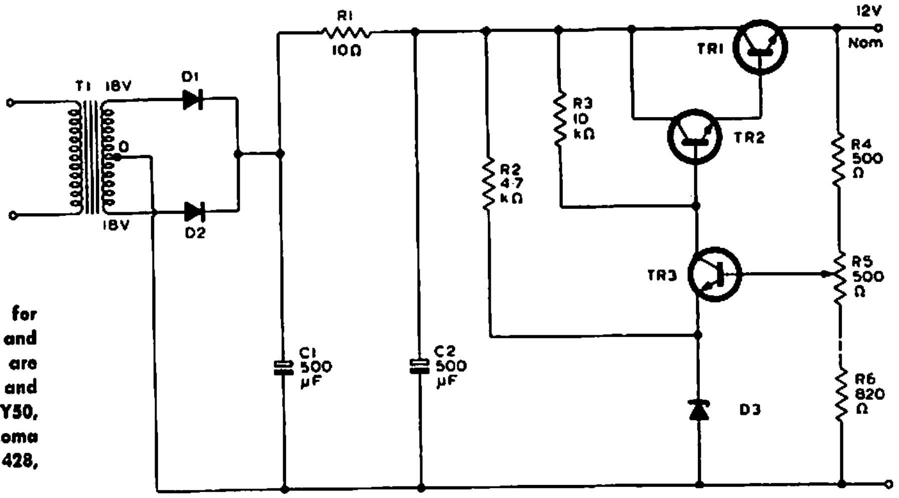

LOAD
115 V 60 CPS
IN1695
IN1695
IN1695
IN1695
R1 1K
2.7K
3.3K 5W
390Ω
22V 1W
R2 50K
SPRAGUE 31Z286
C35B
2N1671A
0.2µf


T1 TRIAD F-67-U
AC LINE INPUT
D1 MR1121
D2 MR1121
Q1 2N3792
R1 100
R2 220Ω
Q2 2N4920
R13 0.2Ω 10 W
L1 8 mH 8 A
TRIAD C-49-U
D5 1N4001
R9 200 2 W
C3 1 µF 100 V
R10 12 k
R3 1.6 k
2N4410 Q3
R7 3.3 k
470 pF
C4
R8 51
D4 6 k 1N4732 in series
R11 3.3 k
C2 5 µF 50 V
REGULATED DC OUTPUT
C1 80 V 2500 µF
D3 1N3880
R4 24
R6 9.1 k
Q4 MPS6575
R14 250Ω 1 W
C6 25 µF 50 V
R12 2.4 k
R5 1 k
+
-

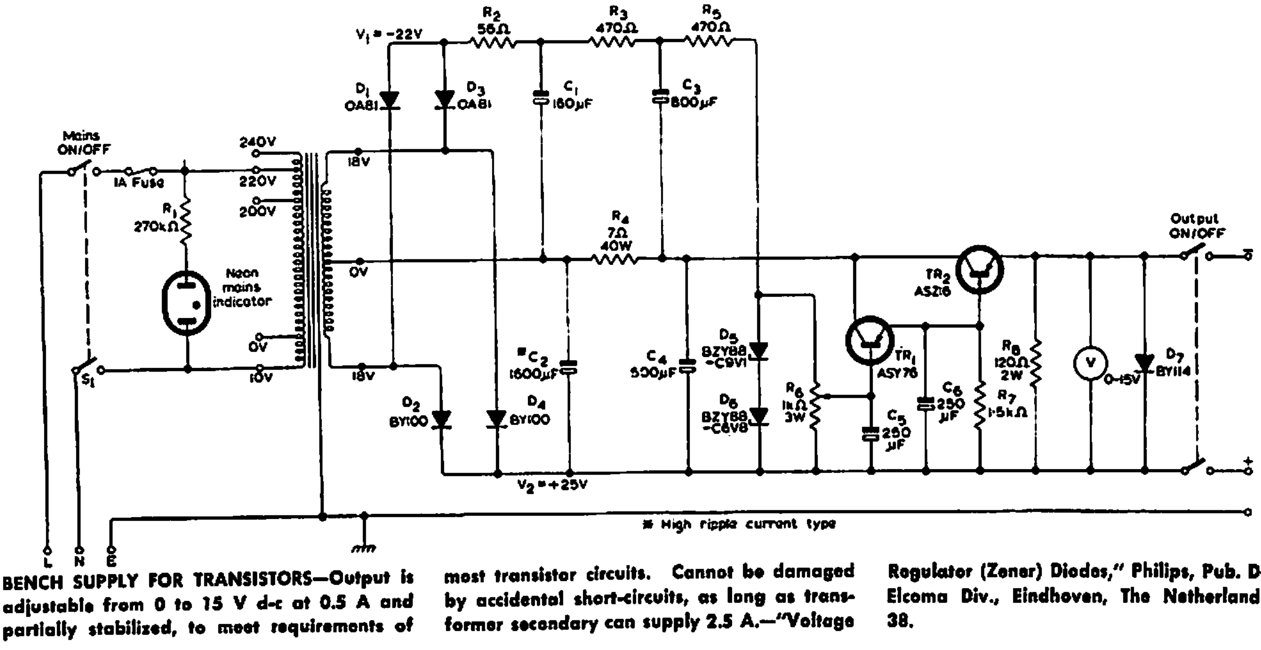
38-V D-C PWM SWITCHING PREREGULATOR—Uses voltage-sensing property of Schmitt trigger Q3-Q4 to provide drive for Darlington series switch Q1-Q2. With values shown, operating frequency is about 16.5 kHz and is essentially constant from no load to full load of 5 A. Output voltage drops only about 150 mV below 38 V at full load.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–21.


+35 V
+25 V
GND
-25 V
-35 V
115 V
60 ~
T1
TRIAD
R-205A
1N4003
(4)
D6
D7
D8
D9
6.3 V
6.3 V
C8
50 V
4000 µF
C9
50 V
4000 µF
Q12
2N3940
R14
1.3 k
5%
R15
3.3 k
2N3904
Q13
R16
2 k
5%
1N4746
(18 V)
D10
R17
270Ω
5%
R18
820Ω
1 W
5%
C10
25 µF
50 V
R20
2 k
5%
1N4746
(18 V)
D11
Q15
R19
820Ω
1 W
5%
R21
1.3 k
5%
R22
3.3 k
2N3906
Q14
2N3766
R23
270Ω
5%
C11
25 µF
50 V

AUDIO AMPLIFIER TEST SUPPLY—Developed for testing 50-W audio amplifiers. Provides filtered but unregulated 35-V outputs of both polarities for output transistors and zener-regulated 25 V for input stages. Two 6.3-V windings are used as bucking voltages because secondary voltage of transformer was too high. Both positive and negative supplies should come on at same time, to prevent damage to transistors if power is applied to only one side.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5—50.

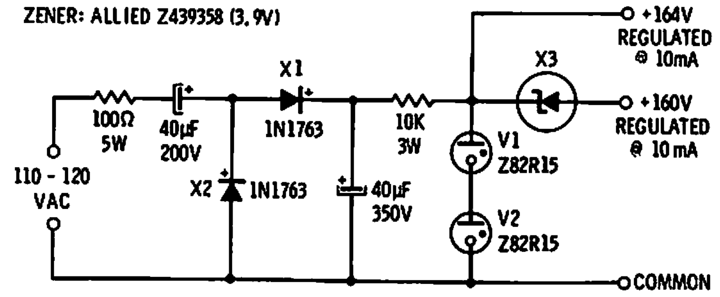

T1
18V
18V
0
D1
D2
R1
10Ω
C1
500
µF
C2
500
µF
R2
4·7
kΩ
R3
10
kΩ
TR1
TR2
TR3
D3
12V
Nom
R4
500
Ω
R5
500
Ω
R6
820
Ω

14-V ADJUSTABLE—Gives 2% regulation for output voltage range of 9.5 to 14 V d-c and up to 250 mA load. All transistors are BFY52, diodes D1 and D2 are BY100, and D3 is OAZ202.—Applications of the BFY50, BFY51 and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


V_1 = -22V
R_2
56Ω
R_3
470Ω
R_5
470Ω
D_1
OA81
D_3
OA81
C_1
160µF
C_3
800µF
Mains
ON/OFF
1A Fuse
240V
220V
200V
0V
10V
18V
0V
18V
R_1
270kΩ
Neon
mains
indicator
S_1
R_4
7Ω
40W
*C_2
1600µF
D_2
BY100
D_4
BY100
C_4
500µF
D_5
BZY88
-C9V1
D_6
BZY88
-C6V8
R_6
1kΩ
3W
TR_1
ASY76
C_5
250
µF
C_6
250
µF
TR_2
ASZ16
R_7
1·5kΩ
R_8
120Ω
2W
V
0-15V
D_7
BY114
Output
ON/OFF
-
+
V_2 = +25V
L
N
E

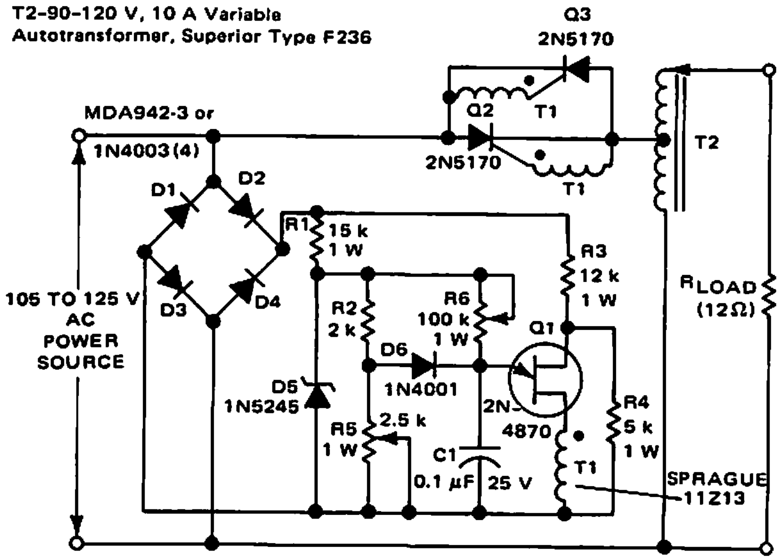
* High ripple current type

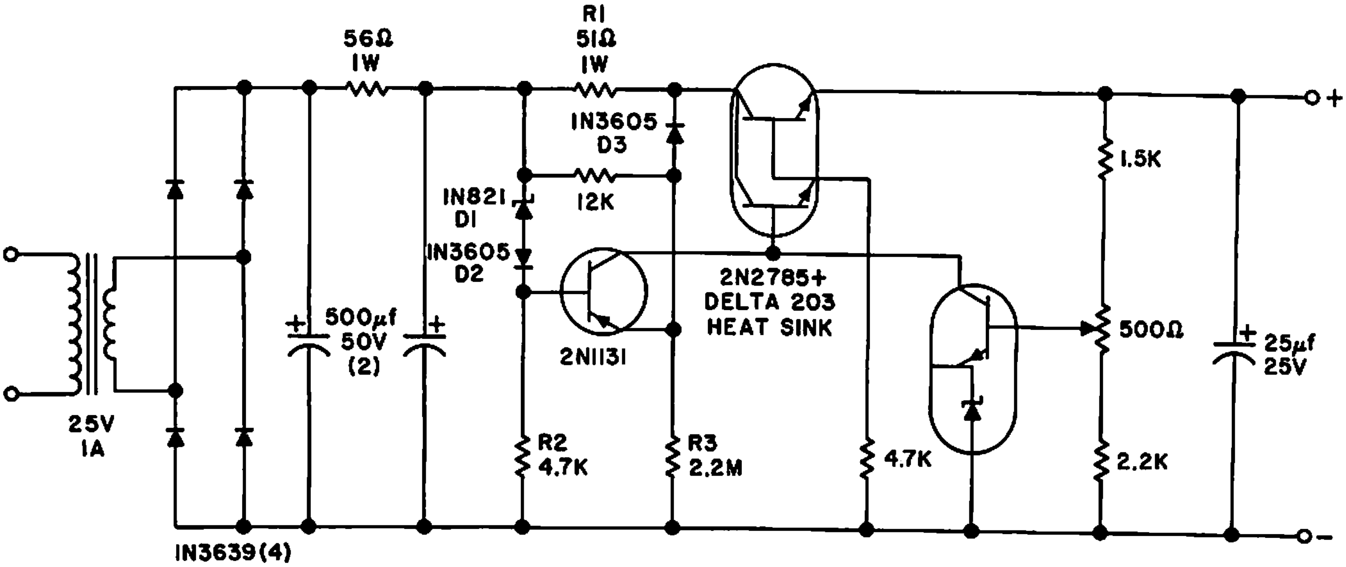
BENCH SUPPLY FOR TRANSISTORS—Output is adjustable from 0 to 15 V d-c at 0.5 A and partially stabilized, to meet requirements of most transistor circuits. Cannot be damaged by accidental short-circuits, as long as transformer secondary can supply 2.5 A.—"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 38.


ZENER: ALLIED Z439358 (3.9V)
+164V REGULATED @ 10mA
X1
X3
100Ω 5W
40μF 200V
1N1763
10K 3W
+160V REGULATED @ 10mA
110 - 120 VAC
X2
1N1763
40μF 350V
V1 Z82R15
V2 Z82R15
COMMON

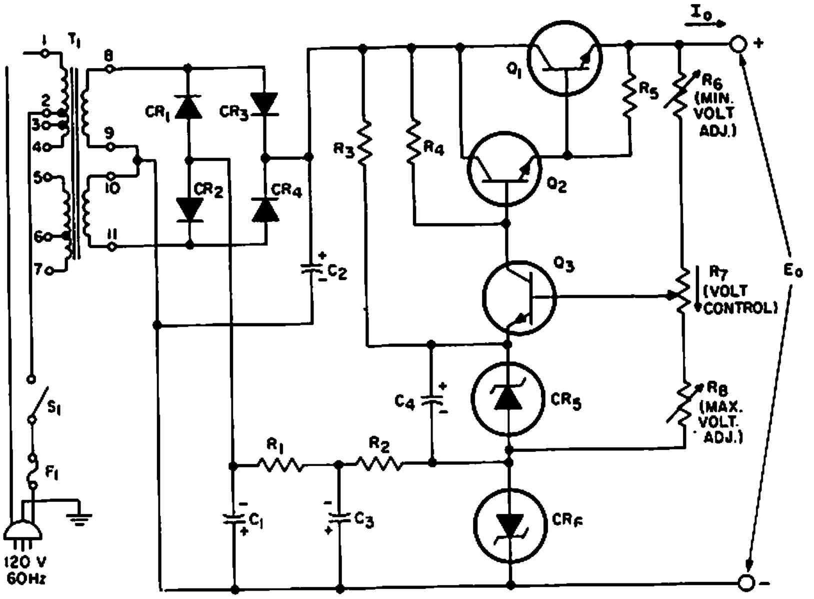
164-V NEON-REGULATED SUPPLY—Provides two stable voltages at low current, for applications such as counters, oscillators, and timers. Consists of half-wave voltage doubler, neon regulator, and zener diode.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 80.

120-V A-C REGULATOR—Circuit holds voltage across 12-ohm load within 2% of 120 V by regulating 90-V input to stepup transformer T2. Load current is 10 A. Circuit has no feedback, but regulation is provided by T2. Q2 and Q3 are both pulsed at same time by ujt Q1 through T1, but only the one that is forward-biased by supply voltage at that instant turns on. R5 and R6 interact and may require several adjustments after load change or supply voltage change, to keep load voltage exactly at 120 V.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–28.


T2-90-120 V, 10 A Variable Autotransformer, Superior Type F236
Q3 2N5170
MDA942-3 or 1N4003(4)
Q2
T1
2N5170
T1
T2
D1
D2
R1
15 k 1 W
R3 12 k 1 W
RLOAD (12Ω)
105 TO 125 V AC POWER SOURCE
D3
D4
R2 2 k
R6 100 k 1 W
Q1
D6
1N4001
D5 1N5245
R5 2.5 k 1 W
2N-4870
R4 5 k 1 W
C1 0.1 μF 25 V
T1
SPRAGUE 11Z13


56Ω IW
RI 51Ω IW
IN3605 D3
12K
IN821 DI
IN3605 D2
500μf 50V (2)
2N1131
2N2785+ DELTA 203 HEAT SINK
1.5K
500Ω
25μf 25V
+
25V IA
R2 4.7K
R3 2.2M
4.7K
2.2K
IN3639(4)
−

REFERENCE AMPLIFIER WITH DARLINGTON—Change in 12-V output voltage is less that 0.0001% for 10% change in a-c line voltage. Output current is 100 mA. 2N2785 Darlington is used as series regulator. R3 is adjusted to optimize regulation. Output impedance is 0.03 ohm, while ripple and noise at full load are below 10 μV.—T. P. Sylvan, An Integrated Reference Amplifier for Precision Power Supplies, General Electric, Syracuse, N.Y., No. 90.15, 1963.


1
T1
2
3
4
5
6
7
8
9
10
11
CR1
CR3
CR2
CR4
+
C2
R3
R4
Q1
Q2
Q3
I0
+
R5
R6 (MIN. VOLT ADJ.)
R7 (VOLT CONTROL)
E0
C4
CR5
R8 (MAX. VOLT. ADJ.)
S1
F1
R1
R2
C1
C3
CR6
120 V 60Hz
-

C_1C_3 = 500 microfarads, 25 volts, electrolytic

C_2 = 5000 microfarads, 25 volts, electrolytic

C_4 = 100 microfarads, 10 volts, electrolytic

$CR_1CR_2CR_3CR_4$ = silicon rectifier, RCA SK3030

CR_5 = zener diode, 6.8 volts, 1 watt

CR_6 = zener diode, 12 volts, 1 watt

F_1 = fuse, 1 ampere, 120 volts

Q_1 = transistor, RCA SK3027

Q_2Q_3 = transistor, RCA SK3020

R_1R_5 = 220 ohms, 1/2 watt, 10%

R_2 = 470 ohms, 1/2 watt, 10%

R_3 = 6800 ohms, 1/2 watt, 10%

R_4 = 10,000 ohms, 1/2 watt, 10%

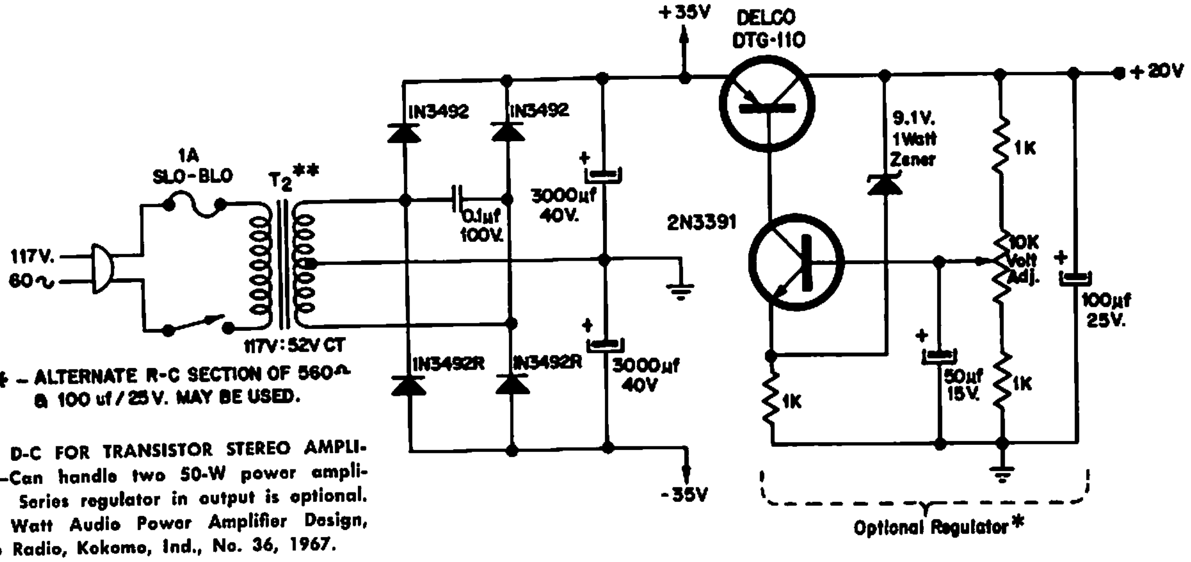
R_6 R_8 = trimmer potentiometer, 5000 ohms, Mallory MTC-1 or equivalent

R_7 = potentiometer, 5000 ohms, linear taper

S_1 = switch, 120 volts, 1 ampere, single-pole, single-throw

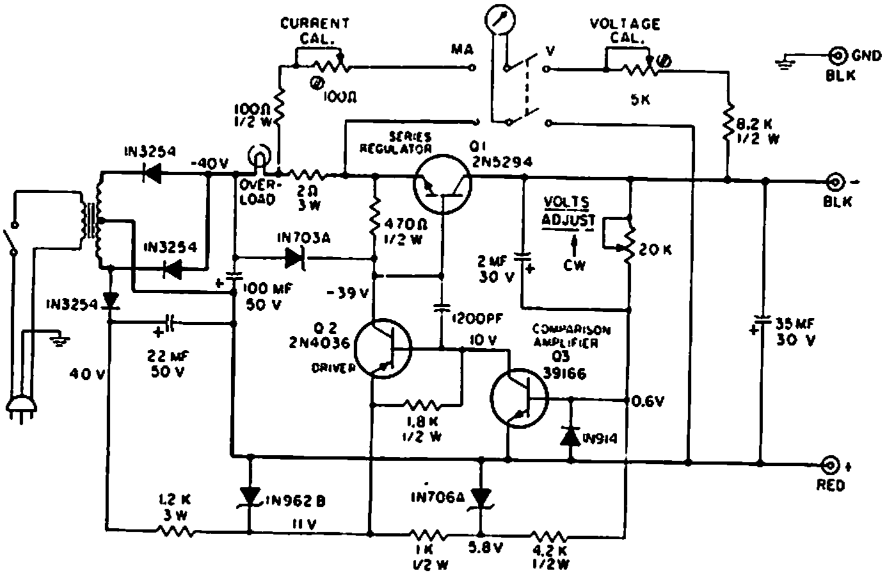
T_1 = transformer, primary 115 volts, secondary 15 volts, 1 ampere, Stancor No. TP-4 or equivalent

12-V VARIABLE-VOLTAGE—Full-range supply provides maximum of 1 A at any voltage up to 12 V, operating from a-c line. Regulator section uses two zeners connected in opposition.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 54.

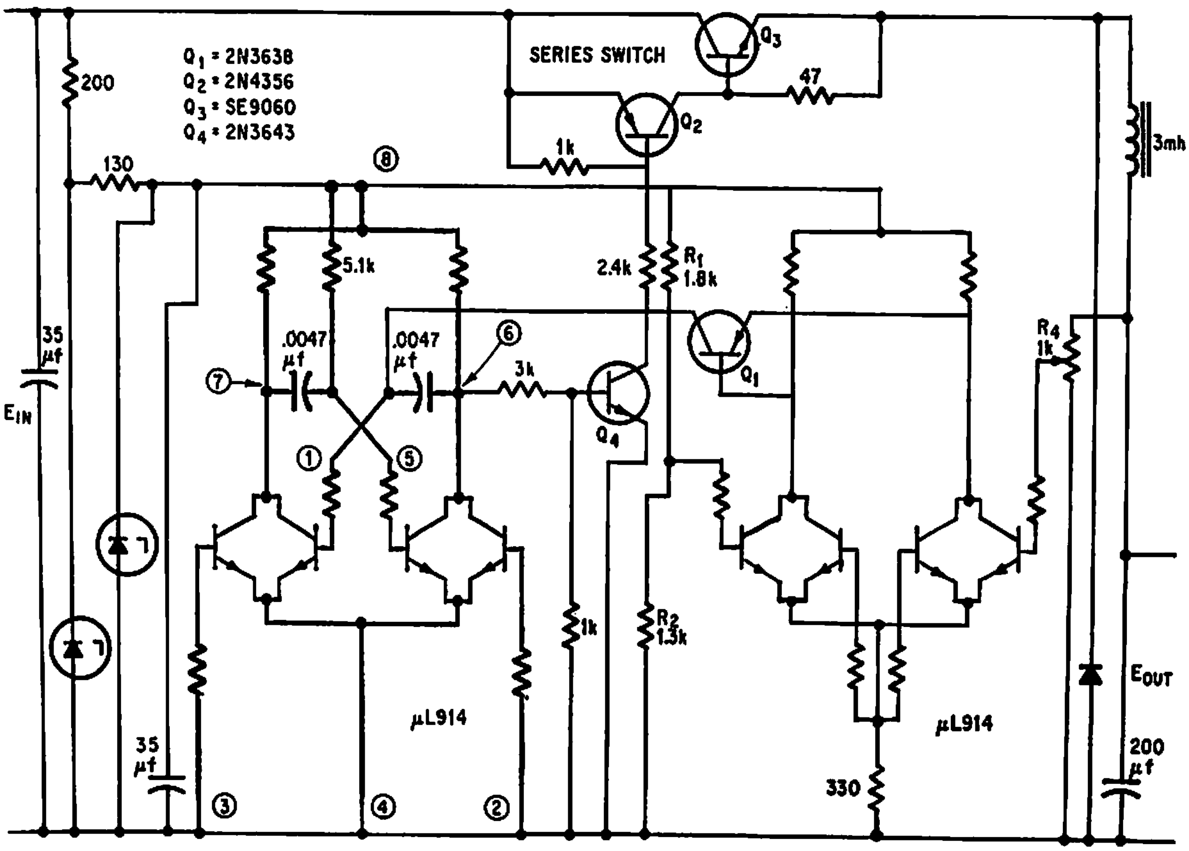

+35V
DELCO
DTG-110
+20V
IN3492
IN3492
1A
SLO-BLO
T2**
.01µf
100V.
+
3000µf
40V.
9.1V.
1Watt
Zener
1K
2N3391
10K
Volt
Adj.
+
100µf
25V.
117V.
60~
117V:52V CT
IN3492R
IN3492R
+
3000µf
40V
+
50µf
15V.
1K
1K
-35V
Optional Regulator*

* - ALTERNATE R-C SECTION OF 560Ω & 100 uf / 25V. MAY BE USED.

20-V D-C FOR TRANSISTOR STEREO AMPLIFIER—Can handle two 50-W power amplifiers. Series regulator in output is optional.—50 Watt Audio Power Amplifier Design, Delco Radio, Kokomo, Ind., No. 36, 1967.

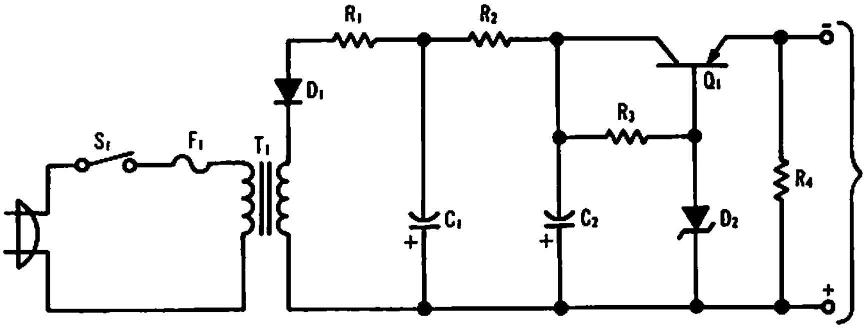

CURRENT CAL.
100Ω
MA
V
VOLTAGE CAL.
5K
GND BLK
100Ω 1/2 W
8.2 K 1/2 W
SERIES REGULATOR
Q1 2N5294
1N3254
-40V
OVER-LOAD
2Ω 3 W
470Ω 1/2 W
VOLTS ADJUST
CW
20K
- BLK
1N703A
1N3254
100 MF 50 V
-39V
2 MF 30 V
1200PF 10 V
Q2 2N4036 DRIVER
COMPARISON AMPLIFIER Q3 39166
35 MF 30 V
1N3254
22 MF 50 V
40 V
1.8 K 1/2 W
0.6V
1N914
+ RED
1N962 B 11 V
1N706A
1.2 K 3 W
1 K 1/2 W
5.8V
4.2 K 1/2W

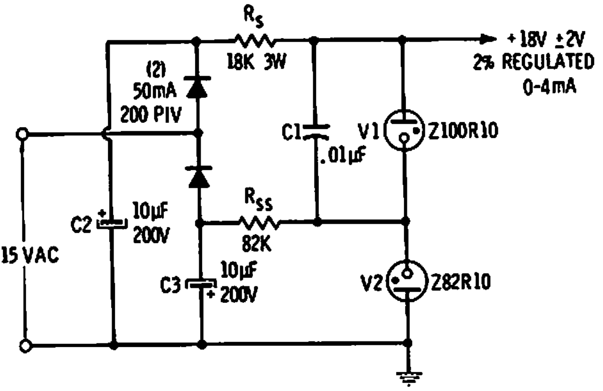
0–20 V AT 20 MA—Commercially available at $48 for single output or $87 for two identical units sharing common power transformer. Overload-indicator lamps glow brightly when output current appreciably exceeds full rated load of 200 mA. Output is continuously adjustable down to zero, with negative-feedback regulator circuit maintaining constant voltage with low ripple at any setting, regardless of variations in load or a-c line voltage.—RCA Models WP-700A, WP-702A Power Supplies, *Electronics World*, March 1969, p 68–69.


Q1 = 2N3638
Q2 = 2N4356
Q3 = SE9060
Q4 = 2N3643
SERIES SWITCH
Q3
47
Q2
200
130
1k
⑧
2.4k
R1 1.8k
5.1k
35 µf
EIN
.0047 µf
.0047 µf
⑥
3k
⑦
Q1
Q4
①
⑤
R4 1k
3mh
1k
R2 1.3k
µL914
µL914
EOUT
35 µf
200 µf
330
③
④
②

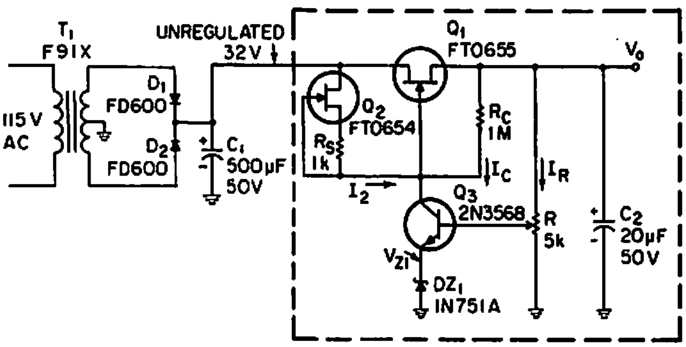
10-V IC SWITCHING REGULATOR—Two RTL AND gates, one used as differential amplifier and the other as astable mvbr, give load regulation of 0.2% from no load to 1 A for output of 10 V. Output ripple is less than 20 mV p-p. Differential amplifier (at right) operates as error detector by sensing difference between reference voltage set by R1-R2 and output voltage tapped by R4. Amplifier then produces error current from Q1 that changes duty cycle of IC mvbr at left and series switch Q3.—M. English, Voltage Regulator Built From Two AND Gates, *Electronics*, Dec. 23, 1968, p 57.

10 V at 250 MA—Furnishes well-filtered and stable voltage, for any transistor circuit requiring 9 to 10 V. Article gives construction details. Parts values are: R1 1; R2 2.4; R3 150; R4 200; C1-C2 500 µF; D1 HEP154; D2 HEP101; Q1 HEP230; F1 0.25 A; T1 117 V:12.6 V Triad F-25X.—"Solid State Projects Manual," Motorola, Phoenix, Ariz., 1968, p 41–43.

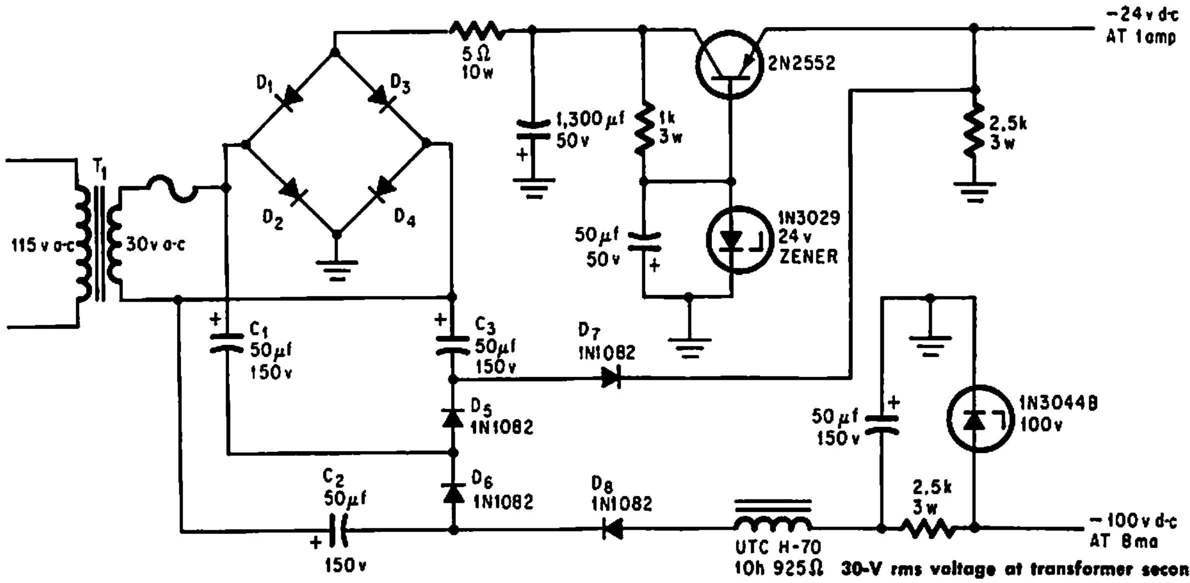

R1
R2
D1
S1
F1
T1
Q1
R3
R4
C1
C2
D2
+
+
-
+


RS
18K 3W
+18V ±2V
2% REGULATED
0-4mA
(2)
50mA
200 PIV
C1
.01µF
V1
Z100R10
C2
10µF
200V
RSS
82K
115 VAC
C3
10µF
200V
V2
Z82R10

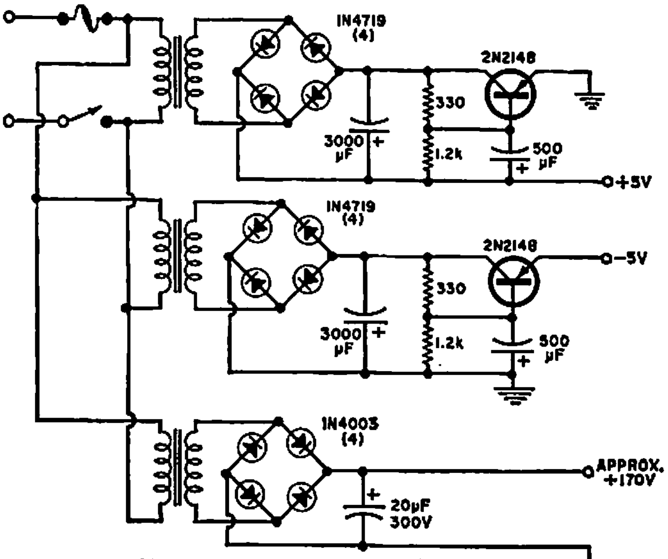
LOW-VOLTAGE NEON REGULATOR—18-V reference is achieved at output by algebraic addition of negative 100-V maintaining voltage of V1 to positive 82 V of V2. Regulator features common ground and is accurate over wide temperature range.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 34.


T1
F91X
UNREGULATED
32V
Q1
FT0655
V0
D1
FD600
115V
AC
Q2
FT0654
RS
1k
RC
1M
D2
FD600
C1
500µF
50V
IC
IR
I2
Q3
2N3568
R
5k
C2
20µF
50V
VZ1
DZ1
1N751A

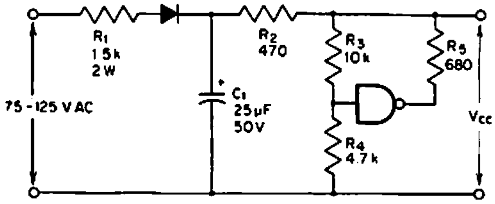
20 V AT 100 MA—Provides 0.5% regulation and short-circuit protection at parts cost under $10. To convert to negative supply, change both n-channel fet's to p-channel and change Q3 to pnp transistor.—H. Wu, Designing Power Supplies with FETs, *EEE*, Dec. 1968, p 68–69.


−24 v d-c
AT 1amp
5Ω
10w
2N2552
D1
D3
1,300µf
50v
1k
3w
2.5k
3w
T1
D2
D4
115 v a-c
30v a-c
50µf
50v
1N3029
24 v
ZENER
C1
50µf
150v
C3
50µf
150v
D7
1N1082
D5
1N1082
50µf
150v
1N3044B
100v
C2
50µf
150v
D6
1N1082
D8
1N1082
2.5k
3w
UTC H-70
10h 925Ω
−100v d-c
AT 8ma

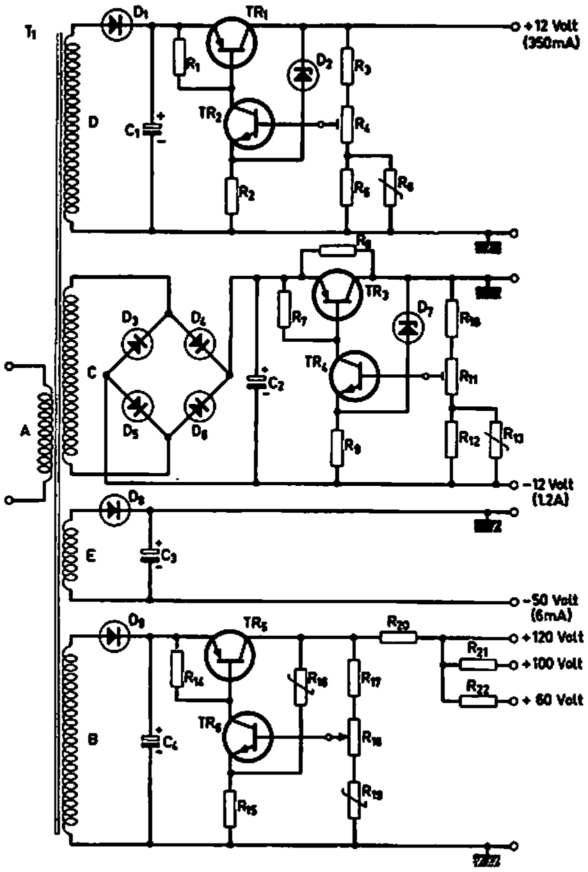
24 and 100 V WITH DIODE MULTIPLIERS—Can provide one output in range of 100 to 200 V and another below 50 V with single transformer secondary. Each capacitor-diode multiplier boosts no-load d-c output of previous stage an amount equal to 1.4 times 30-V rms voltage at transformer secondary.—M. E. Converse, Multiplier Stages Replace Power-Supply Transformer, *Electronics*, Dec. 9, 1968, p 84.


1N4719
(4)
2N2148
330
3000 µF
1.2k
500 µF
+5V
1N4719
(4)
2N2148
-5V
330
3000 µF
1.2k
500 µF
1N4003
(4)
APPROX. +170V
20µF
300V

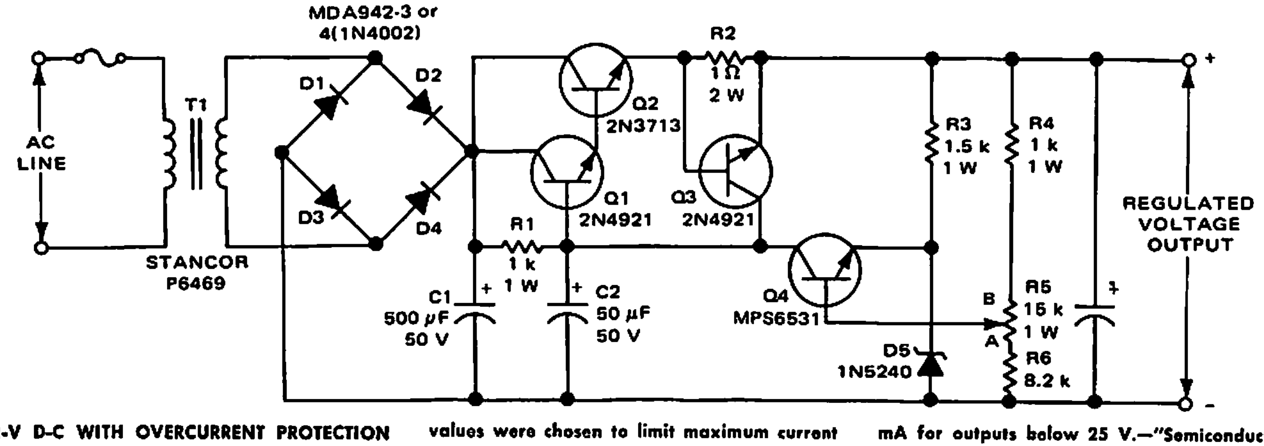
DIGITAL COUNTER SUPPLIES—Isolation transformer is used in 170-V supply, and 6.3-V 3-A filament transformers in the 5-V supplies for precision 50-MHz CB frequency monitor.—F. E. Cody, A 50-MHz Digital Counter, *Electronics World*, March 1969, p 40–42 and 61.


R1
15k
2W
R2
470
R3
10k
R5
680
75 - 125 V AC
C1
25µF
50V
R4
4.7k
Vcc

12 V D-C FROM A-C LINE—Unused gate in Amelco 303CJ multiple-gate IC may be connected as shown to provide regulated 12 V d-c for digital IC and reed relay. Other NAND or NOR gates could be used as well. Will provide up to 10 mA.—B. Horn, Spare IC Gate Serves as Regulator, *EEE*, Feb. 1970, p 115–116.

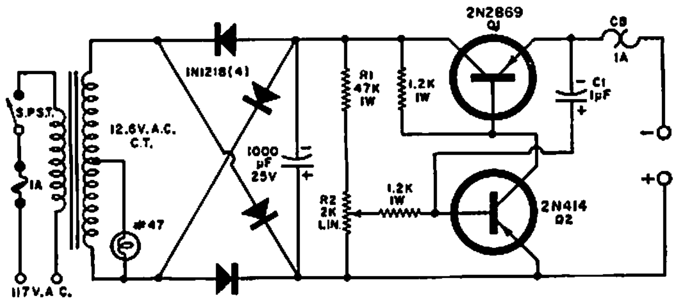

T1
D1
TR1
+12 Volt
(350mA)
R1
D2
R3
D
C1
TR2
R4
R2
R5
R6
R8
TR3
D3
D4
R7
D7
R10
C
C2
TR4
R11
A
D5
D6
R9
R12
R13
-12 Volt
(1.2A)
D8
E
C3
-50 Volt
(6mA)
D9
TR5
R20
+120 Volt
R21
+100 Volt
R14
R16
R17
R22
+60 Volt
TR6
B
C4
R18
R19
R15

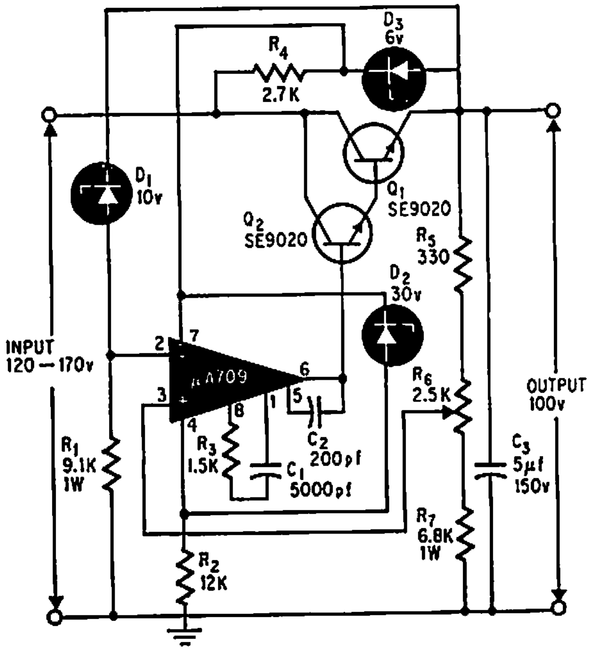
DESK CALCULATOR SUPPLY—Report gives design procedure for meeting power supply requirements for various types of small transistorized calculators, with one circuit as example. Intended for operation from 220-V 50-Hz line, but transformer winding data in report can readily be adjusted for 120-V operation. Provides 3% stabilization for 12-V outputs, and 8% stabilization for higher outputs. Series regulators are used with zeners and voltage-dependent resistors in low-voltage supplies.—A. P. Tanis, Design of Power Supply Units for Electronic Calculators, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 833, 1967.


MDA942-3 or
4(1N4002)
R2
1 Ω
2 W
+
D1
D2
T1
Q2
2N3713
AC
LINE
R3
1.5 k
1 W
R4
1 k
1 W
Q1
2N4921
Q3
2N4921
REGULATED
VOLTAGE
OUTPUT
D3
D4
R1
1 k
1 W
STANCOR
P6469
C1
500 µF
50 V
C2
50 µF
50 V
Q4
MPS6531
B
R5
15 k
1 W
A
D5
1N5240
R6
8.2 k
-

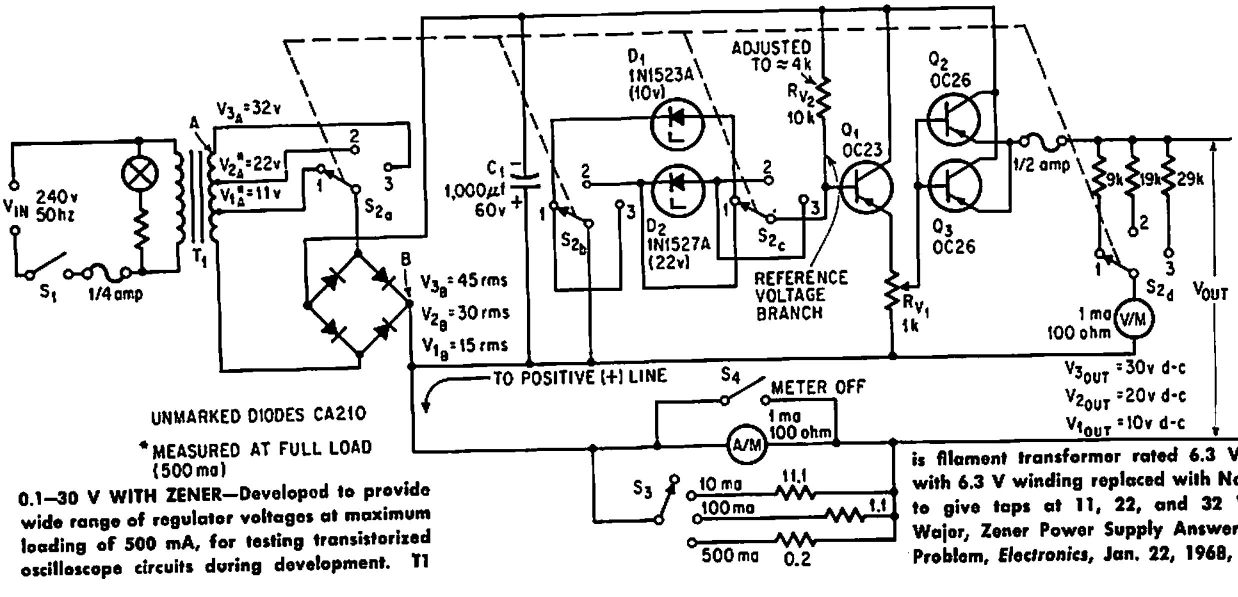
32-V D-C WITH OVERCURRENT PROTECTION—Output voltage is adjustable over range of 11 to 32 V by R5, with overcurrent protection provided by R2 and Q3. Circuit values were chosen to limit maximum current to about 700 mA, which means that voltage regulation is degraded for loads above 500 mA at higher output voltages and above 600 mA for outputs below 25 V.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–12.

12-V 500-MA CONTINUOUSLY VARIABLE—Ripple is below 1%. CB is circuit breaker used in tv receivers. Almost any lower-level pnp transistor can be substituted for the 2N-414.—M. S. Rifkin, Variable Low-Voltage Power Supply, *Electronics World*, Oct. 1967, p 79.


S.P.S.T.
1A
117 V.A.C.
12.6V.A.C.
C.T.
#47
1N1218(4)
1000 µF
25V
R1
47K
1W
1.2K
1W
R2
2K
LIN.
1.2K
1W
2N2869
Q1
CB
1A
C1
1µF
2N414
Q2
−
+


D3
6v
R4
2.7K
D1
10v
Q1
SE9020
Q2
SE9020
R5
330
D2
30v
INPUT
120 — 170v
2
7
µA709
6
3
4
8
1
5
R3
1.5K
C1
5000pf
C2
200pf
R6
2.5K
OUTPUT
100v
C3
5µf
150v
R1
9.1K
1W
R7
6.8K
1W
R2
12K

100 V D-C FROM A-C LINE—Modified bootstrap arrangement, with Fairchild µA709 opamp as control element, gives regulation better than 0.01% for output adjustment range of 60 V below maximum. Power transistors are used. Article contains 13 other IC opamp application circuits. D1, D2, and D3 are zeners.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.

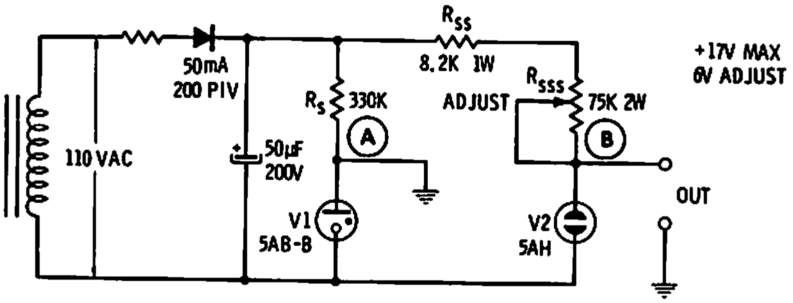

V$_{IN}$ 240v 50hz
S$_1$
1/4 amp
T$_1$
A
V$_{3_A}$=32v
V$_{2_A}$*=22v
V$_{1_A}$*=11v
S$_{2_a}$
B
V$_{3_B}$=45 rms
V$_{2_B}$=30 rms
V$_{1_B}$=15 rms
C$_1$
1,000µf
60v
S$_{2_b}$
D$_1$
1N1523A
(10v)
D$_2$
1N1527A
(22v)
S$_{2_c}$
ADJUSTED
TO ≈ 4k
R$_{V_2}$
10k
Q$_1$
OC23
REFERENCE
VOLTAGE
BRANCH
R$_{V_1}$
1k
Q$_2$
OC26
Q$_3$
OC26
1/2 amp
9k
19k
29k
S$_{2_d}$
1 ma
100 ohm
V/M
V$_{OUT}$
V$_{3_{OUT}}$=30v d-c
V$_{2_{OUT}}$=20v d-c
V$_{1_{OUT}}$=10v d-c
TO POSITIVE (+) LINE
S$_4$
METER OFF
1 ma
100 ohm
A/M
S$_3$
10 ma
11.1
100 ma
1.1
500 ma
0.2

UNMARKED DIODES CA210

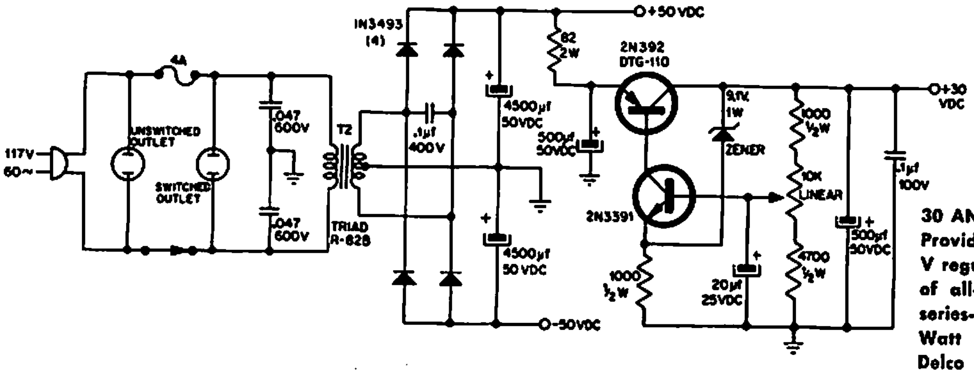
*MEASURED AT FULL LOAD (500 ma)

0.1–30 V WITH ZENER—Developed to provide wide range of regulator voltages at maximum loading of 500 mA, for testing transistorized oscilloscope circuits during development. T1 is filament transformer rated 6.3 V at 9 A, with 6.3 V winding replaced with No. 22 wire to give taps at 11, 22, and 32 V.—B. M. Wajer, Zener Power Supply Answers Current Problem, *Electronics*, Jan. 22, 1968, p 71–72.

DIFFERENTIAL LOW-VOLTAGE REFERENCE—Output voltage is difference between maintaining voltages of neon lamps at points A and B.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 32.

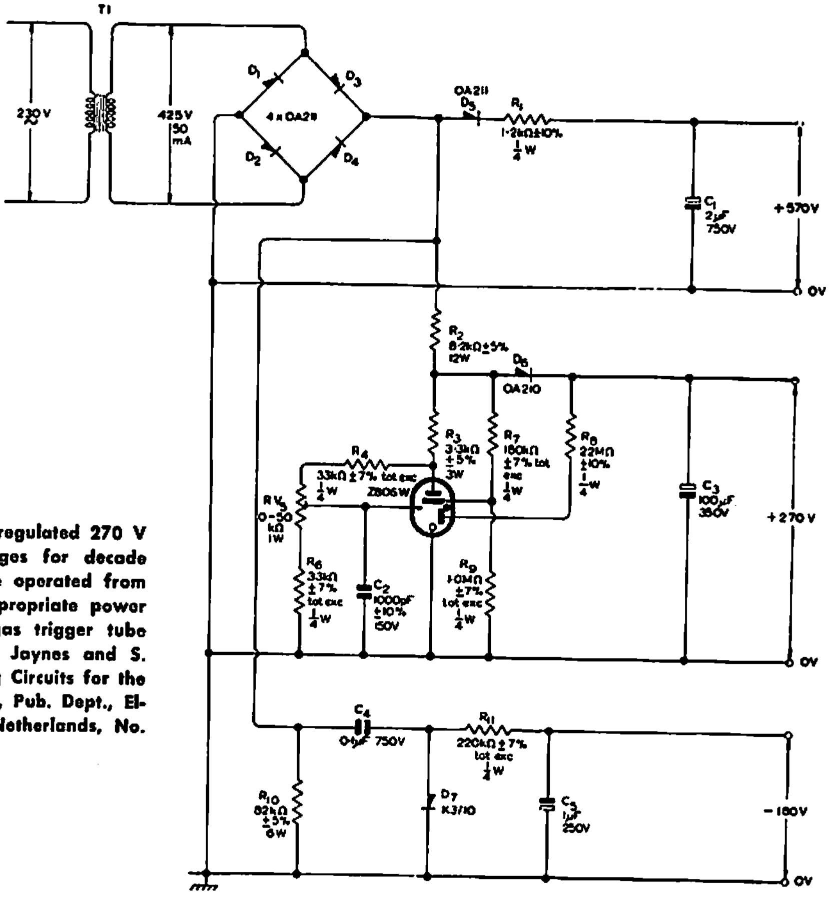


110 VAC
50mA
200 PIV
50µF
200V
R_S
330K
Ⓐ
V1
5AB-B
R_{SS}
8.2K 1W
ADJUST
R_{SSS}
75K 2W
Ⓑ
V2
5AH
+17V MAX
6V ADJUST
OUT



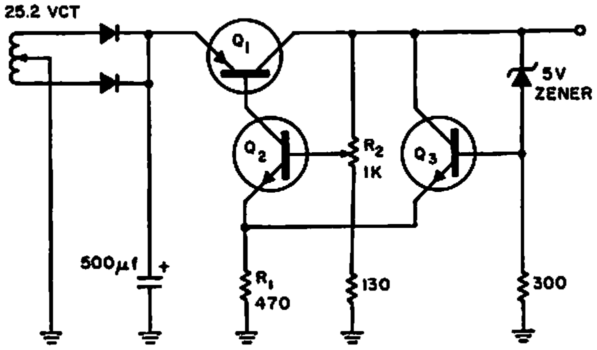
117V
60~
4A
UNSWITCHED OUTLET
SWITCHED OUTLET
.047
600V
.047
600V
T2
TRIAD
R-828
IN3493
(4)
.1µf
400V
4500µf
50VDC
4500µf
50 VDC
82
2W
2N392
DTG-110
500µf
50VDC
9.1V
1W
ZENER
2N3391
1000
½W
20µf
25VDC
1000
½W
10K
LINEAR
4700
½W
500µf
50VDC
.1µf
100V
+50VDC
+30
VDC
-50VDC

30 AND 50 V D-C FOR TRANSISTOR STEREO—Provides unregulated balanced 50-V, plus 30-V regulated, for handling both 80-W channels of all-transistor stereo system. Regulator is series-type using zener for reference.—160 Watt Stereo Audio Power Amplifier Design, Delco Radio, Kokomo, Ind., No. 35, 1968.

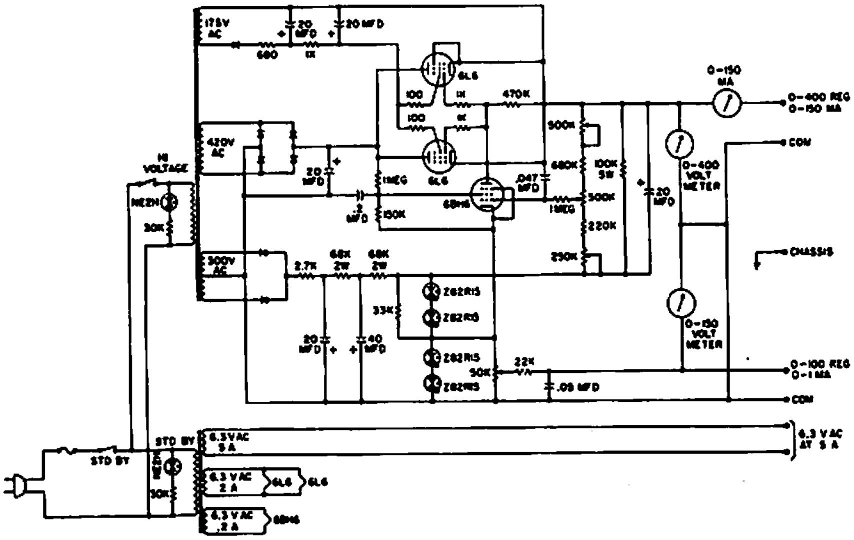


T1
230 V ~
425 V
50
mA
D_1
D_2
D_3
D_4
4 x OA211
OA211
D_5
R_1
1·2kΩ±10%
¼W
C_1
2µF
750V
+570V
0V
R_2
8·2kΩ±5%
12W
D_6
OA210
R_3
3·3kΩ
±5%
3W
R_7
180kΩ
±7% tot
exc
¼W
R_8
22MΩ
±10%
¼W
R_4
33kΩ ±7% tot exc
¼W
Z806W
RV_5
0-50
kΩ
1W
R_6
33kΩ
±7%
tot exc
¼W
C_2
1000pF
±10%
150V
R_9
1·0MΩ
±7%
tot exc
¼W
C_3
100µF
350V
+270 V
0V
C_4
0·1µF 750V
R_{11}
220kΩ ±7%
tot exc
¼W
R_{10}
82kΩ
±5%
6W
D_7
K3/10
C_5
1µF
250V
-180V
0V

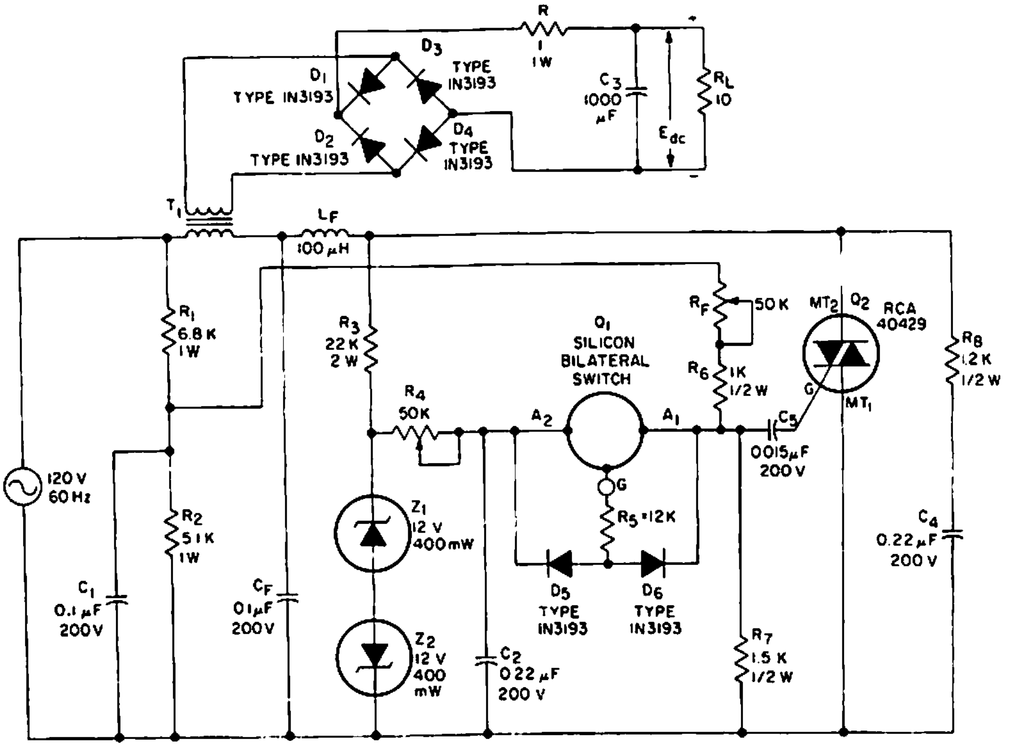
COUNTER SUPPLY—Provides regulated 270 V and two unregulated voltages for decade counter tube chain. Can be operated from 120 V a-c line by using appropriate power transformer. Uses Z806W gas trigger tube as voltage regulator.—G. F. Jaynes and S. Zilkha, Trigger Tube Coupling Circuits for the Z504S Stepping Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 15, 1965, p 16–25.


25.2 VCT
Q1
Q2
Q3
R2
1K
5V
ZENER
500μf
+
R1
470
130
300

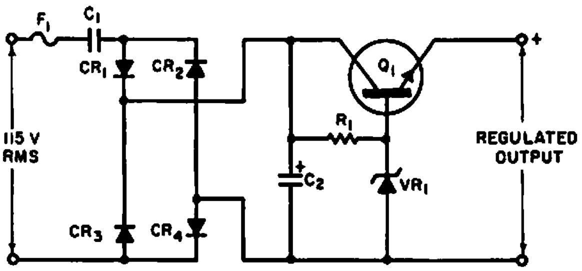
7–15 V WITH OVERLOAD PROTECTION—Uses one pnp and two npn transistors with other inexpensive components. Overload cutout current increases with output voltage setting of R2. Choose Q1 to withstand full d-c input voltage under short-circuit conditions.—W. F. McCarthy, Regulator Power Supply Improves Overload Protection, *Electronic Design*, Sept. 14, 1964, p 71.


175V AC
600
1K
20 MFD
20 MFD
6L6
100
1K
100
1K
470K
6L6
420V AC
20 MFD
1MEG
.2 MFD
150K
6BH6
.047 MFD
500K
680K
100K 5W
500K
1MEG
220K
250K
20 MFD
HI VOLTAGE
NE2H
30K
300V AC
2.7K
68K 2W
68K 2W
33K
Z82R15
Z82R15
Z82R15
Z82R15
20 MFD
40 MFD
50K
22K
.05 MFD
0-150 MA
0-400 REG 0-150 MA
COM
0-400 VOLT METER
CHASSIS
0-150 VOLT METER
0-100 REG 0-1 MA
COM
6.3 VAC AT 5 A
STD BY
STD BY
6.3 VAC 5 A
6.3 VAC 2 A
6L6
6L6
30K
6.3 VAC .2 A
6BH6

0–400 V SUPPLY—Uses four subminiature neon voltage regulators as reference. Bias is 0–100 V and output impedance is less than 10 ohms.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 90.

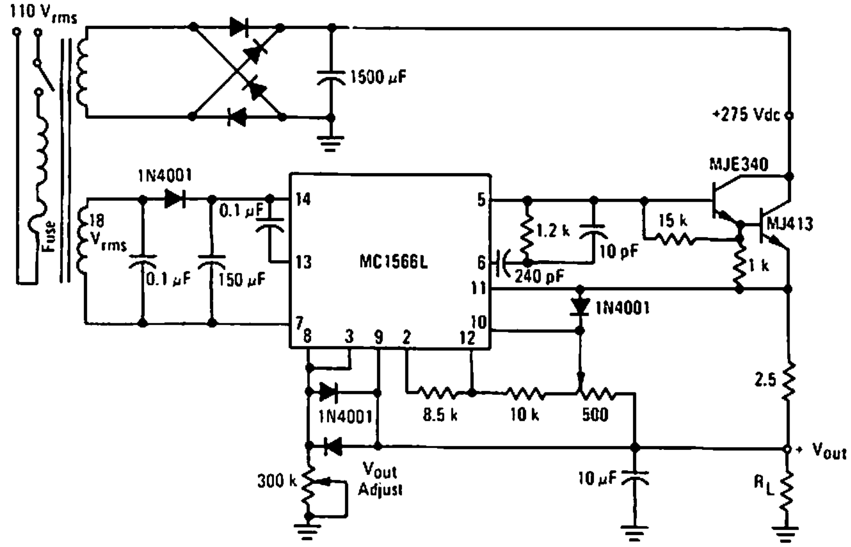

R
1
1W
D3
TYPE IN3193
D1
TYPE IN3193
D2
TYPE IN3193
D4
TYPE IN3193
C3
1000 μF
Edc
RL
10
+
−
T1
LF
100 μH
R1
6.8 K
1W
R3
22 K
2 W
RF
50 K
R6
1K
1/2 W
Q1
SILICON BILATERAL SWITCH
MT2
Q2
RCA 40429
MT1
G
R8
1.2 K
1/2 W
R4
50K
A2
A1
C5
0015μF
200 V
G
R5=12K
120 V
60 Hz
R2
5.1 K
1W
Z1
12 V
400mW
D5
TYPE IN3193
D6
TYPE IN3193
C4
0.22 μF
200 V
C1
0.1 μF
200V
CF
0.1μF
200V
Z2
12 V
400 mW
C2
0.22 μF
200 V
R7
1.5 K
1/2 W

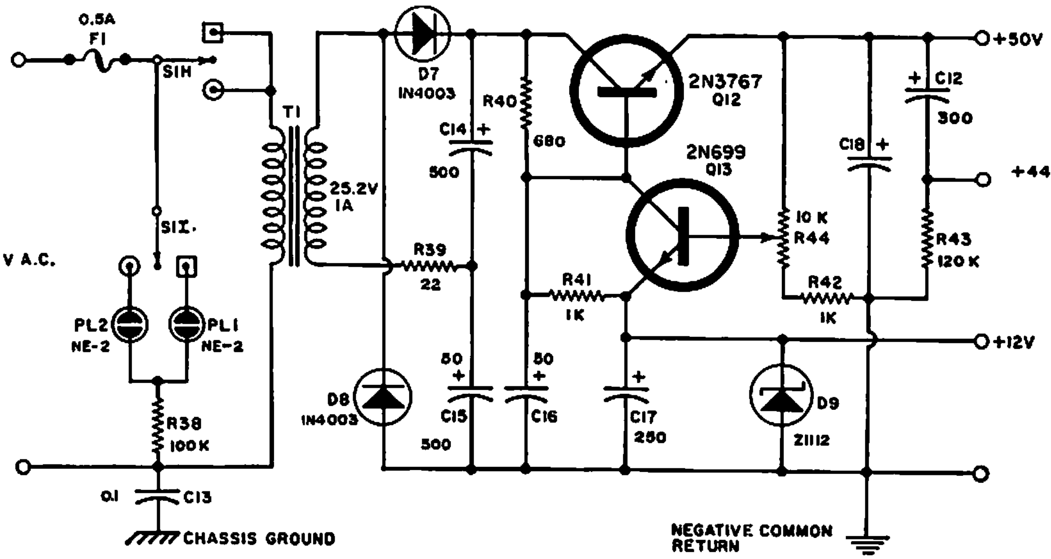
STABLE D-C SUPPLY—Power supply section uses full-wave bridge with R-C filter to provide d-c voltage of about 6 V. Regulator on primary side of line transformer T1 is phase-controlled triac with rfi suppression network. Voltage across 10-ohm load varies less than 2% for 20% change up or down in line voltage.—G. J. Granieri, AC Voltage Regulators Using Thyristors, RCA, Harrison, N.J., No. AN-3886, 1969.


F1
C1
CR1
CR2
115 V RMS
Q1
R1
C2
VR1
CR3
CR4
+
REGULATED OUTPUT

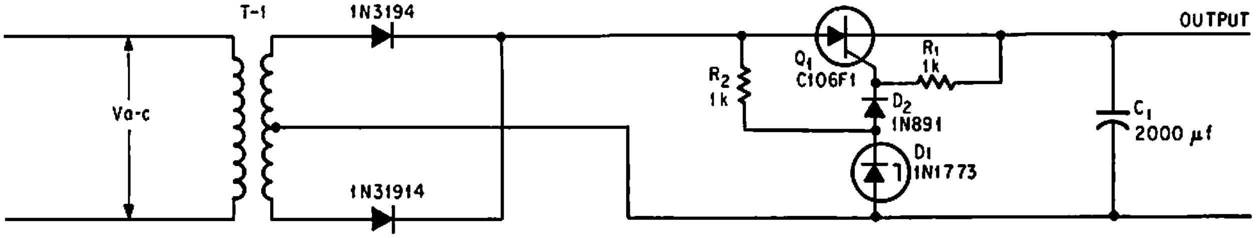
NO TRANSFORMER—Series capacitor C1 provides voltage-producing function of transformer to save space and reduce cost of low-voltage d-c power supply using full-wave bridge-rectifier circuit with conventional series voltage regulator Q1. Ideal for battery chargers. Value of C1 is chosen to give desired rectifier output voltage, and VR1 is selected for desired regulated output. Other components are conventional power supply sizes and are not critical.—A. T. Crane, Capacitor Replaces Transformer in Low Voltage Power Supply, *Electronic Design*, April 12, 1965, p 57.

0–250 V D-C AT 0.1 A—Uses Motorola MC-1566 IC high-voltage regulator to provide complete voltage regulation right up to limiting current.—D. Kesner, Voltage Regulators—Old and New, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 14–20.

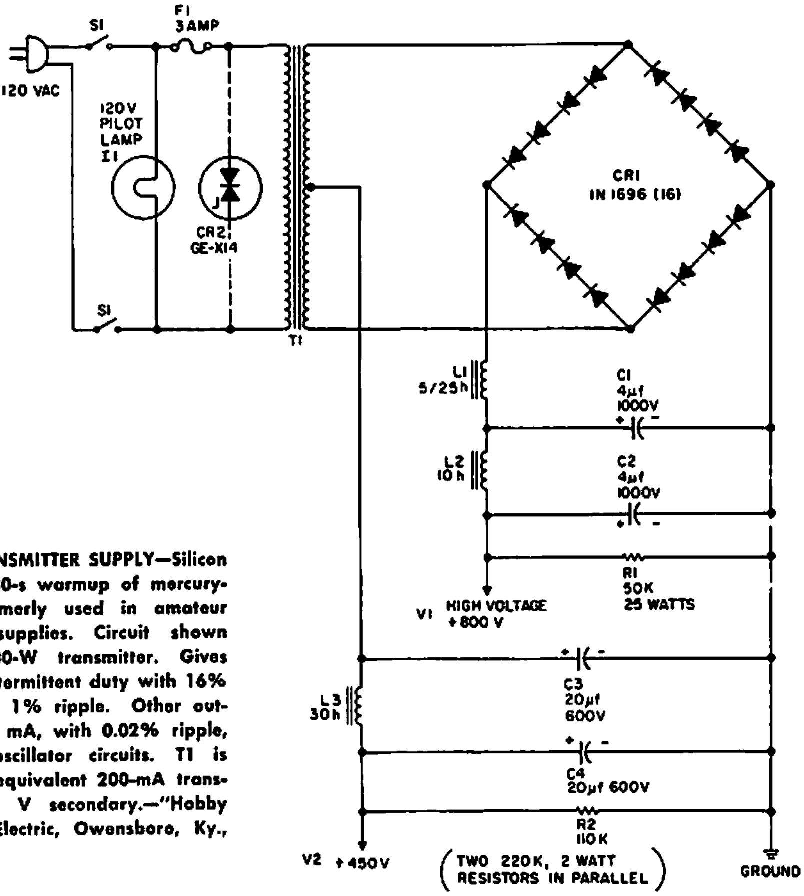

110 Vrms
Fuse
1500 µF
+275 Vdc
1N4001
18 Vrms
0.1 µF
0.1 µF
150 µF
14
13
7
8
3
9
2
12
10
11
6
5
MC1566L
1.2 k
10 pF
240 pF
15 k
MJE340
MJ413
1 k
1N4001
2.5
1N4001
8.5 k
10 k
500
300 k
Vout Adjust
10 µF
+ Vout
RL


0.5A
F1
S1H
117 V A.C.
S1L
PL2
NE-2
PL1
NE-2
R38
100K
0.1
C13
CHASSIS GROUND
T1
25.2V
1A
D7
1N4003
C14
500
R39
22
D8
1N4003
C15
500
50
R40
680
C16
50
R41
1K
2N3767
Q12
2N699
Q13
C17
250
10 K
R44
R42
1K
D9
Z1112
C18
C12
300
R43
120 K
+50V
+44V
+12V
NEGATIVE COMMON RETURN

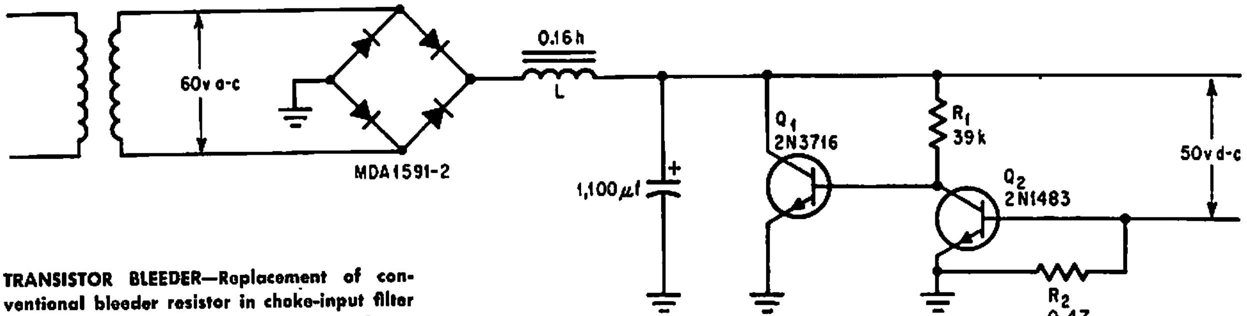
REGULATED 12, 44, and 50 V—Uses conventional voltage doubler with readily available power transformer. Zener D9 provides 12 V for reference, while Q12 and Q13 provide series-shunt regulation that minimizes ripple. Designed for use with transistor curve tracer. —M. Chan, Transistor Curve Tracer, *Electronics World*, Jan. 1968, p 55–58, 60, and 66.


T-1
1N3194
Va-c
1N31914
R2 1k
Q1 C106F1
R1 1k
D2 1N891
D1 1N1773
C1 2000 µf
OUTPUT

$3 SCR REGULATOR—Developed for use with consumer equipment in which cost of conventional regulated power supply would be prohibitive. Regulation is fair; for input range of 95 to 130 V, d-c output range is 11 to 12.5 V for outputs up to 0.3 A, after which transformer gradually saturates and impairs regulation.—P. Volkov, Inexpensive SCR Regulator For Consumer Equipment, *Electronics*, Feb. 5, 1968, p 88–89.

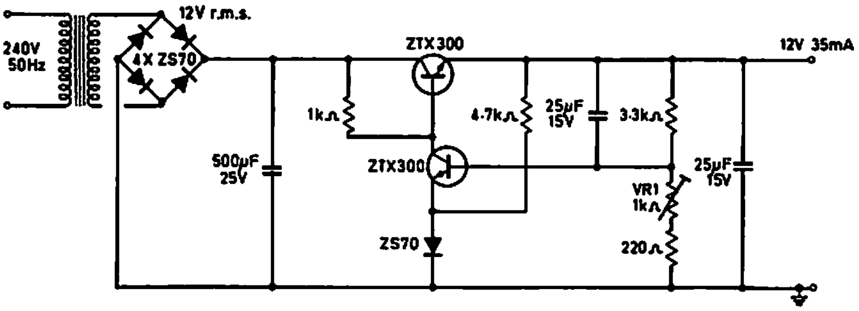

S1
F1 3AMP
120 VAC
120V PILOT LAMP I1
CR2 GE-X14
S1
T1
CR1 IN 1696 (16)
L1 5/25h
C1 4µf 1000V
L2 10h
C2 4µf 1000V
R1 50K 25 WATTS
V1 HIGH VOLTAGE +800 V
C3 20µf 600V
L3 30h
C4 20µf 600V
R2 110K
V2 +450V
(TWO 220K, 2 WATT RESISTORS IN PARALLEL)
GROUND

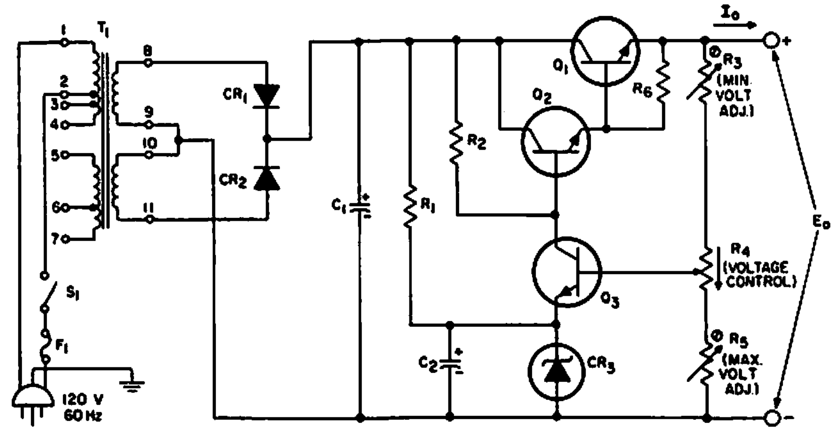
450 and 800 V TRANSMITTER SUPPLY—Silicon rectifiers eliminate 30-s warmup of mercury-vapor rectifiers formerly used in amateur radio transmitter supplies. Circuit shown handles typical 100-W transmitter. Gives 800 V at 175 mA intermittent duty with 16% load regulation and 1% ripple. Other output is 450 V at 25 mA, with 0.02% ripple, for preamp and oscillator circuits. T1 is Stancor PC8412 or equivalent 200-mA transformer having 800 V secondary.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 182.


60v a-c
MDA1591-2
0.16h
L
1,100µf
Q1 2N3716
R1 39k
Q2 2N1483
R2 0.47
50v d-c

TRANSISTOR BLEEDER—Replacement of conventional bleeder resistor in choke-input filter with transistor improves efficiency. Q1 draws 520 mA at no load, just above critical value at which choke loses filtering capability. At full load of 3 A, bleeder transistor current is negligible.—C. K. Fitzsimmons, Transistor Replaces Bleeder and Regulates Power Supply, *Electronics*, Jan. 22, 1968, p 70–71.

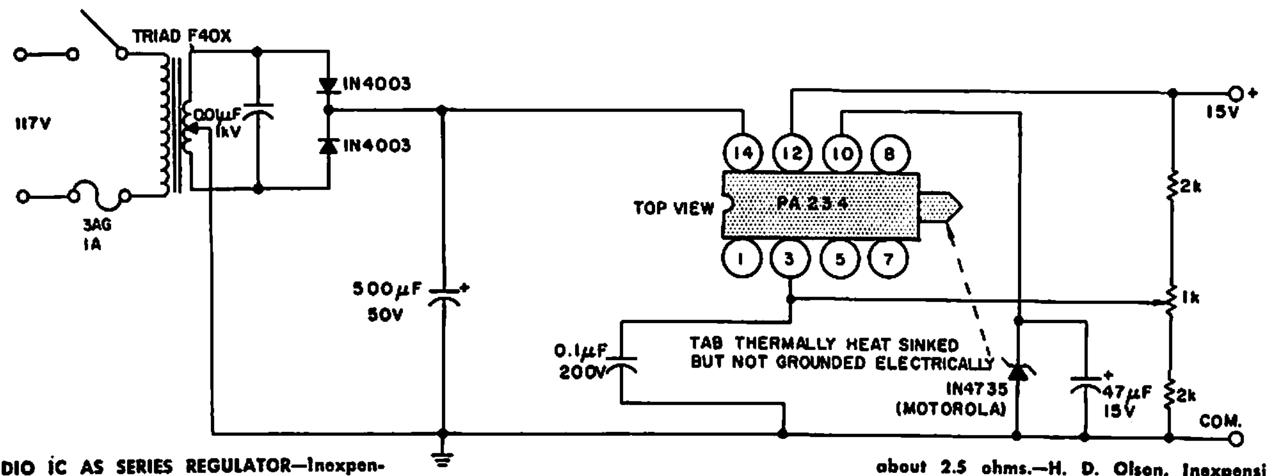
LOW-RIPPLE 12 V AT 35 MA—With values shown, ripple in 12-V output is only about 15 mV p-p.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 47.


240V
50Hz
12V r.m.s.
4X ZS70
ZTX300
12V 35mA
1kΩ
4.7kΩ
25µF 15V
3.3kΩ
500µF 25V
ZTX300
25µF 15V
VR1 1kΩ
ZS70
220Ω

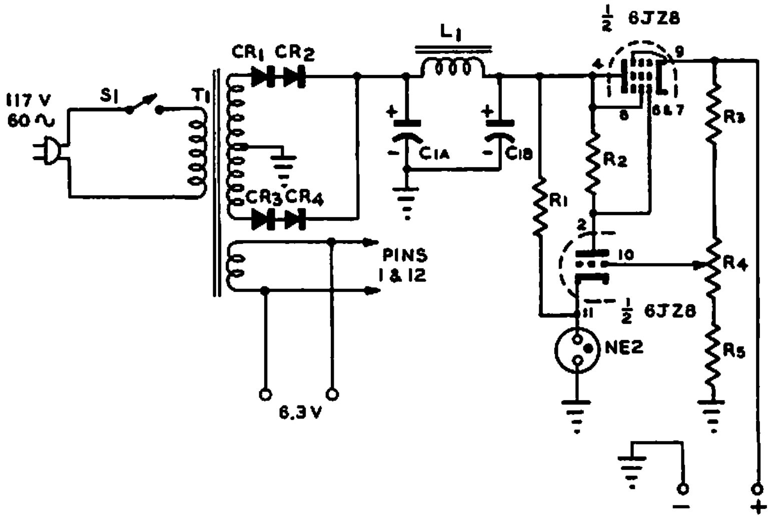

I
T1
8
2
3
4
5
6
7
9
10
11
CR1
CR2
C1
R1
R2
Q1
Q2
Q3
R6
Io
+
R3 (MIN. VOLT ADJ.)
R4 (VOLTAGE CONTROL)
R5 (MAX. VOLT ADJ.)
Eo
CR3
C2
S1
F1
120 V 60 Hz
-

C_1 = 5000 microfarads, 25 volts, electrolytic
C_2 = 100 microfarads, 6 volts, electrolytic
CR_1CR_2 = silicon rectifier, RCA SK3030
CR_3 = zener diode, 3.9 volts, 1/2 watt
F_1 = fuse, 1 ampere, 120 volts
Q_1 = transistor, RCA SK3027
Q_2Q_3 = transistor, RCA SK3020
R_1 = 6800 ohms, 1/2 watt, 10%
R_2 = 10,000 ohms, 1 watt, 10%
R_3 R_5 = trimmer potentiometer, 5000 ohms, Mallory MTC-1 or equivalent
R_4 = potentiometer, 5000 ohms, linear tape:
S_1 = switch, 120 volts, 1 ampere, single-pole, single-throw
T_1 = transformer, primary 115 volts, secondary 15 volts, 1 ampere, Stancor No. TP-4 or equivalent

4.5 TO 12 V AT 1 A—Provides limited range of adjustment for output voltage. Regulation is provided by series transistor Q1, with zener serving as voltage reference for control transistors Q2 and Q3.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 53.

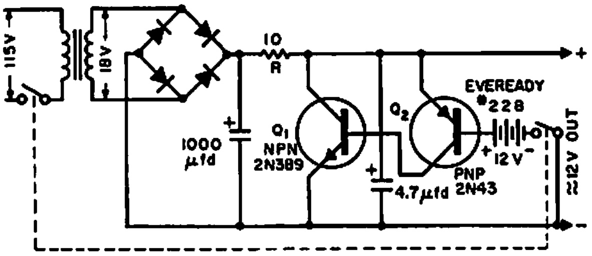

TRIAD F40X
117V
.001µF 1kV
IN4003
IN4003
3AG 1A
500µF 50V
14
12
10
8
TOP VIEW
PA234
1
3
5
7
+
15V
2k
1k
2k
0.1µF 200V
TAB THERMALLY HEAT SINKED BUT NOT GROUNDED ELECTRICALLY
IN4735 (MOTOROLA)
47µF 15V
COM.

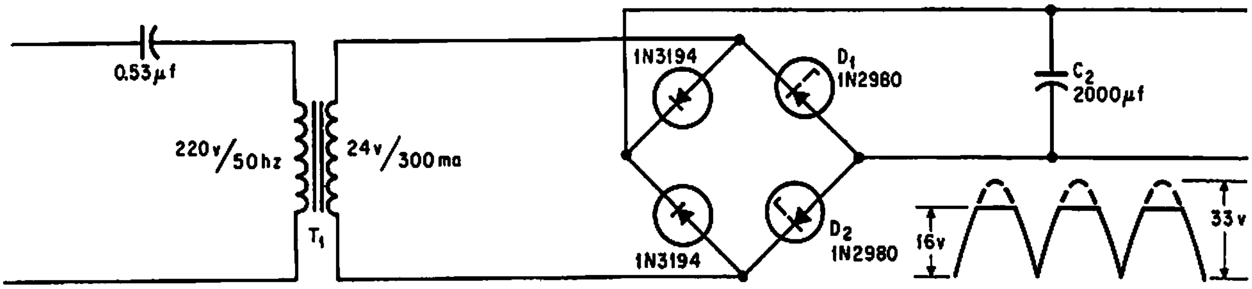
AUDIO IC AS SERIES REGULATOR—Inexpensive 1-W PA234 IC audio amplifier connected as shown provides regulated 15 V at up to several hundred mA, at lower cost than discrete components. Output impedance is about 2.5 ohms.—H. D. Olsen, Inexpensive Audio IC Serves as Regulator, *Electronic Design*, Nov. 8, 1969, p 101.


½ 6JZ8
L1
CR1 CR2
117 V
60 ∿
S1
T1
C1A
C1B
CR3 CR4
PINS
1 & 12
6.3 V
R1
R2
R3
R4
R5
½ 6JZ8
NE2
–
+

250 V WITH COMPACTRON—R4 permits adjusting regulated output from 150 V at 40 mA to 250 V at 60 mA. Pentode section of 6JZ8 compactron is in load circuit as series regulator, with triode section controlling grid bias of pentode. Intended for small receivers and converters. Diodes are 1N1696. Other values are: L1 8-H 75-mA Stancor C1355; T1 Stancor PC8419 with 6.3 V 3 A and 480 V CT 70 mA secondaries; R1 2.2 meg; R2-R4 1 meg; R5 470K.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 187.

12 V AT 0.5 A—Two-transistor shunt regulator and 12-V reference battery provide 0.25% regulation. Battery current drain is negligible. Q1 must be able to dissipate same power as load.—R. Selleck, Transistor Shunt Regulator Improves Voltage Control, *Electronic Design*, June 8, 1964, p 73–74.

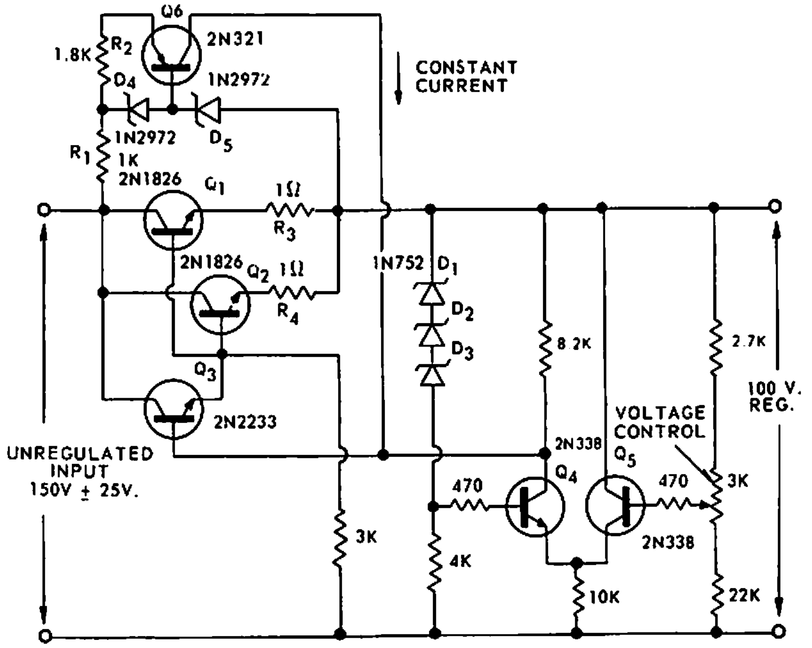

115 V
18 V
10
R
+
1000 µfd
Q1 NPN 2N389
Q2
EVEREADY #228
12 V
PNP 2N43
4.7µfd
≈12 V OUT
–


0.53µf
220v/50hz
24v/300ma
T1
1N3194
D1 1N2980
C2 2000µf
1N3194
D2 1N2980
16v
33v

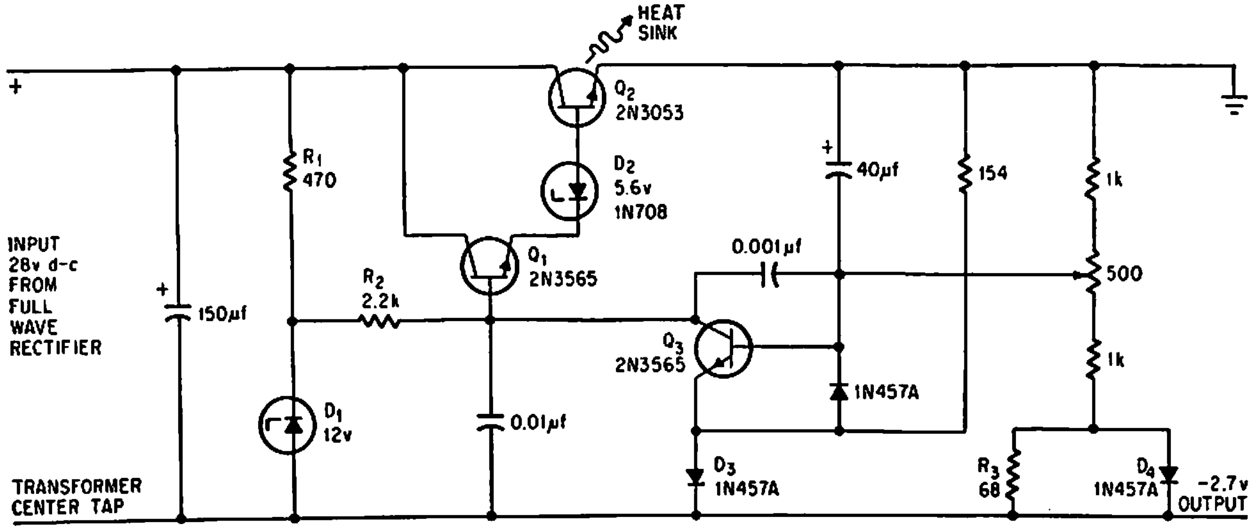
MAGNETIC-RESONANCE CURRENT-LIMITING—With zener diodes in bridge-rectifier power supply, regulating-current drain of diodes is limited by saturation of power supply. Transformer then acts as inductance between its primary and secondary, and this in turn forms low-Q series resonant circuit with capacitor in primary, to limit current flow. With circuit shown, load current remains above about 250 mA until output voltage reaches 16 V, after which current drops rapidly and reaches zero at about 17 V. Article gives design equation. Peak-clipping action makes output voltage easy to filter.—O. A. Horna, Magnetic Resonance Limits Zener Diode Current, *Electronics*, Dec. 11, 1967, p 97–98.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

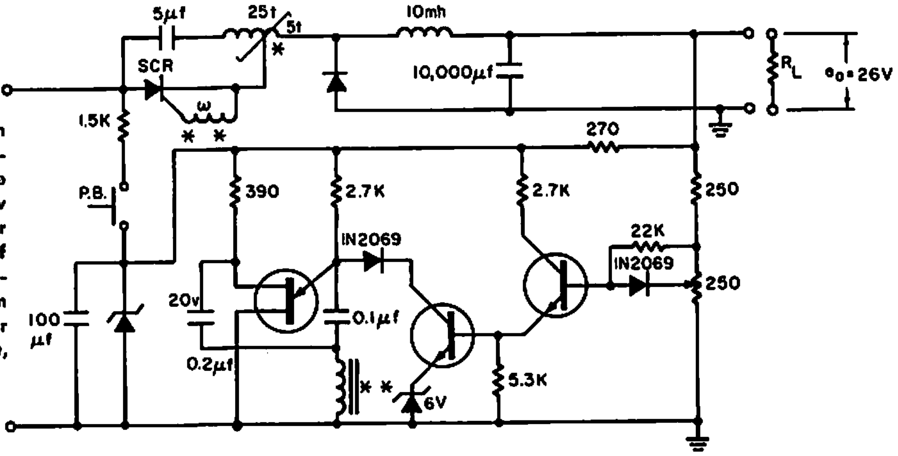
CHAPTER 71
Regulator Circuits


Q6
2N321
1.8K
R2
D4
1N2972
CONSTANT CURRENT
1N2972
D5
R1
1K
2N1826
Q1
1Ω
R3
2N1826
Q2
1Ω
R4
Q3
2N2233
1N752
D1
D2
D3
8.2K
2.7K
100 V. REG.
VOLTAGE CONTROL
2N338
Q4
Q5
470
470
3K
3K
4K
10K
22K
2N338
UNREGULATED INPUT 150V ± 25V.

100 V AT 4 A—Holds d-c output constant within 0.2 V for maximum load variation and 25 V swing in unregulated 150-V input. Paralleled series-regulator transistors are used in design to stay well within safe-area ratings. Three 5-V zeners in series give better temperature coefficient than 15-V zener. Preregulator Q6 supplies constant current to differential amplifier and driver, to help eliminate ripple current.—"Silicon Power Transistor Handbook," Westinghouse, Youngwood, Pa., p 6–19.

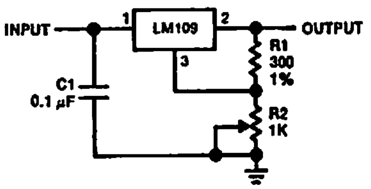

HEAT SINK
+
Q2
2N3053
D2
5.6v
1N708
R1
470
+
40μf
154
1k
INPUT 28v d-c FROM FULL WAVE RECTIFIER
+
150μf
0.001μf
Q1
2N3565
R2
2.2k
500
Q3
2N3565
1k
1N457A
D1
12v
0.01μf
D3
1N457A
R3
68
D4
1N457A
-2.7v OUTPUT
TRANSFORMER CENTER TAP

2.7-V REPLACEMENT FOR MERCURY CELL—Gives 0.01% regulation from 28-V d-c line and load regulation of 1%, at parts cost under $7. Zener diode D2 in regulator boosts operating voltage of amplifier that detects voltage differences. D1 merely acts with R1 to establish constant voltage source at junction with R2, making Q1 less susceptible to input line variations.—E. Luttrell, Low Voltage Supply Produces Good Regulation at Low Cost, *Electronics*, Jan. 23, 1967, p 91.

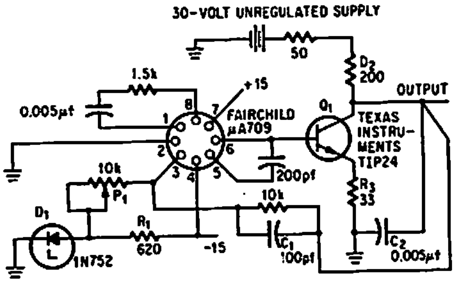

5µf
25t
5t
10mh
SCR
ω
* *
*
10,000µf
R_L
e_o=26V
1.5K
270
P.B.
390
2.7K
2.7K
250
IN2069
22K
IN2069
250
100 µf
20v
0.1µf
0.2µf
* *
6V
5.3K

TRANSISTORS	2N1308
UNIJUNTION	2N494
SCR	2N683A
*	MAGNETICS INC 51001-2A ORTHONOL CORE No.14 WIRE
* *	FERRAMIC 03 TYPE 50t ON PRIMARY 50t ON SECONDARY

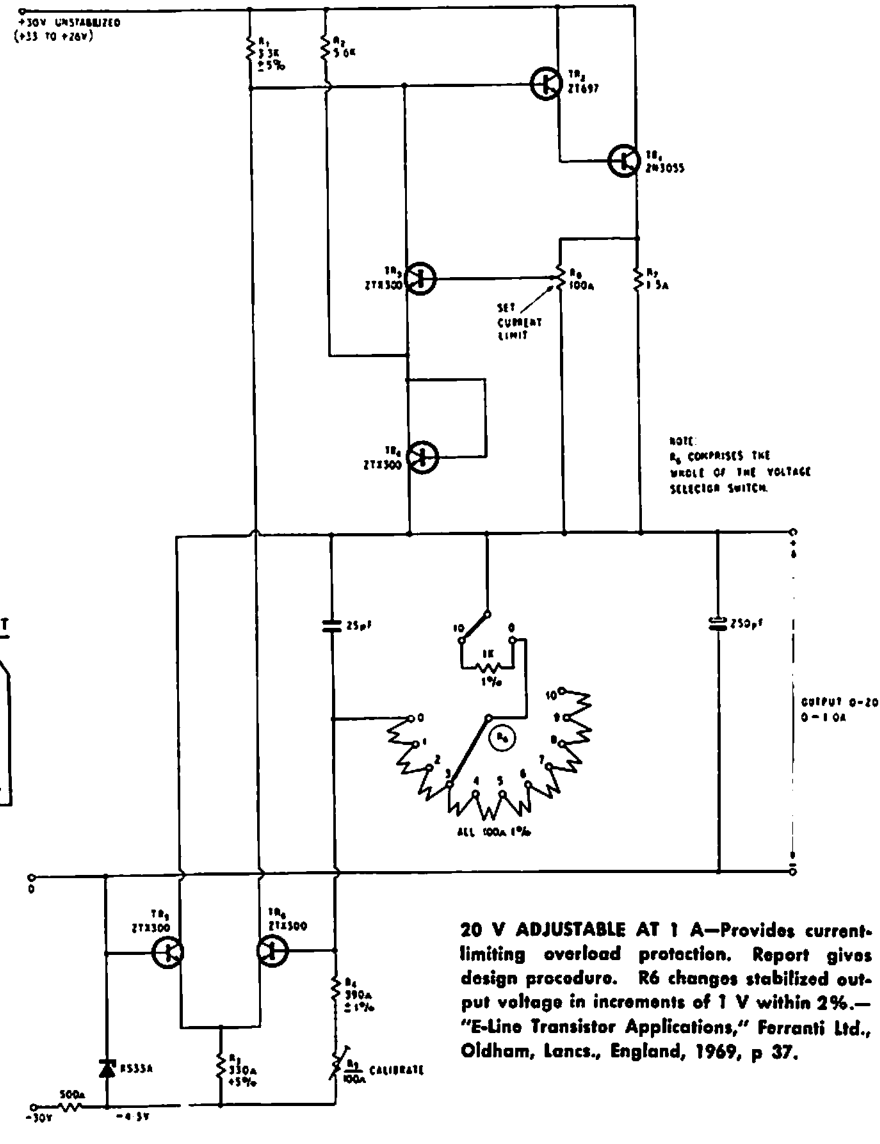
SWITCHING-MODE REGULATOR—Uses scr in commutating circuit. Output voltage is compared with voltage across reference diode and difference used to control current flow into frequency control section of ujt oscillator whose pulses trigger scr on. Frequency of ujt thus controls output voltage. Article describes operation in detail and gives design equations.—R. T. Windecker, Which Device for High-Power Switching?, *Electronic Design*, Sept. 14, 1964, p 64–69.


INPUT
1
LM109
2
OUTPUT
3
R1 300 1%
C1 0.1 µF
R2 1K

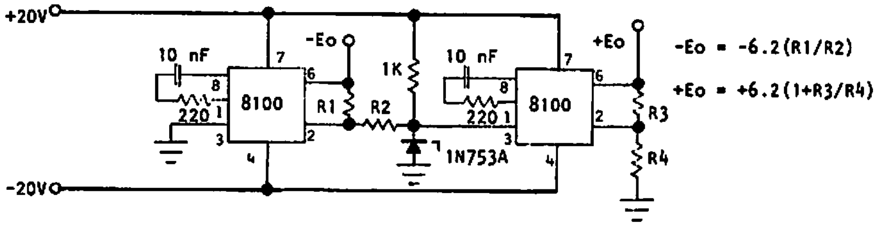
IC REGULATOR FOR LOGIC SUPPLY—Requires only three connections to provide regulation and thermal overload protection for standard 5-V digital logic power supply. Gives output currents over 1 A.—Adjustable-Output Regulator (National Semiconductor ad), *Electronic News*, June 8, 1970, p 11.


30-VOLT UNREGULATED SUPPLY
50
D2 200
OUTPUT
1.5k
+15
0.005µf
8
7
1
FAIRCHILD µA709
Q1
TEXAS INSTRUMENTS TIP24
2
6
3
4
5
200pf
10k
P1
10k
R3 33
D1
R1 620
-15
C1 100pf
C2 0.005µf
1N752

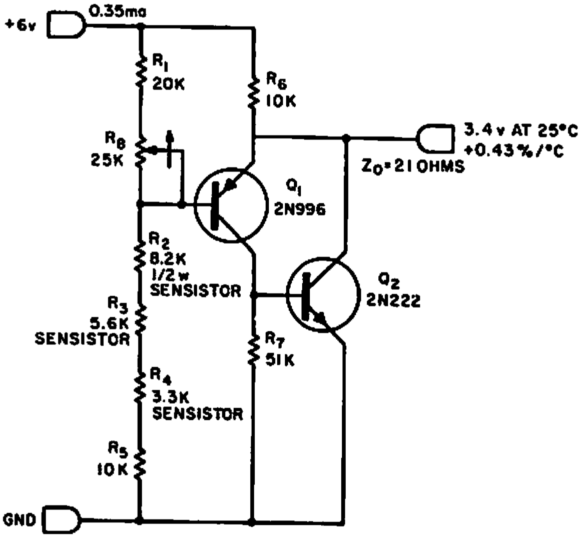
OPAMP REGULATES AND PROTECTS—Shunt regulator Q1 drives Fairchild IC operational amplifier, with zener D1 serving as voltage reference. P1 adjusts opamp gain, thereby changing output voltage over range of 6 to 25 V. At 15 V, load current can vary from 0 to 60 mA with little effect on voltage. Short-circuit current is limited to 120 mA. External low-power zeners provide 15-V supply voltages for IC.—R. D. Guyton, IC Operational Amplifier Makes Supply Short-Circuit Proof, *Electronics*, Sept. 18, 1967, p 106.


+30V UNSTABILIZED (+33 TO +26V)
R1 3.3K ±5%
R2 5.6K
TR2 ZT697
TR1 2N3055
TR3 ZTX300
R6 100Ω
R7 1.5Ω
SET CURRENT LIMIT
TR4 ZTX300
NOTE: R6 COMPRISES THE WHOLE OF THE VOLTAGE SELECTOR SWITCH.
25µf
10
0
1K 1%
250µf
OUTPUT 0-20V 0-1.0A
0 1 2 3 4 5 6 7 8 9 10
R6
ALL 100Ω 1%
0
TR5 ZTX300
TR6 ZTX300
R4 390Ω ±1%
KS33A
R3 330Ω +5%
R5 100Ω CALIBRATE
500Ω
-30V
-4.3V

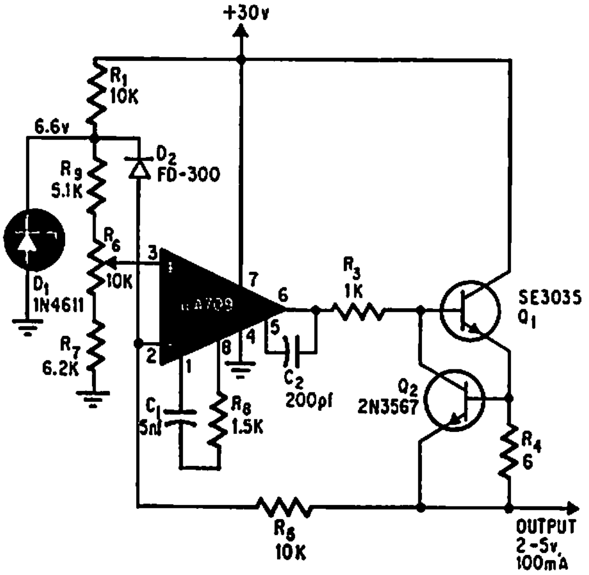
20 V ADJUSTABLE AT 1 A—Provides current-limiting overload protection. Report gives design procedure. R6 changes stabilized output voltage in increments of 1 V within 2%.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 37.


+20V
10 nF
220
8100
1
8
7
6
3
4
2
-Eo
1K
R1
R2
1N753A
10 nF
220
8100
+Eo
R3
R4
-20V
-Eo = -6.2(R1/R2)
+Eo = +6.2(1+R3/R4)

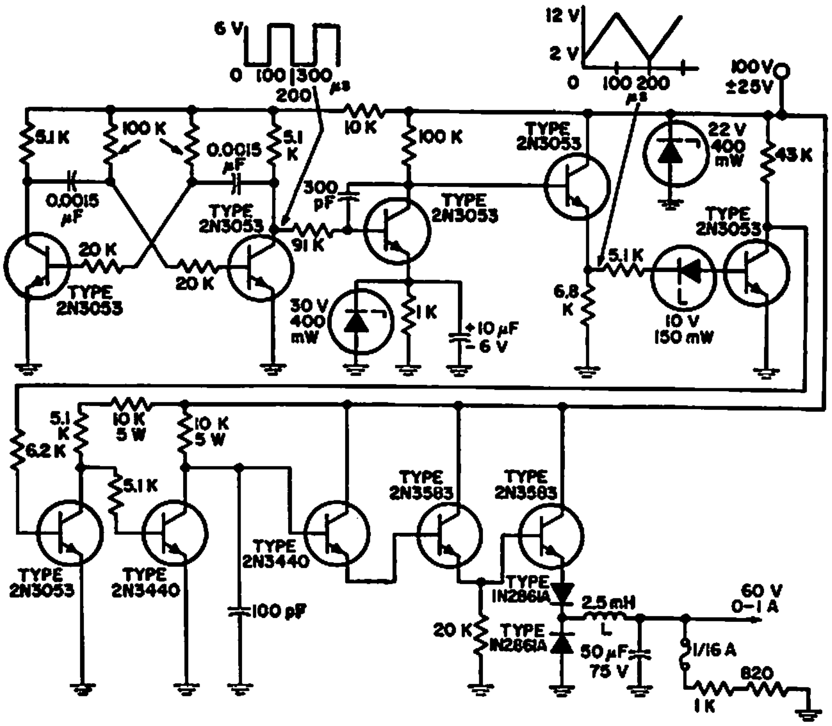
COMMON-REFERENCE DUAL REGULATOR—Provides two voltages having different values and opposite polarities, regulated by means of one zener diode. Voltage values are determined by resistor values.—Applying the Model 8100 Monolithic Voltage Regulator, Optical Electronics, Tucson, Ariz., No. 10141.


+6v
0.35ma
R1 20K
R8 25K
R6 10K
3.4 v AT 25°C
+0.43%/°C
Zo=21 OHMS
Q1 2N996
R2 8.2K 1/2 w SENSISTOR
R3 5.6K SENSISTOR
Q2 2N222
R7 51K
R4 3.3K SENSISTOR
R5 10K
GND

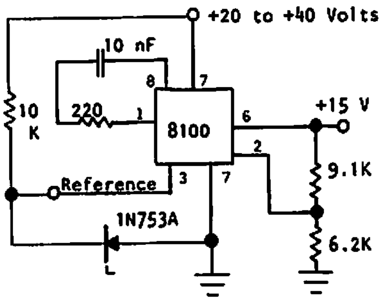
TEMPERATURE COMPENSATION—Uses sensistors to temperature-stabilize voltage at which ranges are changed in count-rate meter. Output of 3.4 V is adjustable. Temperature coefficient is +0.43%.—S. Thomas, N-Decade Count-Rate Meter, *Electronic Design*, March 15, 1965, p 34–39.


+30v
R1 10K
6.6v
D2 FD-300
R9 5.1K
R6 10K
D1 1N4611
R7 6.2K
μA709
3
2
7
6
5
4
8
1
C1 5nf
R8 1.5K
C2 200pf
R3 1K
SE3035 Q1
Q2 2N3567
R4 6
R5 10K
OUTPUT 2-5v, 100mA

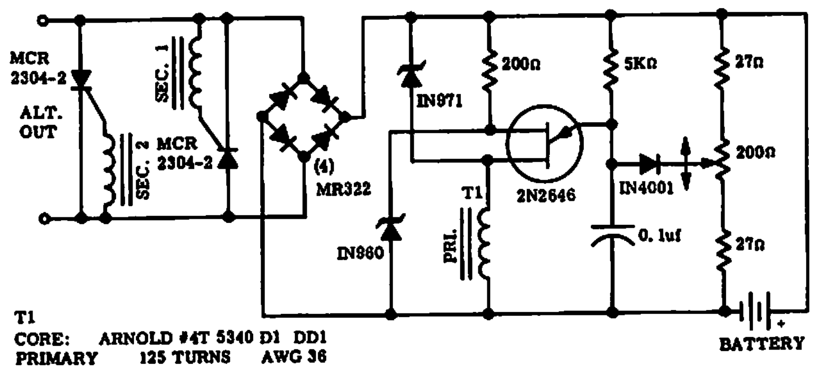
IC VOLTAGE-LOWERING REGULATOR—Uses Fairchild μA709 opamp operating at unity gain, with its input tapped across zener reference D1. Q2 provides surge protection. Article contains 13 other IC opamp application circuits.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


6 V
0 100 300 μs
200
12 V
2 V
0 100 200 μs
100V ±25V
5.1 K
100 K
0.0015 μF
5.1 K
10 K
100 K
0.0015 μF
TYPE 2N3053
20 K
20 K
TYPE 2N3053
91 K
300 pF
TYPE 2N3053
30 V 400 mW
1 K
+10 μF -6 V
TYPE 2N3053
22 V 400 mW
43 K
6.8 K
5.1 K
10 V 150 mW
TYPE 2N3053
5.1 K
6.2 K
10 K 5 W
10 K 5 W
5.1 K
TYPE 2N3053
TYPE 2N3440
TYPE 2N3440
100 pF
TYPE 2N3583
TYPE 2N3583
TYPE 1N2861A
2.5 mH
L
60 V 0–1 A
20 K
TYPE 1N2861A
50 μF 75 V
1/16 A
820
1 K

STEP-DOWN SWITCHING REGULATOR—Can be used as d-c step-down transformer for obtaining low d-c voltage from a-c line. Input to regulator is 100 V d-c obtained from line through rectifier, and output is 60 V d-c for loads up to 1 A.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 225.


+20 to +40 Volts
10 nF
8
7
10 K
220
1
8100
6
+15 V
2
9.1K
Reference
3
7
1N753A
6.2K

POSITIVE SWITCHING REGULATOR—Output voltage is equal to 99% of reference voltage. Small amount of positive feedback causes regulator to switch. Average voltage across output smoothing capacitor is sensed and used to govern output voltage level and switching activity of 8100.—Applying the Model 8100 Monolithic Voltage Regulator, Optical Electronics, Tucson, Ariz., No. 10141.

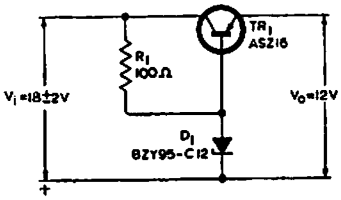

MCR 2304-2
ALT. OUT
SEC. 1
SEC. 2
MCR 2304-2
(4) MR322
IN971
200Ω
5KΩ
27Ω
2N2646
IN4001
200Ω
T1
PRI.
IN960
0.1uf
27Ω
BATTERY

T1

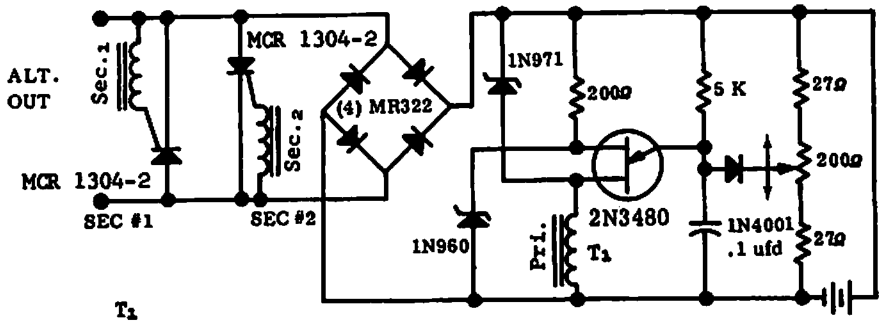
CORE:	ARNOLD #4T 5340 D1 DD1	
PRIMARY	125 TURNS	AWG 36
SEC #1	125 TURNS	AWG 36
SEC #2	125 TURNS	AWG 36

TRIFILAR WOUND

OUTBOARD-ENGINE ALTERNATOR REGULATOR—Controls 15-A d-c charging current to storage battery by shorting output of p-m alternator field when battery is charged, when scr's are triggered by voltage-sensitive ujt circuit. Shorting output does not appreciably increase maximum output current of alternator. Serves to protect bridge rectifiers against high-voltage stress otherwise occurring if alternator circuit were opened.—"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 8-8.


TR₁ ASZ16
R₁ 100Ω
V₁=18±2V
V₀=12V
D₁ BZY95-C12
+

SERIES TRANSISTOR WITH ZENER—Provides essentially constant output of 12 V d-c at 250 mA for input of 16 to 20 V d-c. Book gives design equations.—"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 35.

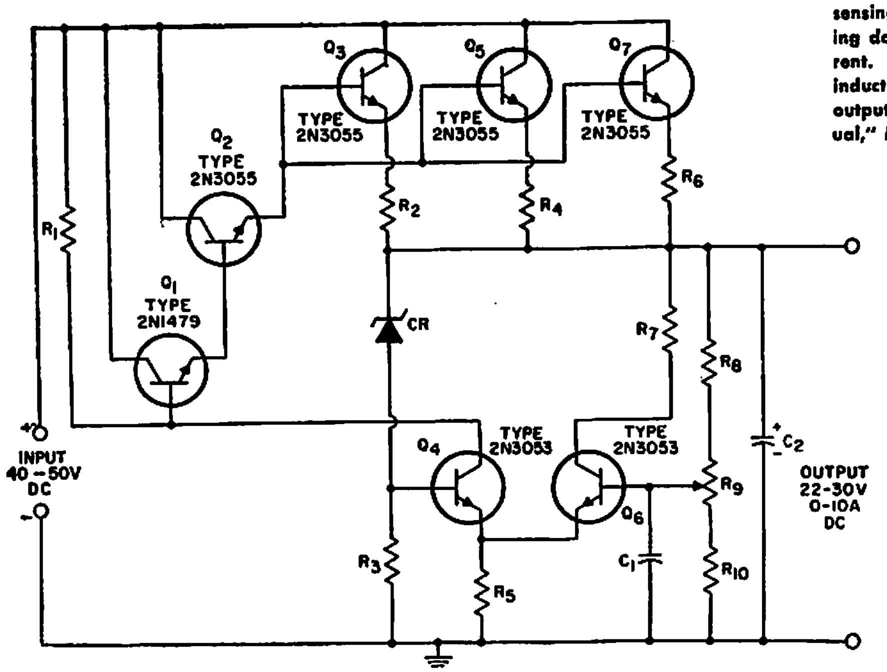

ALT. OUT
Sec. 1
MCR 1304-2
MCR 1304-2
Sec. 2
(4) MR322
SEC #1
SEC #2
1N971
200Ω
5 K
27Ω
2N3480
1N4001
200Ω
1N960
Pri.
T₁
.1 ufd
27Ω
BATTERY

T₁

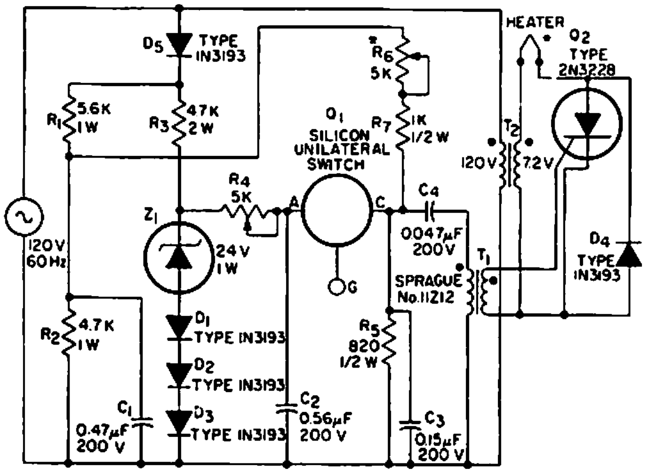
CORE:	ARNOLD #4T 5340 D1 DD1	
PRIMARY	125 TURNS	AWG 36
SEC #1	125 TURNS	AWG 36
SEC #2	125 TURNS	AWG 36

TRIFILAR WOUND

OUTBOARD-ENGINE ALTERNATOR REGULATOR—Designed for alternators having permanent-magnet fields. Regulates 15-A charging current for battery by shorting output of alternator when triggered by ujt voltage-sensing circuit. With most alternators, shorting does not appreciably increase output current. Avoids damaging bridge rectifiers with inductive voltage spikes that would occur if output circuit were opened.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 8-4-3.

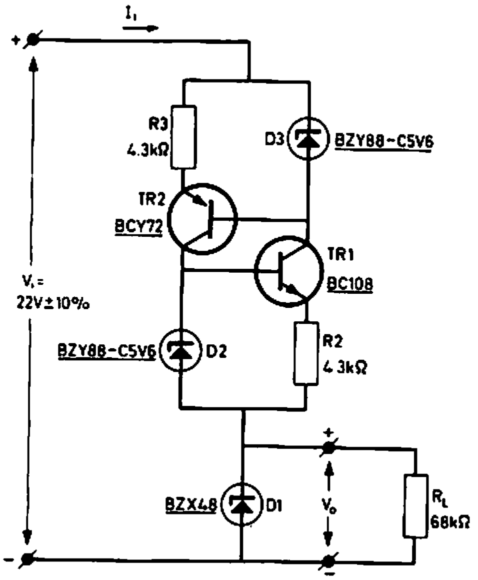

Q₃
Q₅
Q₇
TYPE 2N3055
TYPE 2N3055
TYPE 2N3055
Q₂ TYPE 2N3055
R₁
R₂
R₄
R₆
Q₁ TYPE 2N1479
CR
R₇
R₈
+
INPUT 40-50V DC
-
Q₄ TYPE 2N3053
TYPE 2N3053
Q₆
+ C₂
OUTPUT 22-30V 0-10A DC
R₉
R₃
R₅
C₁
R₁₀

22–30 V SERIES REGULATOR—Uses three paralleled transistors in series with load to hold output voltage constant by varying load current. Reference is zener CR connected with reverse bias. Gives line regulation within 1% and load regulation within 0.5%. R9 varies output voltage. Values: R1 1.2K; R2, R4, R6 0.1; R3 2K; R5 570; R7 270; R8, R10 1K; R9 1K pot; C1 1 μF; C2 100 μF; CR 12-V zener.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 515.

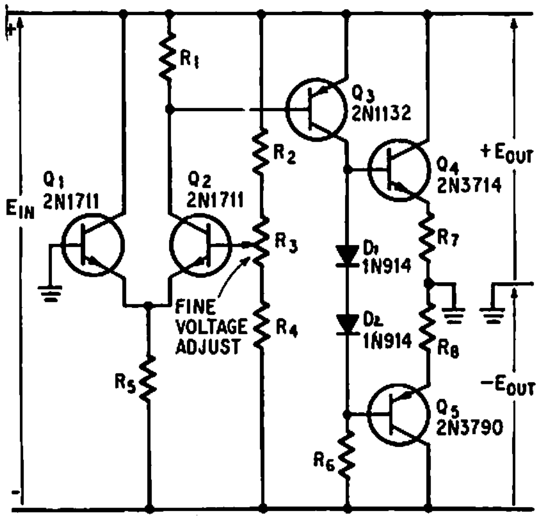

D5
TYPE 1N3193
R1
5.6K
1W
R3
47K
2W
Q1
SILICON UNILATERAL SWITCH
R6 *
5K
R7
1K
1/2 W
HEATER
Q2
TYPE 2N3228
T2
120V
7.2V
R4
5K
A
C
C4
.0047µF
200V
Z1
24V
1W
G
T1
SPRAGUE No.11212
D4
TYPE 1N3193
120V
60Hz
R2
4.7K
1W
D1
TYPE 1N3193
D2
TYPE 1N3193
D3
TYPE 1N3193
C1
0.47µF
200 V
C2
0.56µF
200 V
R5
820
1/2 W
C3
0.15µF
200 V

* IN THE CLOSED-LOOP REGULATOR R_6 IS REPLACED BY A PHOTOCELL RCA SQ2520 AND A POTENTIOMETER IN SERIES WITH A 6-VOLT INCANDESCENT LAMP IS CONNECTED IN PARALLEL WITH THE HEATER TERMINALS
NOTE: ALL RESISTOR VALUES ARE IN OHMS

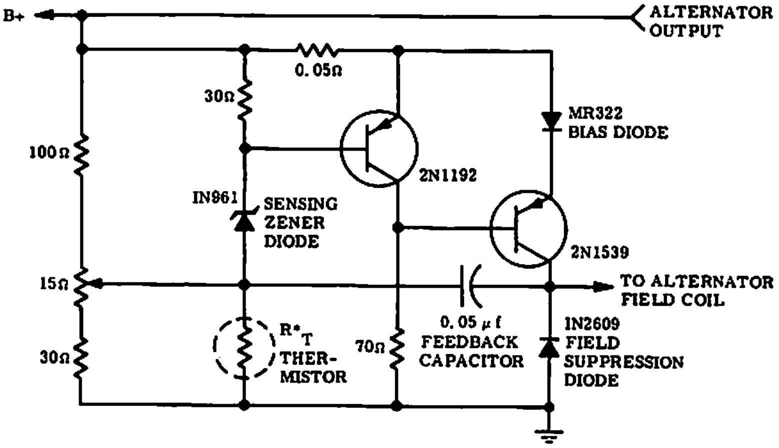
CONSTANT LAMP VOLTAGE—Used to maintain constant voltage across heater of tube or filament of incandescent lamp. Full voltage is applied for one half-cycle through D4, while other half-cycle is phase-controlled by scr to provide regulation. Circuit is open-loop regulator with built-in protection against open or short-circuited component. Q1 has thyristor characteristics approximating those of ideal four-layer diode, switching at about 8 V.—G. J. Granieri, AC Voltage Regulators Using Thyristors, RCA, Harrison, N.J., Application Note AN-3886, 1969.


I1
+
R3
4.3kΩ
TR2
BCY72
D3
BZY88-C5V6
TR1
BC108
V1 =
22V±10%
BZY88-C5V6
D2
R2
4.3kΩ
+
BZX48
D1
V0
RL
68kΩ
-
-

COMPLEMENTARY CONSTANT-CURRENT SOURCE—Highly stable constant-current source provides stabilized 6.5 V d-c output across load for input voltage as low as 18.5 V.—High-Stability Reference Diodes BZX47 Family, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 331, 1968.

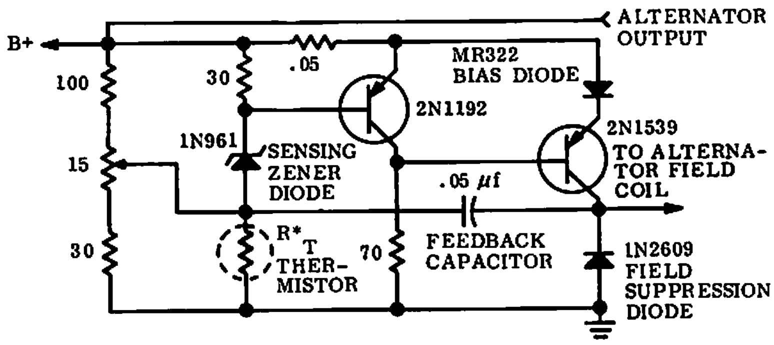

+
R1
Q3
2N1132
R2
Q4
2N3714
+EOUT
Q1
2N1711
Q2
2N1711
EIN
R3
D1
1N914
R7
FINE VOLTAGE ADJUST
R4
D2
1N914
R8
R5
-EOUT
Q5
2N3790
R6
-

POSITIVE AND NEGATIVE VOLTAGES—Shunt regulator can provide any combination of positive and negative output voltages whose sum is equal to output of single regulated supply. Differential amplifier Q1-Q2 compares ground reference (formed by R2-R3-R4) to ground. Table gives values of components for two combinations of input and output voltages.—A. J. Mayle, Shunt Regulator Provides Dual Output Voltages, *Electronics*, Oct. 14, 1968, p 121–122.


B+
ALTERNATOR OUTPUT
0.05Ω
30Ω
MR322
BIAS DIODE
100Ω
2N1192
1N961
SENSING ZENER DIODE
2N1539
15Ω
TO ALTERNATOR FIELD COIL
0.05 µf
FEEDBACK CAPACITOR
1N2609
FIELD SUPPRESSION DIODE
30Ω
R*T
THERMISTOR
70Ω

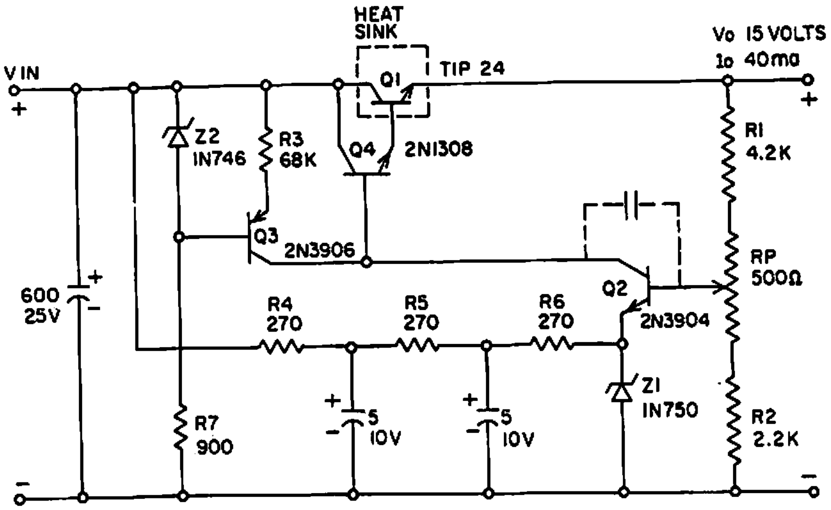
* THE VALUE OF R_T DEPENDS ON THE SLOPE OF THE VOLTAGE REGULATION VERSUS TEMPERATURE CURVE.

ALTERNATOR VOLTAGE REGULATOR—Monitors battery voltage level, allowing charging current to flow from alternator when battery voltage is low, and switching off charging current when battery is fully charged. Uses 1N2609 diode across alternator field to prevent buildup of high induced voltage when coil current is interrupted. Switching action occurs many times per second, to keep battery fully charged at all times.—"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 8-4.



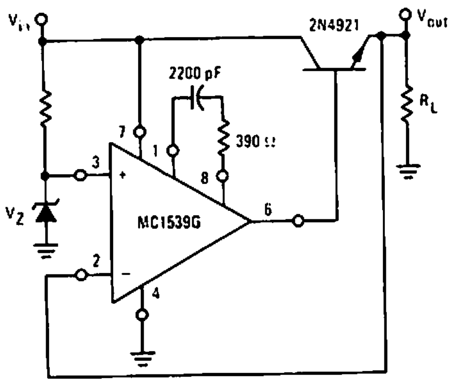
B+
ALTERNATOR OUTPUT
100
30
.05
MR322 BIAS DIODE
2N1192
2N1539
TO ALTERNATOR FIELD COIL
1N961
SENSING ZENER DIODE
15
.05 μf
30
R*T THERMISTOR
70
FEEDBACK CAPACITOR
1N2609 FIELD SUPPRESSION DIODE

ALTERNATOR VOLTAGE REGULATOR—Used to control charging rate of auto storage battery. Switching action occurs many times per second, to keep battery charge essentially constant at maximum value for optimum operation. Choice of thermistor resistance depends on slope of curve for voltage regulation vs temperature.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 8-3-2.



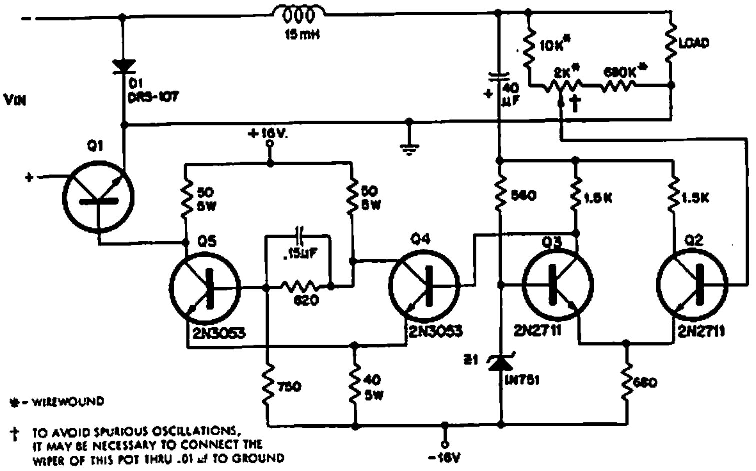
HEAT SINK
VIN
+
Q1
TIP 24
Vo 15 VOLTS
Io 40ma
+
Z2
IN746
R3
68K
Q4
2N1308
R1
4.2K
Q3
2N3906
RP
500Ω
600
25V
R4
270
R5
270
R6
270
Q2
2N3904
Z1
IN750
R7
900
5
10V
5
10V
R2
2.2K
−
−

15 V AT 40 MA—Gives about 1% regulation. Developed from design equations given in report, covering transistorized regulators having various degrees of complexity, for output voltages of 2 to 30 V.—J. G. Rogers, Simple, Inexpensive Low-Voltage Regulators, NBS Technical Note 371, National Bureau of Standards, Washington, D.C., 1968.



V_{in}
2N4921
V_{out}
2200 pF
390 Ω
R_L
7
1
8
3
+
V_Z
MC1539G
6
2
−
4

ERROR-SENSING OPAMP—Motorola opamp compares output voltage of power supply with zener reference voltage and adjusts current through series-pass transistor accordingly. Opamp derives its own operating power from input voltage. Load regulation is better than 0.1% for currents up to 300 mA.—K. Huehne, The Continuing Dominance of the Operational Amplifier, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 5–13.



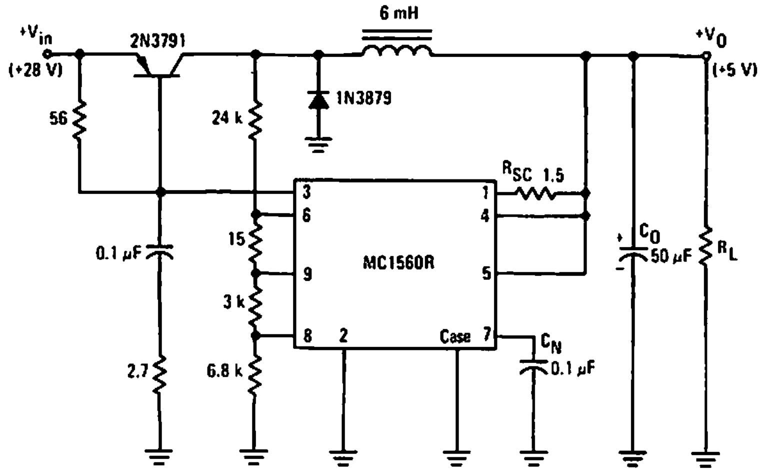
−
15 mH
10K*
LOAD
D1
DRS-107
2K*
680K*
VIN
+
40 μF
†
+16V.
Q1
+
50 5W
50 5W
560
1.5K
1.5K
Q5
.15μF
Q4
Q3
Q2
620
2N3053
2N3053
2N2711
2N2711
Z1
IN751
750
40 5W
680
−16V

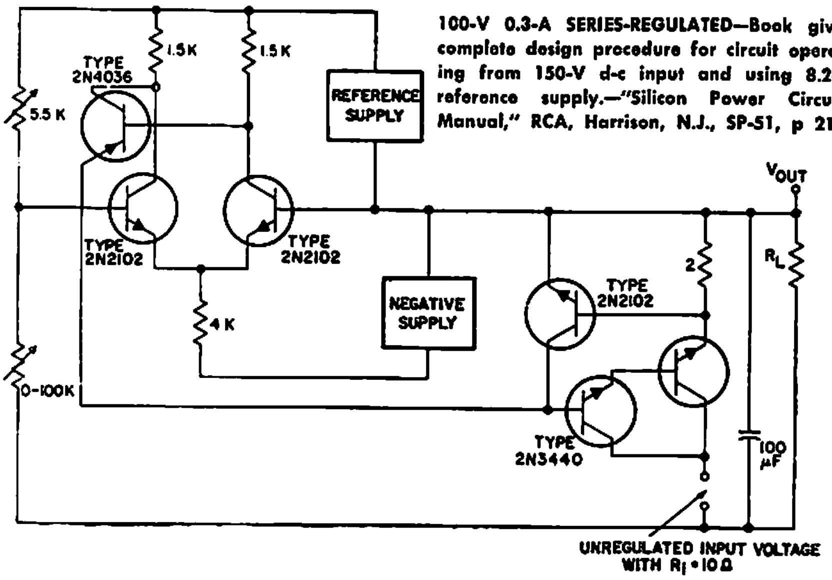
*- WIREWOUND

† TO AVOID SPURIOUS OSCILLATIONS, IT MAY BE NECESSARY TO CONNECT THE WIPER OF THIS POT THRU .01 μf TO GROUND

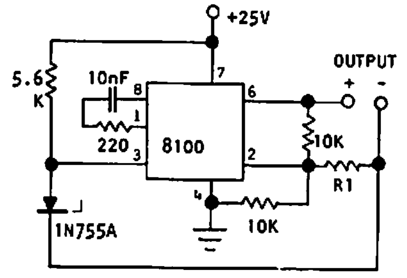
PWM SWITCHING REGULATOR—With d-c input varying 25 V above and below 250 V, output is constant at 200 V within fraction of volt for 2-A load current. Efficiency varies with power output, in range of 80% to 92%. Differential amplifier Q2-Q3 senses proportional amount of ripple present in output, compares it with reference zener, and delivers error signal to trigger Q4-Q5 for turning series transistor Q1 on or off in accordance with load requirements. Off and on times of Schmitt trigger change with load, as also does switching frequency, to give pulse width modulation.—Pulse Width Modulated Switching Regulator, Delco Radio, Kokomo, Ind., No. 39, 1967.

SWITCHING REGULATOR—Self-oscillating circuit using IC voltage regulator serves as efficient switching regulator.—D. Kesner, Voltage Regulators—Old and New, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 14–20.

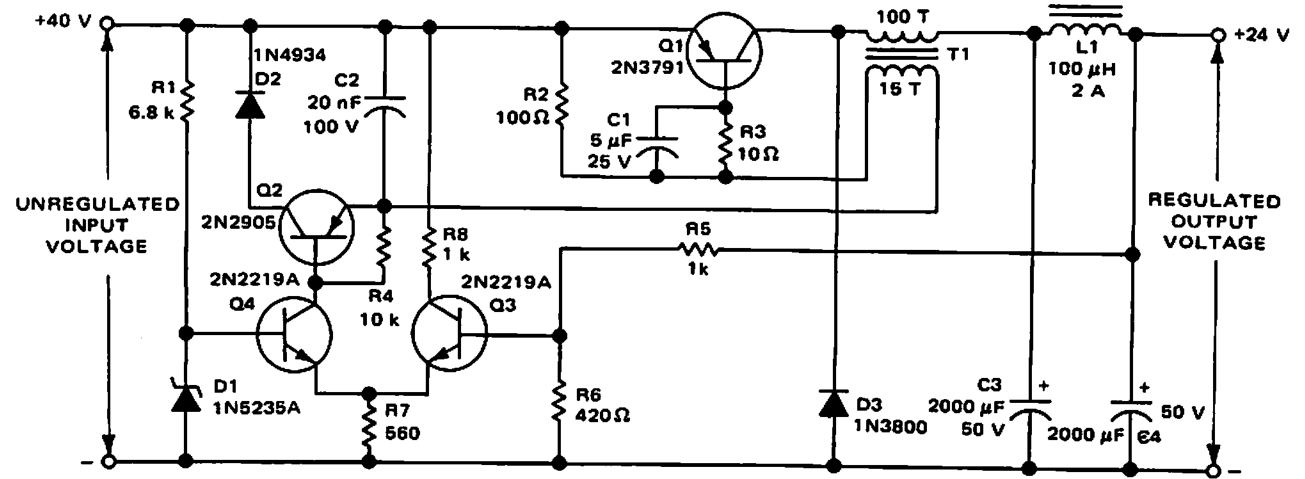

+Vin
(+28 V)
2N3791
6 mH
+V0
(+5 V)
56
24 k
1N3879
RSC 1.5
3
6
9
8
2
Case
7
1
4
5
MC1560R
0.1 μF
15
3 k
2.7
6.8 k
CN
0.1 μF
C0
50 μF
RL


1.5K
1.5K
TYPE
2N4036
5.5 K
REFERENCE SUPPLY
TYPE
2N2102
TYPE
2N2102
VOUT
4 K
NEGATIVE SUPPLY
TYPE
2N2102
2
RL
0-100K
TYPE
2N3440
100 μF
UNREGULATED INPUT VOLTAGE
WITH Rl = 10Ω

100-V 0.3-A SERIES-REGULATED—Book gives complete design procedure for circuit operating from 150-V d-c input and using 8.2-V reference supply.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 215.


+25V
OUTPUT
+
-
5.6 K
10nF
8
1
220
3
7
8100
6
2
4
10K
R1
1N755A
10K

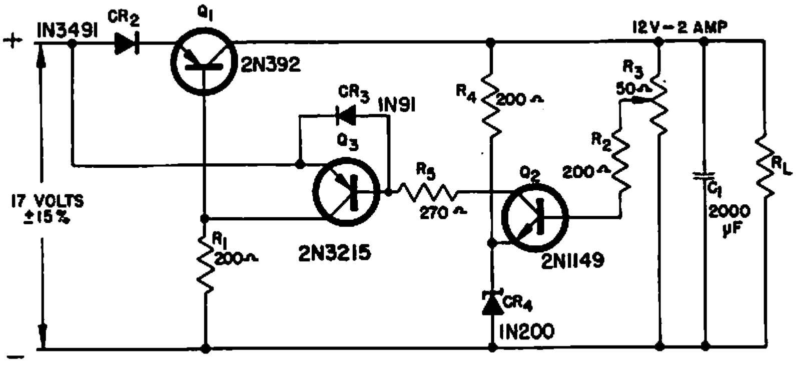
LONG-LINE COMPENSATION—Used to overcome poor regulation in system having remote sensing of many physically scattered loads. Insertion of small amount of positive feedback into IC regulator causes voltage to increase in proportion to increasing load current.—Applying the Model 8100 Monolithic Voltage Regulator, Optical Electronics, Tucson, Ariz., No. 10141.


+40 V
R1
6.8 k
1N4934
D2
C2
20 nF
100 V
R2
100Ω
Q1
2N3791
C1
5 μF
25 V
R3
10Ω
100 T
15 T
T1
L1
100 μH
2 A
+24 V
UNREGULATED INPUT VOLTAGE
Q2
2N2905
R8
1 k
R5
1k
REGULATED OUTPUT VOLTAGE
2N2219A
Q4
R4
10 k
2N2219A
Q3
D1
1N5235A
R7
560
R6
420Ω
D3
1N3800
C3
2000 μF
50 V
2000 μF
C4
50 V
-
-

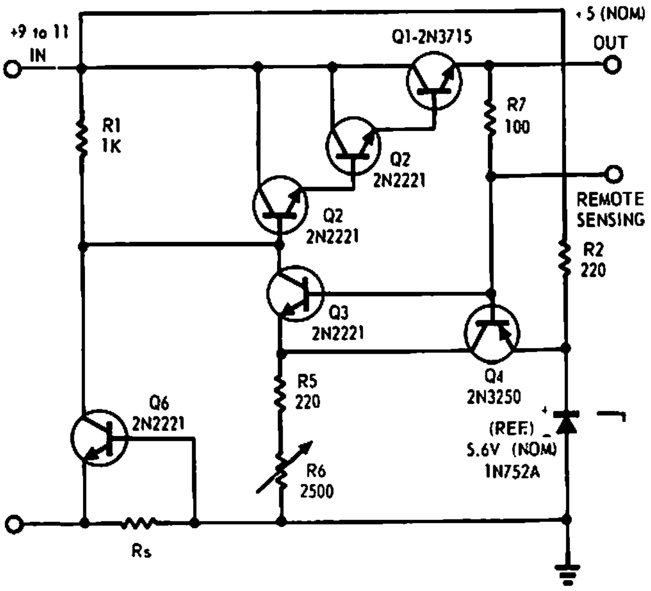
24-V D-C SWITCHING VOLTAGE REGULATOR—Output is held within 1% of 24 V for load currents of 100 mA to 2 mA and for supply voltage changes of 10% above and below 40 V d-c. Power switching transistor Q1 is controlled by feedback winding of T1 and transistors Q2-Q4. Q3 and Q4 serve as differential voltage comparator with zener D1. Maximum frequency of blocking oscillator action is 6 kHz at highest input voltages.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–15.

T1 — FERROX CUBE POT CORE
3622P-3E; 100 T PRIMARY
15 T SECONDARY

PROPORTIONAL VOLTAGE REGULATOR—Provides 12 V at 2 A while d-c input varies as much as 15% in either direction from 17 V. Voltage proportional to output is compared to that of reference diode CR4, differential signal is amplified by Q3, and resulting output is used to control current through series transistor Q1 in such a way that voltage across load remains constant. Best suited for applications requiring very low internal impedance to a-c load currents.—Pulse Width Modulated Voltage Regulator, Delco Radio, Kokomo, Ind., No. 9B, 1965.



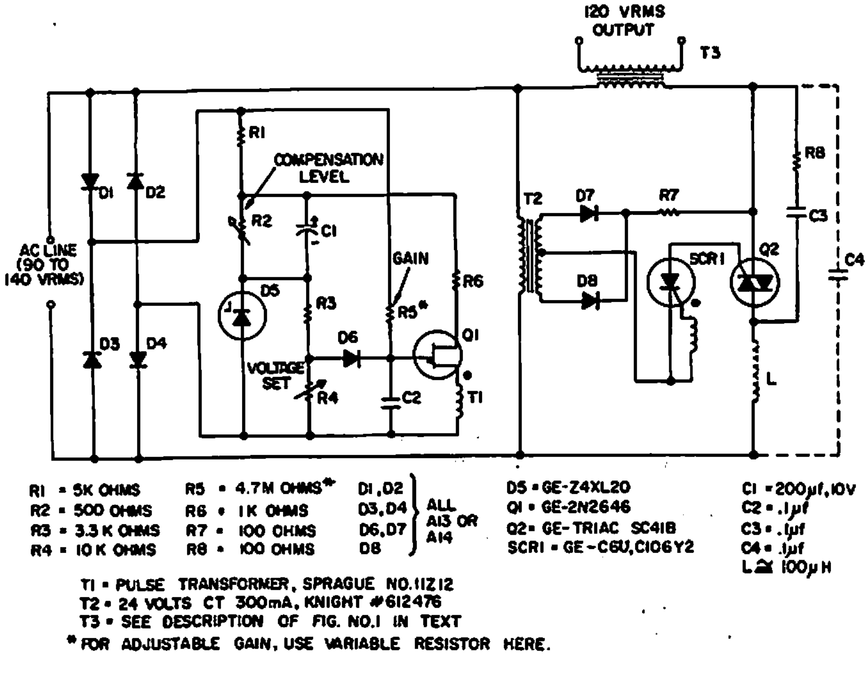
+
IN3491
CR2
Q1
2N392
12V-2 AMP
CR3
IN91
R4
200 Ω
R3
50 Ω
R2
200 Ω
Q3
R5
270 Ω
Q2
17 VOLTS ±15%
R1
200 Ω
2N3215
2N1149
CR4
IN200
C1
2000 μF
RL
−



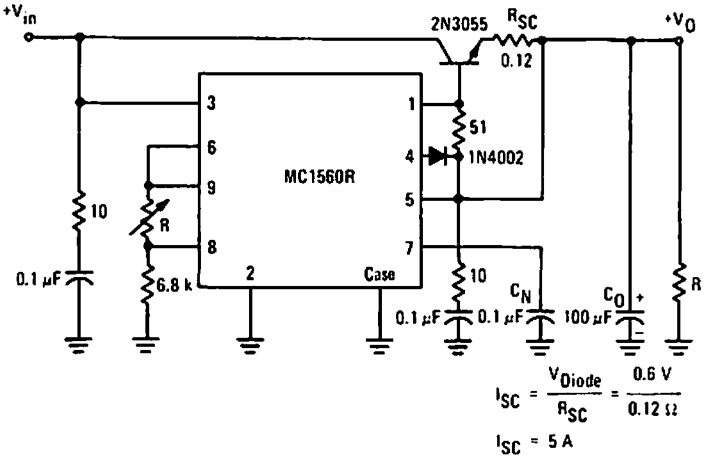
+9 to 11
IN
+5 (NOM)
OUT
Q1-2N3715
R1
1K
R7
100
Q2
2N2221
Q2
2N2221
REMOTE SENSING
R2
220
Q3
2N2221
Q4
2N3250
Q6
2N2221
R5
220
(REF)
5.6V (NOM)
1N752A
R6
2500
Rs

5 V FOR HIGH-CURRENT LOGIC—High-power pass transistor Q1 permits handling large currents up to limits of heat sink used. Includes short-circuit protection and connection for remote sensing of output voltage. Location of Rs ahead of control loop damps supply impedance and improves stability.—R. C. Sanford, 'Perfect' Regulator Satisfies Logic Circuits, *EDN*, Dec. 15, 1969, p 51–53.

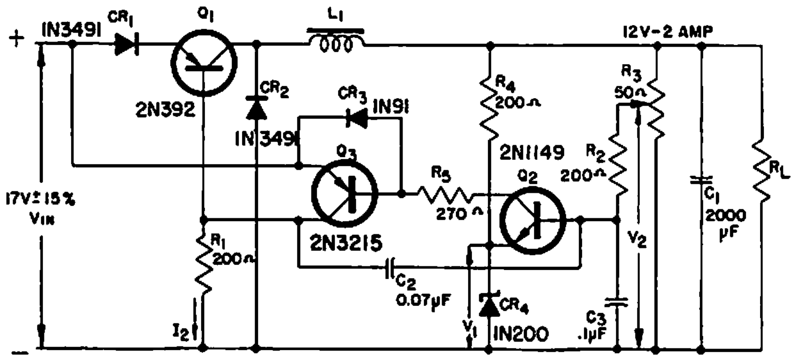
500-W A-C LINE VOLTAGE REGULATOR—Holds a-c output voltage within 2% of 120 V for a-c input line voltage range of 90–140 V. Uses phase-controlled triac Q2 to adjust voltage applied to output transformer. Control circuit is basic ramp-and-pedestal type for scr. Article gives adjustment procedure and load options. Some types of a-c motors may not function properly on output because of its harmonic content.—S. Zimmer, 500 Watt AC Line Voltage and Power Regulator, General Electric, Syracuse, N.Y., No. 201.12, 1965.



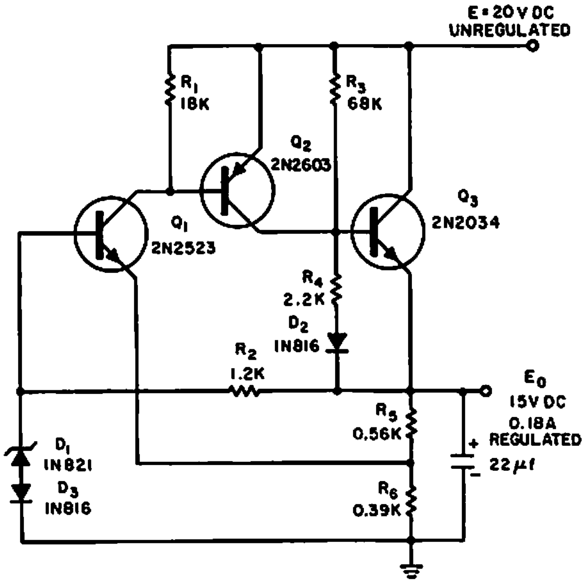
120 VRMS OUTPUT
T3
R1
COMPENSATION LEVEL
D1
D2
R2
C1
AC LINE (90 TO 140 VRMS)
GAIN
R6
D5
R3
R5*
D6
Q1
VOLTAGE SET
R4
C2
T1
D3
D4
T2
D7
R7
D8
SCR1
Q2
R8
C3
C4
L
R1 = 5K OHMS
R2 = 500 OHMS
R3 = 3.3 K OHMS
R4 = 10 K OHMS
R5 = 4.7M OHMS*
R6 = 1K OHMS
R7 = 100 OHMS
R8 = 100 OHMS
D1, D2, D3, D4, D6, D7, D8 ALL A13 OR A14
D5 = GE-Z4XL20
Q1 = GE-2N2646
Q2 = GE-TRIAC SC41B
SCR1 = GE-C6U, C106Y2
C1 = 200μf, 10V
C2 = .1μf
C3 = .1μf
C4 = .1μf
L ≅ 100μH
T1 = PULSE TRANSFORMER, SPRAGUE NO. 11Z12
T2 = 24 VOLTS CT 300mA, KNIGHT #612476
T3 = SEE DESCRIPTION OF FIG. NO. 1 IN TEXT
*FOR ADJUSTABLE GAIN, USE VARIABLE RESISTOR HERE.


+V_in
2N3055
R_SC
0.12
+V_O
3
1
6
9
8
2
4
5
7
Case
MC1560R
51
1N4002
10
R
6.8 k
0.1 µF
10
0.1 µF
C_N
0.1 µF
C_O
100 µF
+
R_L
I_SC = V_Diode / R_SC = 0.6 V / 0.12 Ω
I_SC = 5 A

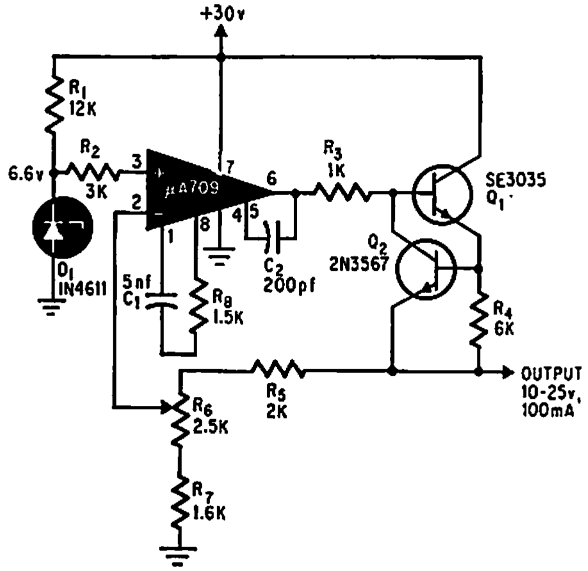
NPN CURRENT BOOSTER—Uses Motorola IC voltage regulator with npn transistor to boost maximum output current available at regulated output voltage above 500-mA rating for IC alone. Input voltage is 20 V.—D. Kesner, Voltage Regulators—Old and New, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 14–20.


+
IN3491
CR1
Q1
2N392
L1
12V-2 AMP
CR2
IN3491
CR3
IN91
Q3
2N3215
R4
200Ω
R3
50Ω
2N1149
Q2
R2
200Ω
R5
270Ω
R_L
C1
2000 µF
17V±15%
V_IN
R1
200Ω
I2
C2
0.07µF
CR4
IN200
V1
C3
.1µF
V2
–

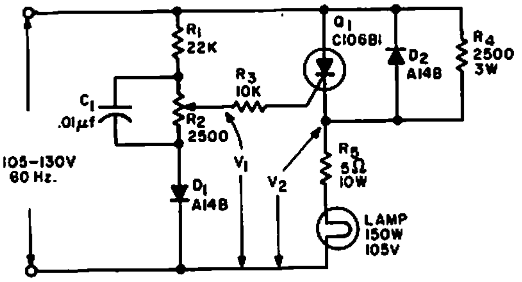
SWITCHING VOLTAGE REGULATOR—Gives efficiencies as high as 80%, even when d-c input voltage is several times larger than d-c output voltage. Q2-Q3 form free-running mvbr whose duty cycle is function of current flowing into base of Q2. Mvbr turns Q1 on and off in such a manner as to keep voltage across load constant. Report gives design criteria. Operates satisfactorily only when ripple in source and load voltages is at frequency substantially below switching frequency of regulator.—Pulse Width Modulated Voltage Regulator, Delco Radio, Kokomo, Ind., No. 9B, 1965.


E=20V DC
UNREGULATED
R1
18K
R3
68K
Q2
2N2603
Q1
2N2523
Q3
2N2034
R4
2.2K
D2
IN816
R2
1.2K
E0
15V DC
0.18A
REGULATED
R5
0.56K
R6
0.39K
+
22µf
D1
IN821
D3
IN816

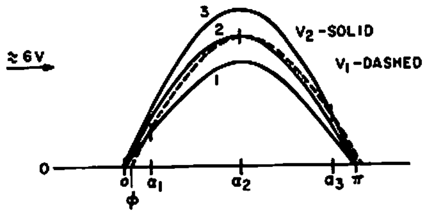
SHORT-CIRCUIT STABLE—Provides stability over wide temperature range, with no more components than for non-short-circuit-stable voltage regulator. Regulation from no load to 180 mA is 0.7%. Regulation for 15% change in unregulated 20-V supply is also 0.7%. Article gives design equations.—R. L. Moser, Self-starting Voltage Regulator is Short-circuit Stable, *Electronic Design*, Feb. 15, 1965, p 79–81.


+30v
R1
12K
R2
3K
6.6v
3
2
7
6
µA709
1
8
4
5
R3
1K
SE3035
Q1
Q2
2N3567
D1
IN4611
5nf
C1
R8
1.5K
C2
200pf
R4
6K
OUTPUT
10-25v,
100mA
R5
2K
R6
2.5K
R7
1.6K

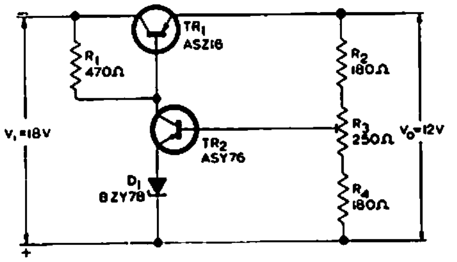
IC VOLTAGE-RAISING REGULATOR—Operates from single positive supply, using Fairchild µA709 opamp, and delivers precisely regulated output voltage above that of temperature-dependent zener reference D1. Q2 provides surge protection when output exceeds 100 mA. Article contains 13 other IC opamp application circuits.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


R1
22K
C1
.01µf
R2
2500
R3
10K
Q1
C106B1
D2
A14B
R4
2500
3W
105-130V
60 Hz.
V1
V2
D1
A14B
R5
5Ω
10W
LAMP
150W
105V

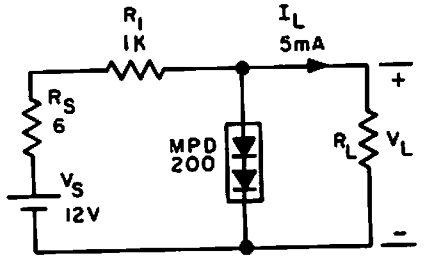
LAMP VOLTAGE REGULATOR—Simple regulator, designed for specific 150-W lamp, measures lamp power by measuring filament resistance. During negative half-cycle, lamp receives full current through D2. At beginning of positive half-cycle, R4 provides bias current to develop voltage V2 that depends on lamp resistance, for comparison with reference voltage V1. Phase-controlled triggering of scr occurs when V1 is more positive than V2. Drawbacks are 13-W power dissipation in R4 and R5 and flicker noticeable with peripheral vision.—E. K. Howell, Small Scale Integration in Low Cost Control Circuits, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 20.



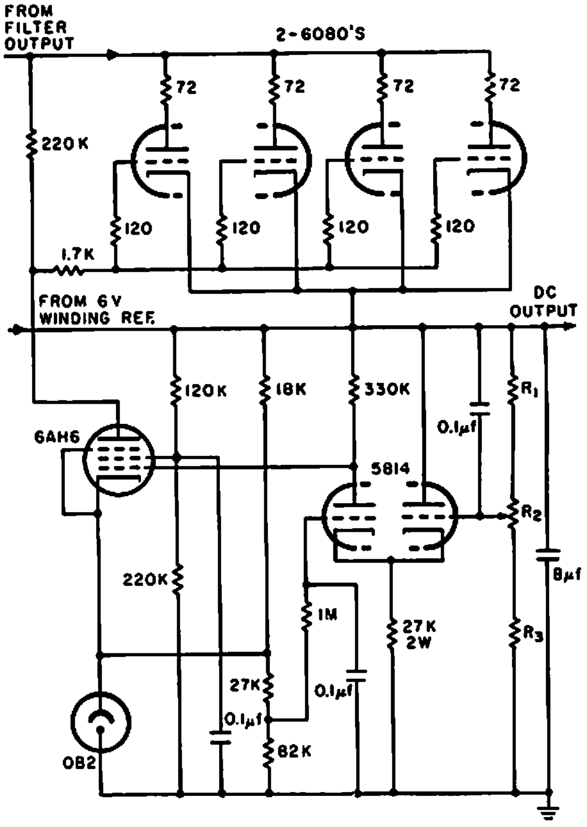
CASE 1 : LAMP R LOW, TRIGGERING ADVANCES TO α_1 ; LOW LINE VOLTAGE.
CASE 2 : LAMP R NORMAL, TRIGGERING AT α_2 ; MEDIAN LINE VOLTAGE.
CASE 3 : LAMP R HIGH, TRIGGERING AT α_3 ; HIGH LINE VOLTAGE.
NOTE: GAIN & STABILITY CONTROLLED BY C_1 (PHASE SHIFT ϕ)


TR1
ASZ16
R1
470Ω
R2
180Ω
V1=18V
TR2
ASY76
R3
250Ω
V0=12V
D1
BZY78
R4
180Ω
+

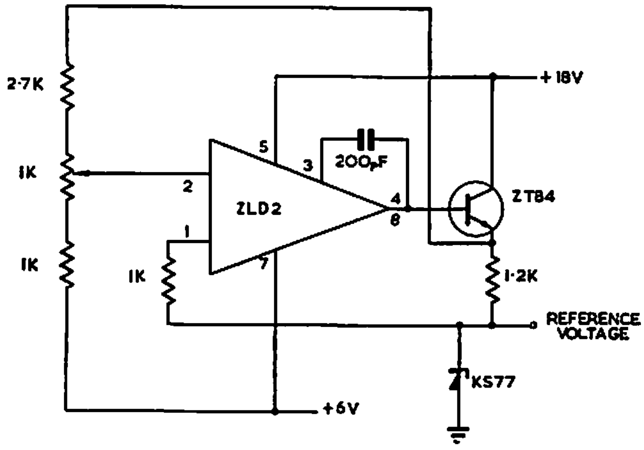
12 V AT 50 MA FROM 18 V D-C—Two-transistor series regulator uses zener as reference. Use of amplifier stage TR2 to control series transistor reduces output impedance of supply and thus greatly improves stabilization factor. —"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 43.


R1
1K
IL
5mA
RS
6
VS
12V
MPD
200
RL
VL
+
-

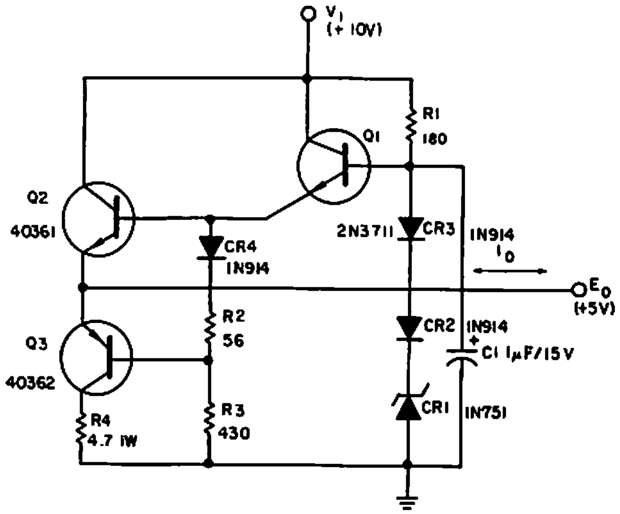
12-V DIODE REGULATOR—Multi-pellet diode provides good regulation (about 0.5%) against change in voltage source for transistors. Output impedance of regulator is about 5 ohms, and efficiency is high compared to that of resistive voltage-divider regulator for same impedance.—Silicon Multi-Pellet Diodes MPD200/MPD300/MPD400, General Electric, Syracuse, N.Y., No. 75.42, 1966.


FROM
FILTER
OUTPUT
2-6080'S
72
72
72
72
220K
120
120
120
120
1.7K
FROM 6V
WINDING REF.
DC
OUTPUT
120K
18K
330K
R1
0.1µf
6AH6
5814
R2
220K
8µf
1M
27K
2W
R3
27K
0.1µf
0.1µf
OB2
82K

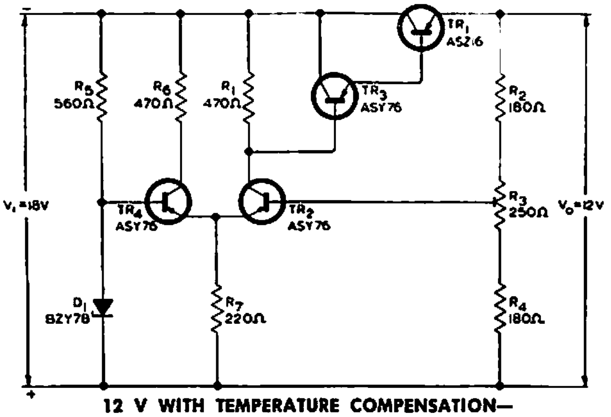
REDUCING OUTPUT IMPEDANCE—Modification of series-regulator power supply for servo provides 400 mA with dynamic impedance below 1 ohm at frequencies from 1 Hz to 100 kHz. Two-stage double-differentiated d-c amplifier is referenced to constant d-c voltage of OB2. Corrected output signal of 6AH6 final amplifier is applied to grids of series regulators to keep output voltage constant within very narrow limits despite load changes.—E. G. Fonda, Servo-Modification Improved Dynamic Impedance, *Electronic Design*, Feb. 3, 1964, p 48 and 50.


2·7K
IK
IK
IK
ZLD2
1
2
3
4
5
7
8
200pF
ZT84
1·2K
+18V
+6V
KS77
REFERENCE VOLTAGE

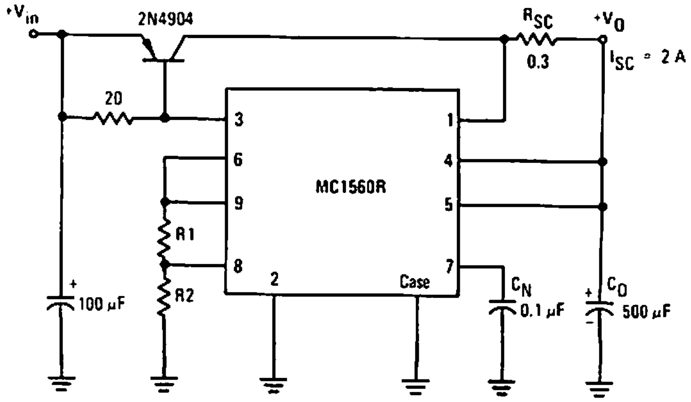
REFERENCE VOLTAGE SUPPLY—Reference voltage is generated by Ferranti KF77 reference voltage package, which has high stability if operating current is held within 5% of 5 mA. Combination of Ferranti ZLD2 IC differential amplifier and npn transistor provide this current with required stability over temperature range of −50 to 120 C and with large variations in d-c supply voltages. Potentiometer is adjusted to give 5 mA accurately through KS77.—Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 16.


V$_I$ (+10V)
R1 180
Q1 2N3711
Q2 40361
Q3 40362
CR4 IN914
CR3 IN914
CR2 IN914
CR1 IN751
R2 56
R3 430
R4 4.7 IW
C1 1μF/15V
I$_O$
E$_O$ (+5V)

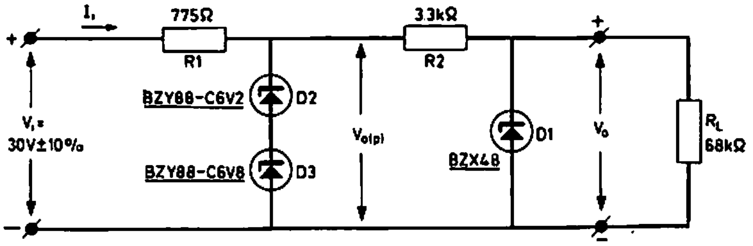
COMBINATION CURRENT SOURCE AND SINK—Provides constant 5-V output by sinking up to 100 mA when output voltage rises above 5 V. Zener CR1 establishes value of output voltage.—R. S. Conero, Voltage Regulator is a Current Source or Sink, *Electronic Design*, June 7, 1970, p 102.


−
+
V$_i$=18V
V$_o$=12V
R$_5$ 560Ω
R$_6$ 470Ω
R$_1$ 470Ω
TR$_1$ ASZ16
TR$_3$ ASY76
R$_2$ 180Ω
TR$_4$ ASY76
TR$_2$ ASY76
R$_3$ 250Ω
D$_1$ BZY78
R$_7$ 220Ω
R$_4$ 180Ω

12 V WITH TEMPERATURE COMPENSATION—Effects of temperature changes on TR2 are reduced to about 0.045% per deg C by adding similar transistor TR4 to series regulator. Arrangement does not compensate for effect of temperature changes on zener, however.—"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p. 44.

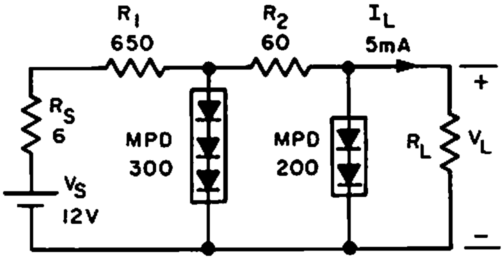

+V$_{in}$
2N4904
R$_{SC}$ 0.3
+V$_O$
I$_{SC}$ = 2 A
20
MC1560R
3
6
9
8
2
Case
1
4
5
7
R1
R2
100 μF
C$_N$ 0.1 μF
C$_O$ 500 μF

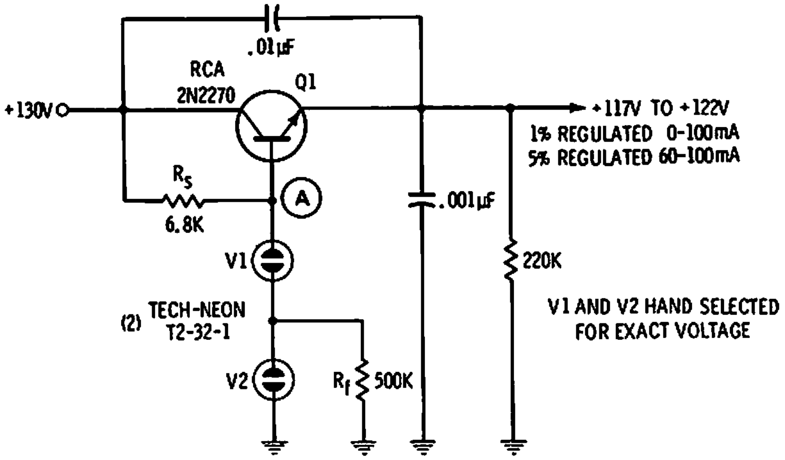
PNP CURRENT BOOSTER—Uses Motorola IC voltage regulator with pnp transistor to boost maximum output current above 500-mA rating for IC alone. Input voltage is 20 V.—D. Kesner, Voltage Regulators—Old and New, "State-of-the-Art—Linears in Action," Motorola, Phoenix, Ariz., 1969, p 14–20.


I₁
775Ω
R1
3.3kΩ
R2
+
V₁=
30V±10%
BZY88-C6V2
D2
BZY88-C6V8
D3
Vo(p)
BZX48
D1
Vo
RL
68kΩ
−

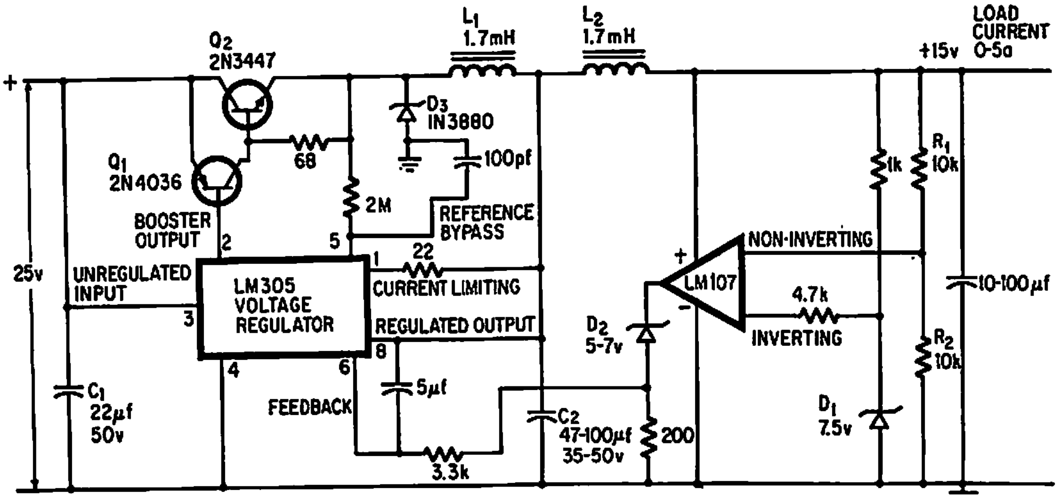
PRESTABILIZATION—Two zeners stabilize input voltage, to make output zener much more effective in holding output voltage at desired 6.5 V d-c.—High-Stability Reference Diodes BZX47 Family, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 331, 1968.

DOUBLE SHUNT-DIODE 12-V REGULATOR—Use of two multi-pellet diodes instead of one gives much better regulation (about 0.07%) against voltage source changes.—Silicon Multi-Pellet Diodes MPD200/MPD300/MPD400, General Electric, Syracuse, N.Y., No. 75.42, 1966.

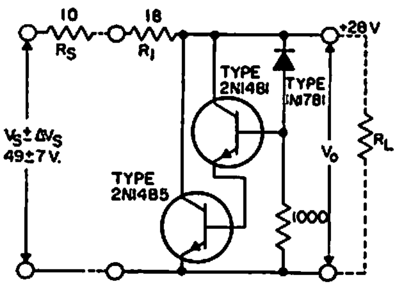

R1
650
R2
60
IL
5mA
RS
6
VS
12V
MPD
300
MPD
200
RL
VL
+
−


.01µF
RCA
2N2270
Q1
+130V
+117V TO +122V
1% REGULATED 0-100mA
5% REGULATED 60-100mA
RS
6.8K
A
.001µF
V1
220K
(2) TECH-NEON
T2-32-1
V1 AND V2 HAND SELECTED
FOR EXACT VOLTAGE
V2
Rf
500K

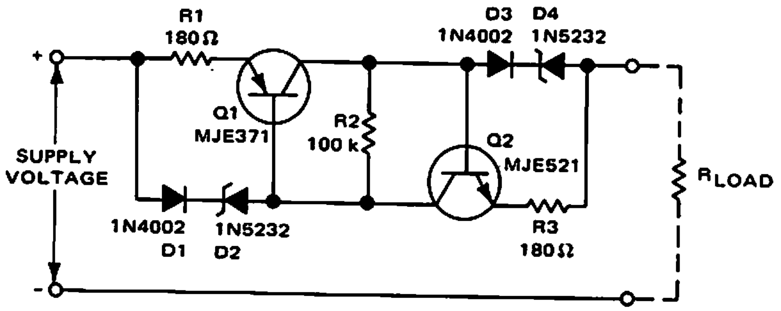
TWO-NEON VOLTAGE REGULATOR—Output voltage is sum of maintaining voltages of neons minus 0.6 V junction drop of transistor.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 35.


L1
1.7mH
L2
1.7mH
LOAD
CURRENT
+15v 0-5a
Q2
2N3447
D3
IN3880
+
100pf
Q1
2N4036
68
2M
REFERENCE
BYPASS
1k
R1
10k
BOOSTER
OUTPUT
2
5
NON-INVERTING
1
22
25v
UNREGULATED
INPUT
LM305
VOLTAGE
REGULATOR
CURRENT LIMITING
+
LM107
−
4.7k
10-100µf
3
REGULATED OUTPUT
D2
5-7v
INVERTING
R2
10k
4
6
8
5µf
C1
22µf
50v
FEEDBACK
C2
47-100µf
35-50v
200
D1
7.5v
3.3k

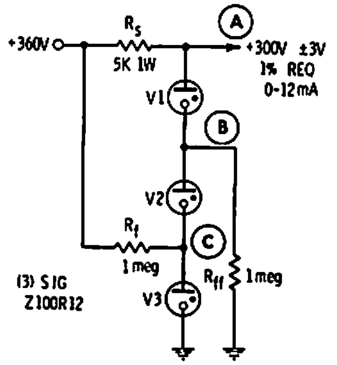
15-V SWITCHING REGULATOR—Operates at 20-kHz switching rate. Shunt opamp provides additional d-c loop voltage gain of up to 100,000 for maintaining d-c load voltage within few microvolts for load currents of 0 to 5 A.—W. L. Brown, IC's Save Power, Boost Efficiency of Regulated Power Supplies, *Electronics*, July 20, 1970, p 94–97.


10
18
RS
R1
+28V
TYPE 2N1481
TYPE 1N781
VS ± ΔVS
49±7V.
Vo
RL
TYPE 2N1485
1000

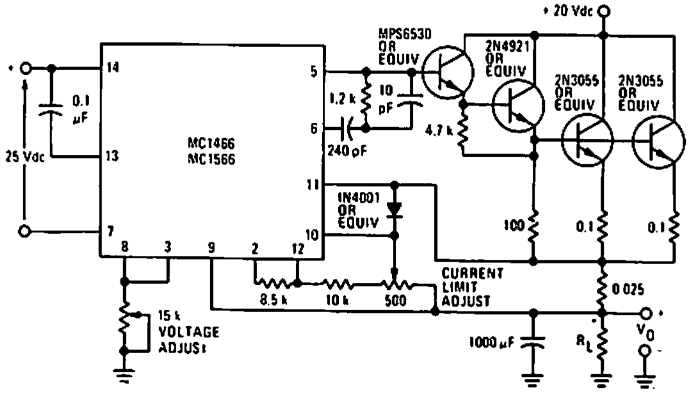
28-V SHUNT REGULATOR—Holds output voltage constant within 0.0125 V of 28 V for input changes of 7 V above and below 49 V d-c. Book gives detailed design procedure. —"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 218.


R1
180Ω
D3 D4
1N4002 1N5232
+
SUPPLY VOLTAGE
Q1
MJE371
R2
100 k
Q2
MJE521
RLOAD
1N4002
D1
1N5232
D2
R3
180Ω
-

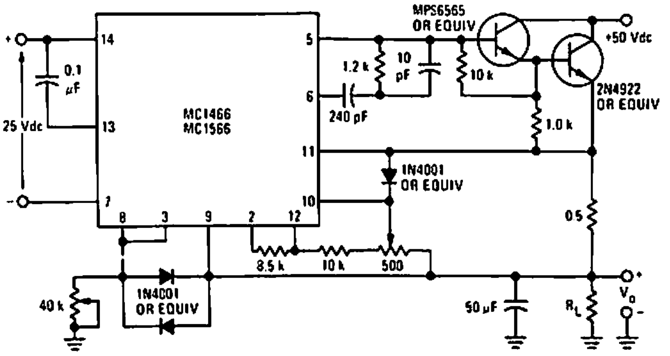
70-MA D-C TWO-TERMINAL CURRENT REGULATOR—Provides current regulation only if supply voltage is greater than sum of voltage drops across all four diodes, which is 12.5 V for components shown. Level of current regulation is diode drop divided by value of R1 (or R3). Circuit can be operated at regulated current levels up to 700 mA if supply voltage is above 13.5 V.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–25.


RS
+360V
5K 1W
A
+300V ±3V
1% REG
0-12mA
V1
B
V2
Rf
1 meg
C
Rff
1meg
V3
(3) SIG
Z100R12

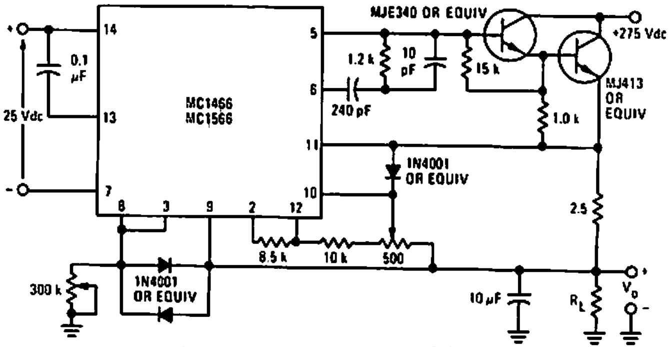
300-V THREE-LAMP REGULATOR—Neon lamps are initially ionized by current through 1-meg shunts which also permit use of supply voltage less than sum of breakdown voltages of lamps.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 30.


+20 Vdc
MPS6530 OR EQUIV
2N4921 OR EQUIV
2N3055 OR EQUIV
2N3055 OR EQUIV
+
0.1 µF
25 Vdc
14
13
7
MC1466
MC1566
5
6
11
10
1.2 k
10 pF
240 pF
4.7 k
1N4001 OR EQUIV
100
0.1
0.1
8
3
9
2
12
8.5 k
10 k
500
CURRENT LIMIT ADJUST
0.025
15 k
VOLTAGE ADJUST
1000 µF
RL
Vo
+
-

0–5 V D-C AT 10 A—Uses precision wide-range Motorola IC voltage and current regulator, with output voltage and current both adjustable. Both line and load voltage regulation are 0.01% plus 1 mV, and current regulation is 0.1% plus 1 mA.—Precision Wide-Range Voltage and Current Regulator MC1566L/MC1466L, Motorola, Phoenix, Ariz., DS9130, 1969.

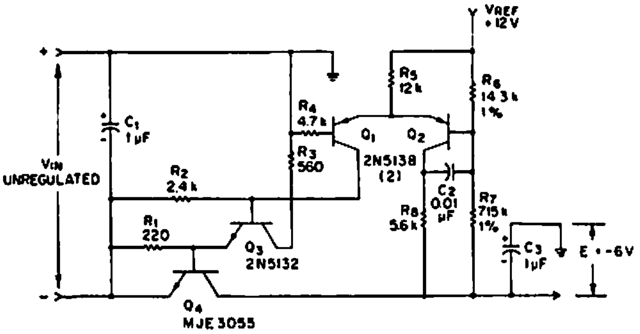

MPS6565 OR EQUIV
+50 Vdc
+
0.1 µF
25 Vdc
-
14
13
7
MC1466
MC1566
5
6
11
10
1.2 k
10 pF
10 k
240 pF
2N4922 OR EQUIV
1.0 k
1N4001 OR EQUIV
0.5
8
3
9
2
12
8.5 k
10 k
500
40 k
1N4001 OR EQUIV
50 µF
RL
Vo

0–40 V D-C AT 0.5 A—Gives laboratory power supply performance, with line and load voltage regulation 0.01% plus 1 mV, using Motorola IC for stepping up 25-V d-c source voltage.—Precision Wide-Range Voltage and Current Regulator MC1566L/MC1466L, Motorola, Phoenix, Ariz., DS9130, 1969.

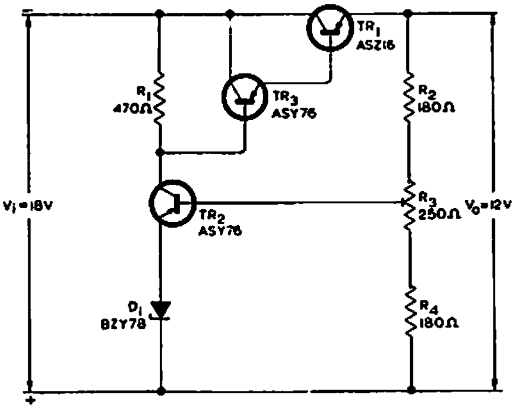

MJE340 OR EQUIV
+275 Vdc
+
0.1 µF
25 Vdc
-
14
13
7
MC1466
MC1566
5
6
11
10
1.2 k
10 pF
15 k
240 pF
1.0 k
MJ413 OR EQUIV
1N4001 OR EQUIV
2.5
8
3
9
2
12
8.5 k
10 k
500
300 k
1N4001 OR EQUIV
10 µF
RL
Vo

0–250 V D-C AT 0.1 A—Gives laboratory power supply performance, with line and load voltage regulation 0.01% plus mV, using Motorola IC for stepping up 25-V d-c source voltage.—Precision Wide-Range Voltage and Current Regulator MC1566L/MC1466L, Motorola, Phoenix, Ariz., DS9130, 1969.

IMPROVING EFFICIENCY—Permits lower unregulated input voltage to series-pass regulator for low-voltage (5–6 V) regulated output for IC circuits. With circuit shown, no device junctions are in series with output to subtract from available output voltage. Pnp differential pair Q1-Q2 drives pseudo-Darlington Q3-Q4. Handles loads up to 300 mA with 1% regulation.—W. G. Jung, High-Efficiency Series Regulator, *EEE*, April 1970, p 100–101.

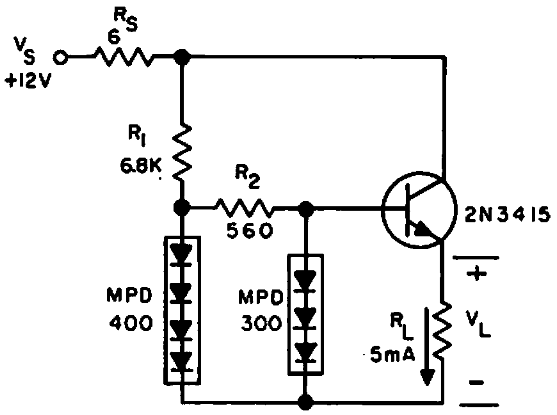


VREF +12V
+
−
VIN UNREGULATED
C1 1 μF
R2 2.4 k
R1 220
R4 4.7 k
R3 560
Q1
Q2
2N5138 (2)
R5 12 k
R6 14.3 k 1%
C2 0.01 μF
R8 5.6 k
R7 715 k 1%
C3 1 μF
E = −6V
Q3 2N5132
Q4 MJE 3055



−
+
TR1 ASZ16
TR3 ASY76
TR2 ASY76
R1 470Ω
R2 180Ω
R3 250Ω
R4 180Ω
D1 BZY78
Vi=18V
Vo=12V

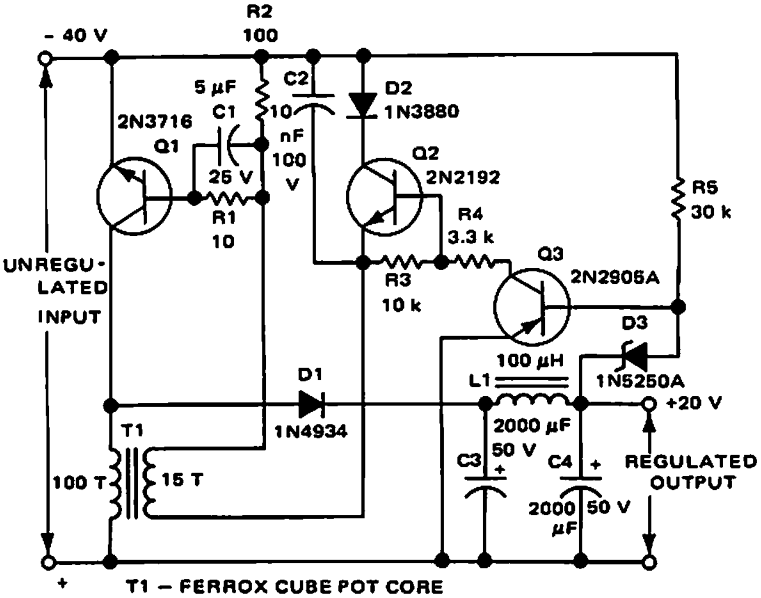
12 V AT 360 MA FROM 18 V D-C—Addition of third transistor amplifier stage to series regulator boosts maximum load current, although at expense of increased ripple in output.—"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 43.



VS +12V
RS 6
R1 6.8K
R2 560
MPD 400
MPD 300
2N3415
RL 5mA
VL
+
−

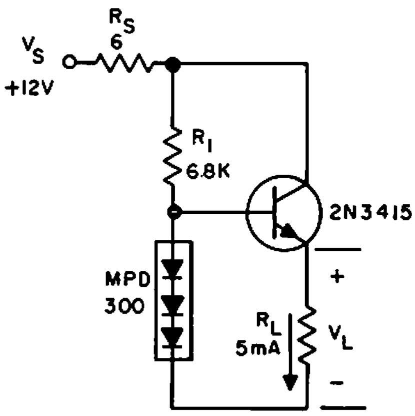
12-V DOUBLE-DIODE WITH EMITTER-FOLLOWER—Addition of transistor improves both efficiency and regulation in transistor supply applications.—Silicon Multi-Pellet Diodes MPD-200/MPD300/MPD400, General Electric, Syracuse, N.Y., No. 75.42, 1966.

20-V D-C INVERTED OUTPUT—Switching voltage regulator regulates output within 1% for load currents of 50 mA to 1 A. Drive for blocking oscillator Q1-T1 is obtained by feedback from output. Operating frequency of 6 kHz provides optimum compromise between output ripple (which decreases at higher frequencies for given filter) and transistor power dissipation which along with core loss increases with frequency. Voltage regulation is 1% for 10% input voltage changes at output currents up to 1 A.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–18.

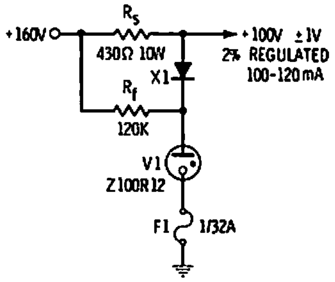


− 40 V
R2 100
C2 10 nF 100 V
D2 1N3880
5 μF C1 25 V
2N3716 Q1
R1 10
Q2 2N2192
R4 3.3 k
R3 10 k
Q3 2N2905A
R5 30 k
D3 1N5250A
UNREGULATED INPUT
D1 1N4934
100 μH L1
+20 V
T1
100 T
15 T
C3 2000 μF 50 V
C4 2000 μF 50 V
REGULATED OUTPUT
+

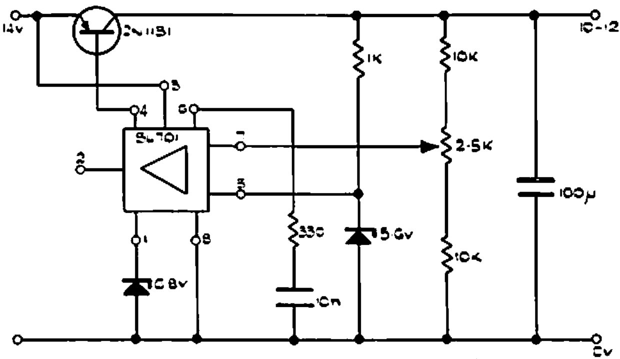
T1 – FERROX CUBE POT CORE
3622P-3E; PRIMARY – 100 TURNS
SECONDARY – 15 TURNS


R_S
6
V_S
+12V
R_1
6.8K
2N3415
MPD
300
+
R_L
5mA
V_L
-

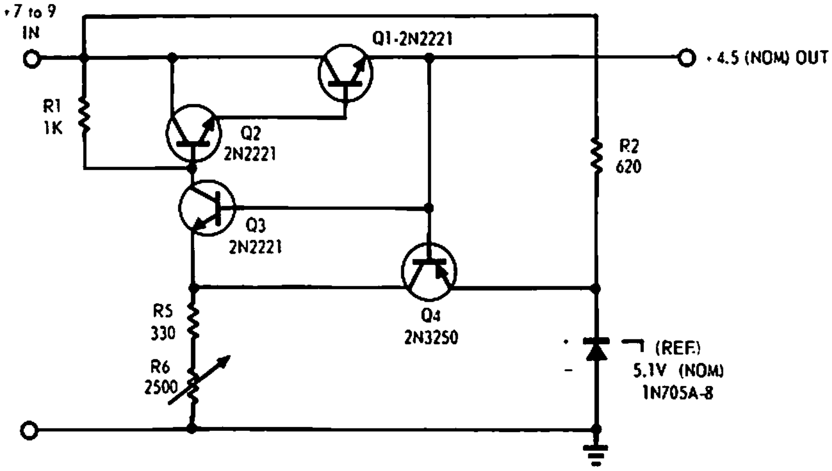
DIODE REGULATOR WITH EMITTER-FOLLOWER—Addition of cathode follower to diode voltage regulator gives higher efficiency and better regulation against voltage source changes. Output impedance is higher than with diode alone.—Silicon Multi-Pellet Diodes MPD200/MPD300/MPD400, General Electric, Syracuse, N.Y., No. 75.42, 1966.


+160V
R_S
430Ω 10W
+100V ±1V
2% REGULATED
100-120mA
X1
R_f
120K
V1
Z100R12
F1
1/32A

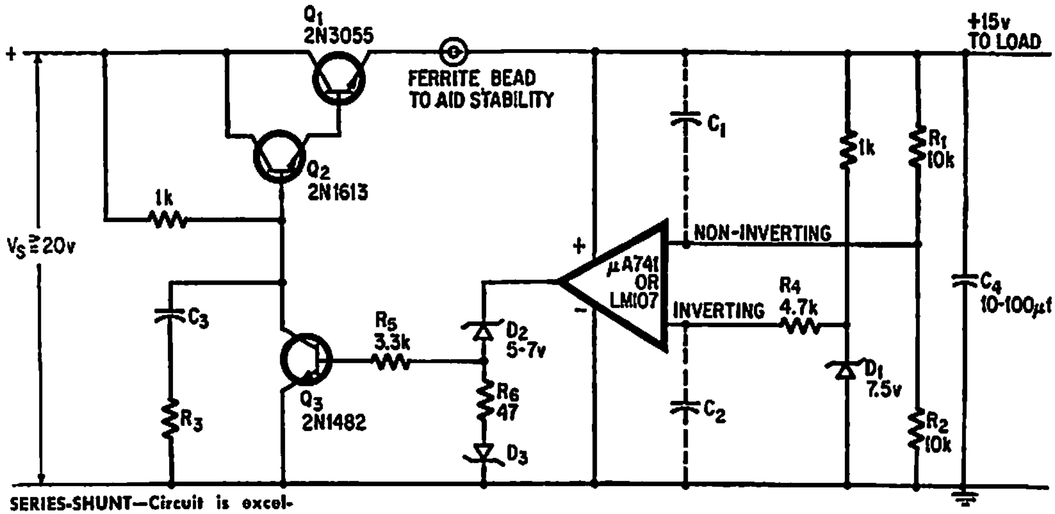
HIGH-CURRENT NEON REGULATOR—Permits load currents many times maximum rating of lamp. Fuse protects neon if load is removed or reduced. X1 may be any 400-piv 200-mA or better diode.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 32.


14v
2N1131
3
4
6
SL701
2
7
5
1
8
10-12v
1K
10K
2·5K
10K
100μ
330
10n
5·6v
6·8v
0v

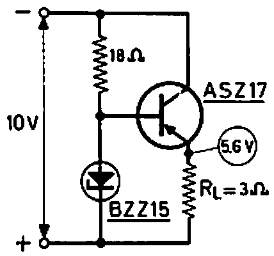
10–12 V STABILIZED FROM 14 V—Uses Plessey high-gain d-c amplifier with two zeners and series regulator transistor to give stabilization ratio of over 1,000 and output resistance less than 0.1 ohm.—R. C. Foss and B. J. Green, The SL700 Series and Applications, Plessey, Swindon, England, No. 7.


+7 to 9
IN
Q1-2N2221
+4.5 (NOM) OUT
R1
1K
Q2
2N2221
R2
620
Q3
2N2221
Q4
2N3250
R5
330
R6
2500
+
-
(REF.)
5.1V (NOM)
1N705A-8

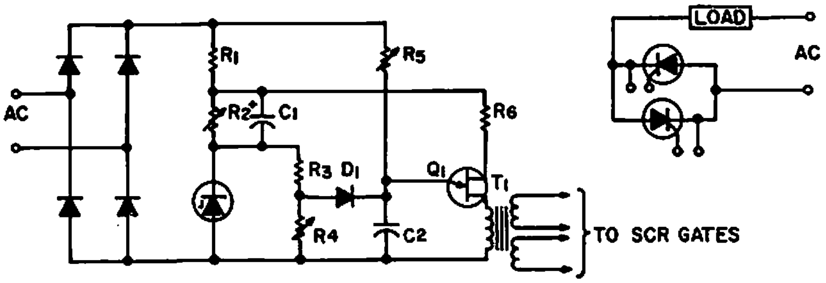
4.5 V AT 100 MA FOR LOGIC—Simple regulator acts like trigger having two stable states, corresponding to conditions before and after change in load current. Darlington pass transistor acts as emitter-follower. Developed for logic circuits in which line regulation is much less important than load regulation.—R. C. Sanford, 'Perfect' Regulator Satisfies Logic Circuits, *EDN*, Dec. 15, 1969, p 51–53.


Q_1
2N3055
FERRITE BEAD
TO AID STABILITY
+15v
TO LOAD
+
Q_2
2N1613
1k
$V_S ≧ 20v$
C_1
1k
R_1
10k
NON-INVERTING
+
μA741
OR
LM107
-
INVERTING
R_4
4.7k
C_4
10-100μf
C_3
R_5
3.3k
D_2
5-7v
D_1
7.5v
Q_3
2N1482
R_6
47
C_2
R_3
D_3
R_2
10k

15-V LINEAR SERIES-SHUNT—Circuit is excellent for use when desired output is large fraction of source voltage. Dashed lines indicate optional components, with C2 for noise suppression and C1 for loop stabilization. Values of C1, C3, and R3 are chosen to minimize load voltage overshoot when driving fast-switching load.—W. L. Brown, IC's Save Power, Boost Efficiency of Regulated Power Supplies, *Electronics*, July 20, 1970, p 94–97.

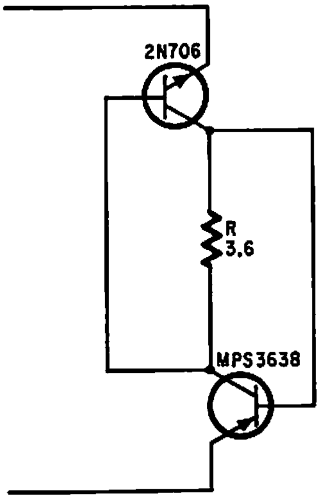

18Ω
ASZ17
10V
5.6V
BZZ15
$R_L=3Ω$
−
+

5.6 V D-C WITH ZENER AND TRANSISTOR—Power transistor, mounted on same heat sink with power zener, but electrically insulated, provides voltage stabilization at higher power level than zener alone.—Zener Diodes and Their Applications, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1966.

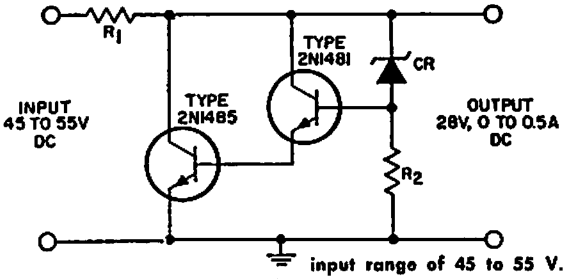

AC
R1
R2
C1
R3
D1
R4
R5
R6
Q1
T1
C2
TO SCR GATES
LOAD
AC

R_1 : 5000Ω R_3:3300 R_5 :5M C_1 : 200μf, 10v Q_1 : 2N2646 C_2 : 0.1μf
R_2: 500Ω R_4:10K R_6 : 1K

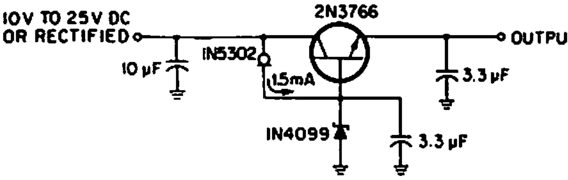
A-C LINE VOLTAGE COMPENSATION—Ramp-and-pedestal control depends on relationship between pedestal height and peak point voltage of ujt. Cosine-shaped ramp provides good regulation over wide range of a-c input voltages.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 13.


2N706
R
3.6
MPS3638

REGULATING BELOW ZENER MINIMUM—Two transistors and resistor provide zener action for regulating voltages below 2-V zener minimum. Arrangement has 1.5-V zener characteristic and zero dynamic impedance from 20 to 150 mA. When applied voltage is greater than 1.4 V, both transistors begin to conduct.—H. Stadler, Transistor "Zener" has Zero Dynamic Impedance, *Electronics*, March 31, 1969, p 86—87.

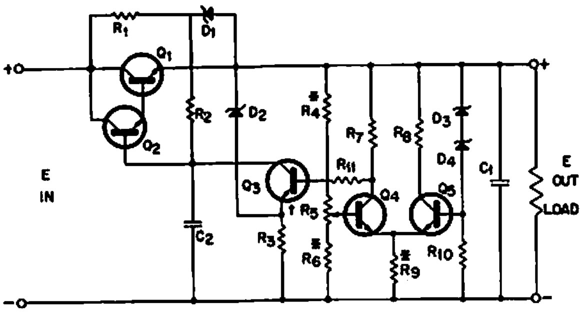

R1
INPUT
45 TO 55V
DC
TYPE
2N1485
TYPE
2N1481
CR
OUTPUT
28V, 0 TO 0.5A
DC
R2

28-V SHUNT—Simple two-transistor shunt-type regulator holds output voltage constant within 0.5% for load currents up to 0.5 A, over d-c input range of 45 to 55 V. CR is 27-V reference diode, R1 is 28, and R2 is 1,000.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 516.


10V TO 25V DC
OR RECTIFIED
10 μF
IN5302
15mA
2N3766
OUTPUT
3.3 μF
IN4099
3.3 μF

EXTENDING ZENER RANGE—Constant-current diode added to conventional zener of series regulator extends range of reference voltage, for handling wide range of input voltages. With values shown, regulator delivers 40 mA at nominal 6 V d-c.—P. Kestenbaum, Fixed Bias Extends Zener Range, *EEE*, May 1970, p 103—104.

R_1 −1K 5 Watt
R_2 −5.6K
R_3 −68K 1 Watt
*R_4 −6.34K ½ Watt
†R_5 −5K Pot.
*R_6 −191K 1 Watt
R_7 −5600Ω
R_8 −5600Ω
*R_9 −121K 1 Watt
R_{10}−150K

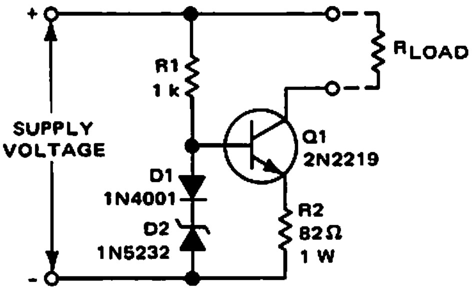

R1
D1
Q1
+
Q2
R2
D2
R4
R7
R8
D3
D4
E
IN
Q3
R11
Q4
Q5
C1
E
OUT
LOAD
R5
C2
R3
R6
R9
R10
−

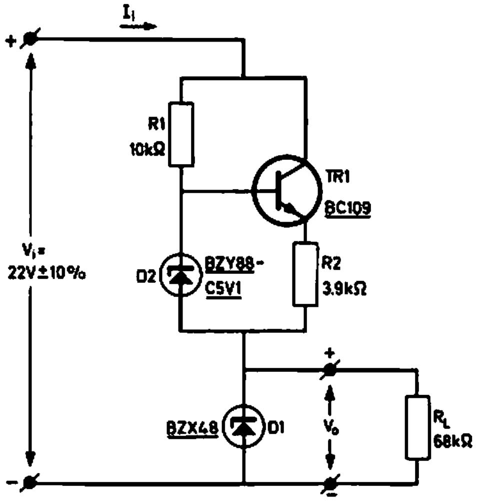
R_{11}−120K
D_1 −IN1767
D_2 −IN4735A
D_3 −IN4735A
D_4 −IN4734A
Q_1 −DTS413
Q_2 −2N3439
Q_3 −2N2711
Q_4 Q_5 −2N2712
C_1 −5mfd 450V
C_2 −0.01mfd 1 KV

* DENOTES HIGH-STABILITY FIXED FILM RESISTORS
† WIRE WOUND LOW TEMPERATURE COEFFICIENT

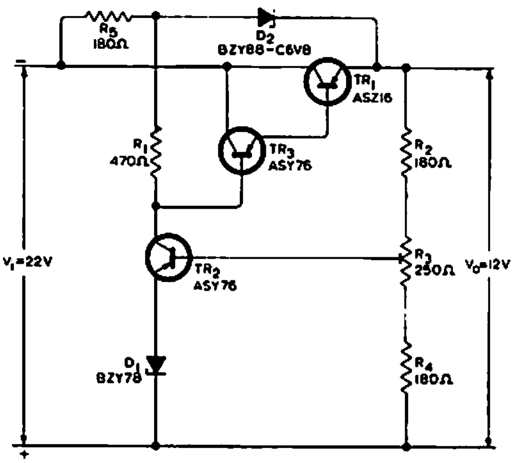
SERIES D-C VOLTAGE REGULATOR—Provides output of 290 V d-c for loads up to 600 mA, with regulation better than 0.5% for 15% change in 320-V d-c input voltage. Report describes sensing and correcting operation of circuit in detail. Circuit is not overload-proof.—DC Voltage Regulator With High Voltage Silicon Transistors, Delco Radio, Kokomo, Ind., No. 38, 1966.

70-MA D-C CURRENT REGULATOR WITH ZENER—Combination of 5.6-V zener and value of R2 gives current regulation at 70 mA for load range of 10 to 50 ohms. Value of R1 is not critical. Circuit has good regulation with temperature.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–24.

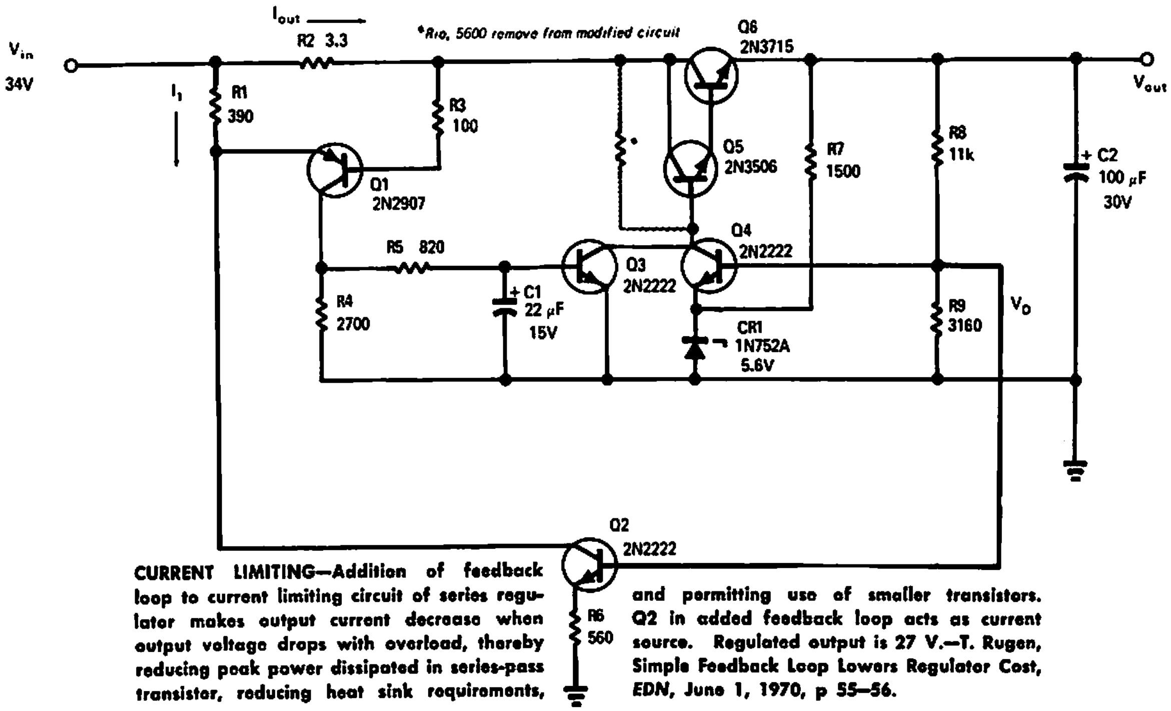

+
-
SUPPLY VOLTAGE
R1
1 k
RLOAD
Q1
2N2219
D1
1N4001
D2
1N5232
R2
82Ω
1 W


I1
+
-
V1=
22V±10%
R1
10kΩ
TR1
BC109
D2
BZY88-
C5V1
R2
3.9kΩ
BZX48
D1
+
V0
-
RL
68kΩ

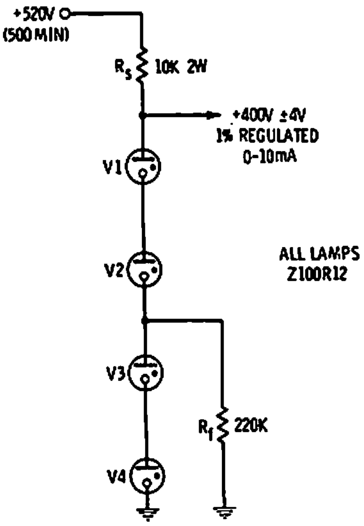
CONSTANT-CURRENT SOURCE—Use of two-terminal constant-current generator to stabilize input current permits use of lower input voltage than with voltage prestabilizer. With 2 mA supplied to reference diode D1, 100 μA is supplied to load at essentially constant 6.5 V d-c.—High-Stability Reference Diodes BZX47 Family, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 331, 1968.


R5
180Ω
D2
BZY88-C6V8
TR1
ASZ16
-
R1
470Ω
TR3
ASY76
R2
180Ω
V1=22V
TR2
ASY76
R3
250Ω
V0=12V
D1
BZY78
R4
180Ω
+

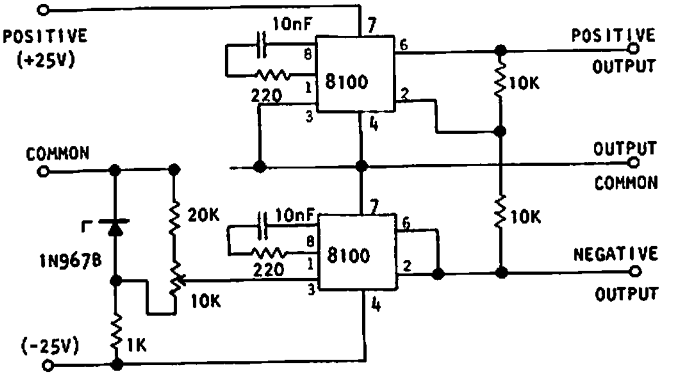
12 V AT 360 MA WITH LOW RIPPLE—Additional zener D2 acts with R5 to reduce amount of ripple fed into output through R1 and TR3, but input voltage must be increased to 22 V to allow for voltage drop across these components.—"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, p 44.


Vin
34V
Iout
R2 3.3
*R10, 5600 remove from modified circuit
Q6
2N3715
Vout
I1
R1
390
R3
100
Q1
2N2907
*
Q5
2N3506
R7
1500
R8
11k
+ C2
100 μF
30V
R5 820
Q4
2N2222
Q3
2N2222
+ C1
22 μF
15V
R4
2700
CR1
1N752A
5.6V
R9
3160
V0
Q2
2N2222
R6
560

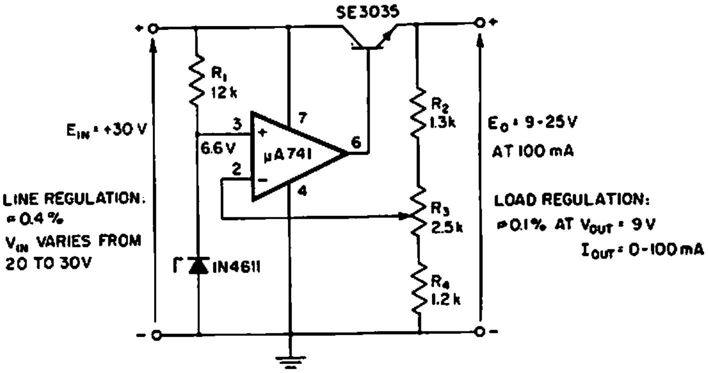
CURRENT LIMITING—Addition of feedback loop to current limiting circuit of series regulator makes output current decrease when output voltage drops with overload, thereby reducing peak power dissipated in series-pass transistor, reducing heat sink requirements, and permitting use of smaller transistors. Q2 in added feedback loop acts as current source. Regulated output is 27 V.—T. Rugen, Simple Feedback Loop Lowers Regulator Cost, *EDN*, June 1, 1970, p 55–56.


+520V (500 MIN)
R_S 10K 2W
+400V ±4V
1% REGULATED
0-10mA
V1
V2
V3
V4
ALL LAMPS
Z100R12
R_1 220K

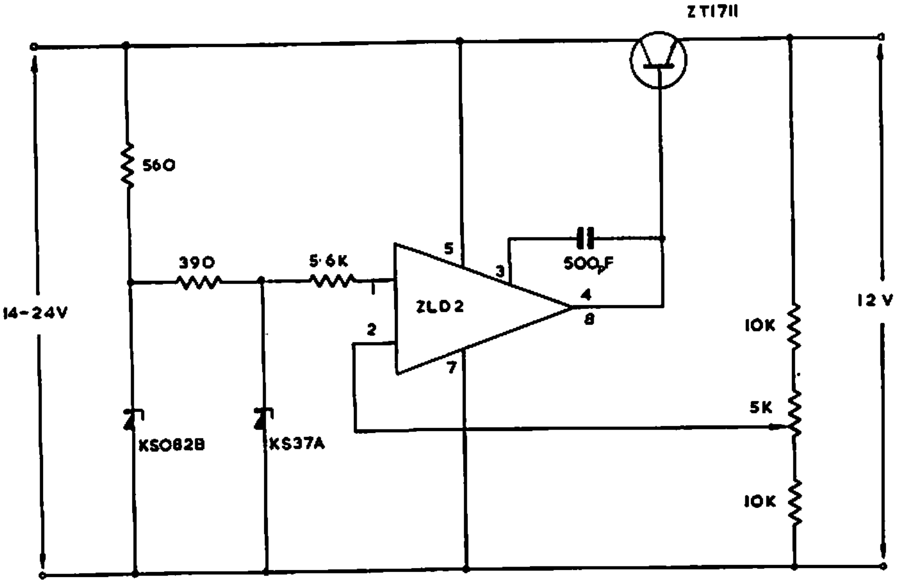
400-V NEON REGULATORS—Adding lamps in series permits higher reference voltages. Use of additional resistors lowers supply voltage requirements, as in circuit at right. All neons are Z100R12.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 30.


POSITIVE (+25V)
COMMON
(-25V) NEGATIVE
10nF
220
8100
10nF
220
8100
1N967B
20K
10K
1K
10K
10K
POSITIVE OUTPUT
OUTPUT COMMON
NEGATIVE OUTPUT

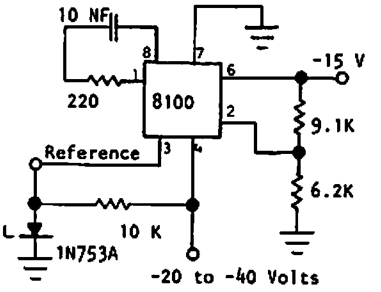
DUAL 15-V REGULATOR—Uses pair of OEI regulator chips with circuit in which only one reference is needed. One adjustment sets output voltage for both positive and negative outputs. Developed for opamps requiring tracking in which any change in negative output voltage causes corresponding change in positive output. Range is 12 to 18 V.—Applying the Model 8100 Monolithic Voltage Regulator, Optical Electronics, Tucson, Ariz., No. 10141.


SE3035
E_{IN} = +30 V
LINE REGULATION: ≈0.4%
V_{IN} VARIES FROM 20 TO 30V
R_1 12k
6.6V
μA741
IN4611
R_2 1.3k
R_3 2.5k
R_4 1.2k
E_0 = 9-25V AT 100 mA
LOAD REGULATION: ≈0.1% AT V_{OUT} = 9V
I_{OUT} = 0-100mA

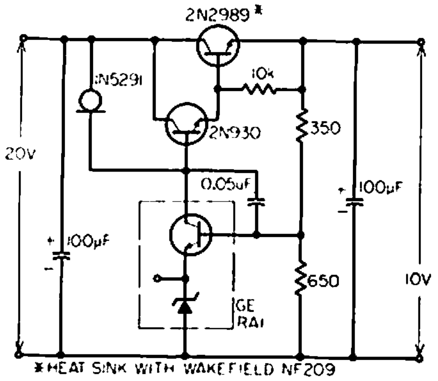
9–25 V AT 100 MA—Opamp isolates zener reference from load changes, improving load regulation. Simple divider changes output voltage. Output impedance is below 0.1 ohm.—M. English, Applications for Fully Compensated Op-Amp ICs, *EEE*, Jan. 1969, p 63–65.


ZT1711
560
390
5·6K
ZLD2
500pF
14-24V
KS082B
KS37A
10K
5K
10K
12 V

STABILIZED D-C SUPPLY—Uses Ferranti ZLD2 IC as d-c error signal amplifier, with noninverting input held at constant voltage derived from reference diodes. Inverting input receives error signal proportional to output voltage stabilized by series power transistor. Output voltage deviates from desired 12 V by only 5 mV per volt of change in input voltage.—Microlin Amplifiers ZLD2S and ZLD-2T, Ferranti Ltd., Oldham, Lancs., England, No. 11, 1967, p 15.

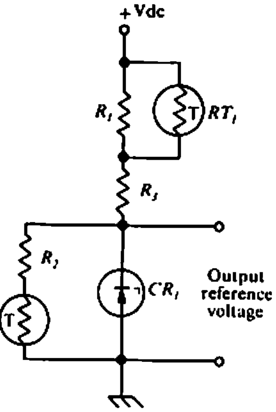

10 NF
220
8
7
6
8100
2
1
3
4
-15 V
9.1K
6.2K
Reference
10 K
L
1N753A
-20 to -40 Volts

NEGATIVE SWITCHING REGULATOR—Negative regulated output voltage is essentially same as negative reference voltage.—Applying the Model 8100 Monolithic Voltage Regulator, Optical Electronics, Tucson, Ariz., No. 10141.

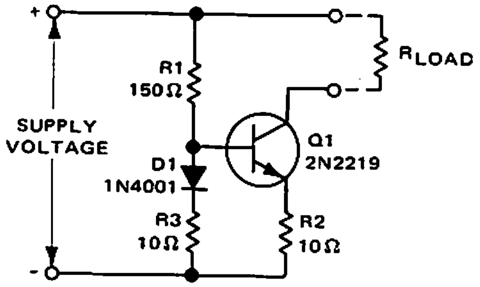

2N2989*
1N5291
10k
2N930
350
20V
0.05μF
100μF
100μF
650
10V
GE
RA1

*HEAT SINK WITH WAKEFIELD NF209

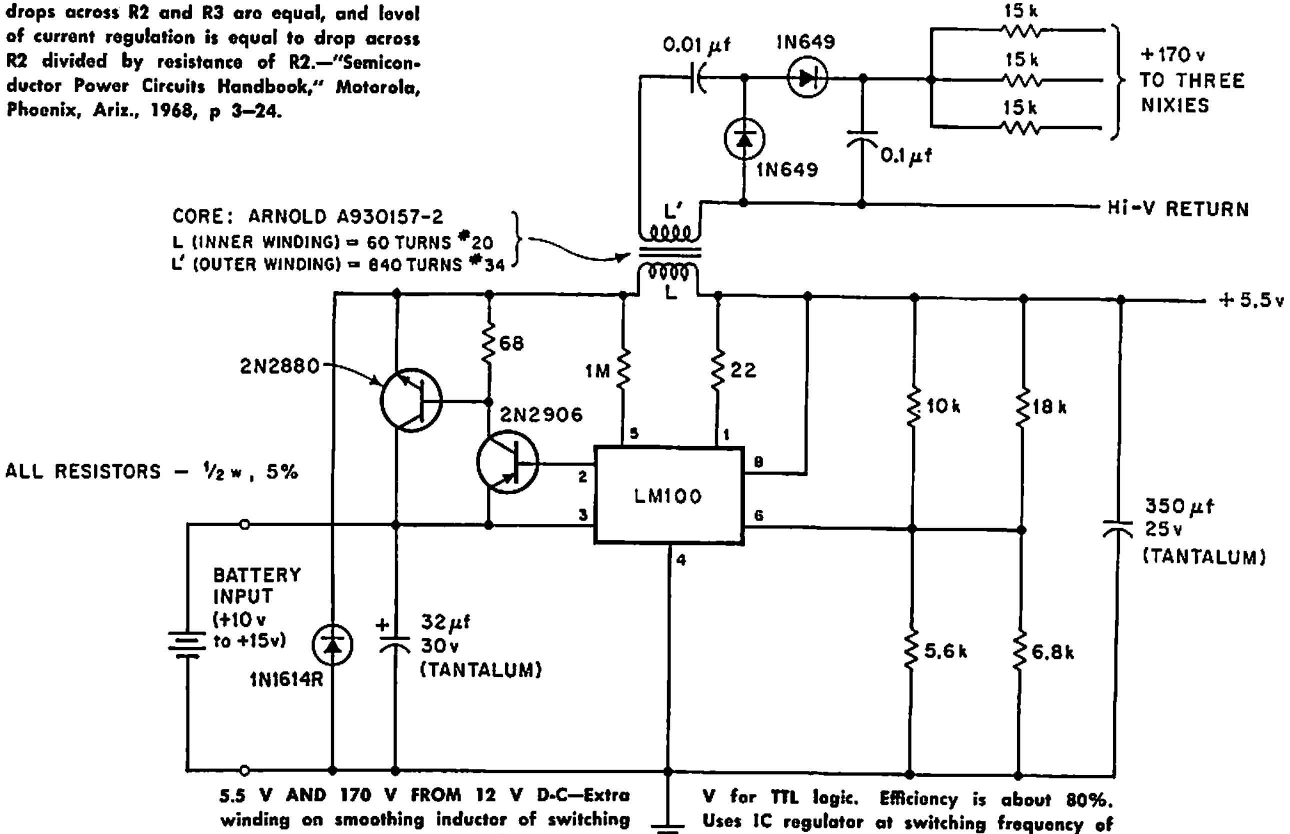
DIODE PREREGULATOR—Field-effect current-regulator diode 1N5291 functions as constant-current source that eliminates effect of input variations on bias voltage of 2N930 error amplifier in series voltage regulator. Designed for 200-mA load current. Load regulation is 0.1% from zero to full load, and line regulation is 0.02%.—A. Butvidas, CRD Simplifies Design of Voltage Regulators, *EEE*, May 1968, p 124 and 126.


+Vdc
R_1
T
RT_1
R_3
R_2
RT_2
T
CR_1
Output reference voltage

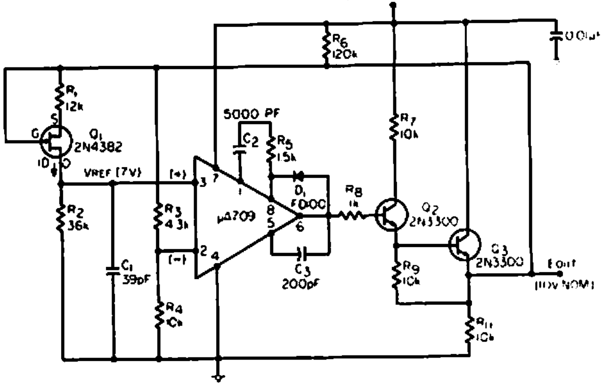
TEMPERATURE COMPENSATION FOR REFERENCE DIODE—Thermistor is used to reduce temperature drift of zener, for applications requiring precise internal reference voltage. Intended for use with zeners having inverted-parabola temperature-drift characteristic. For 1N940 zener, RT1 is 100 ohms, RT2 10K, R1 22 ohms, R2 47K, and R3 715 ohms.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 65.


+
R1
150Ω
RLOAD
SUPPLY VOLTAGE
D1
1N4001
Q1
2N2219
R3
10Ω
R2
10Ω
-

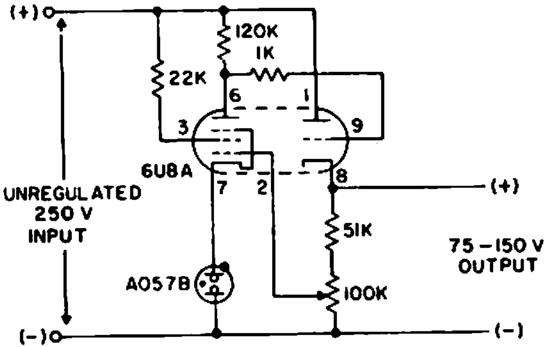
70-MA D-C CURRENT REGULATOR WITH SINGLE DIODE—Provides very good current regulation for loads from 10 to 100 ohms if supply voltage is held constant. Voltage drops across R2 and R3 are equal, and level of current regulation is equal to drop across R2 divided by resistance of R2.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–24.


15 k
0.01 μf
1N649
15 k
+170 v TO THREE NIXIES
15 k
1N649
0.1 μf
Hi-V RETURN
CORE: ARNOLD A930157-2
L (INNER WINDING) = 60 TURNS #20
L' (OUTER WINDING) = 840 TURNS #34
L'
L
+5.5 v
68
2N2880
1M
22
10 k
18 k
2N2906
5
1
8
ALL RESISTORS — ½ w, 5%
2
LM100
3
6
350 μf 25 v (TANTALUM)
4
BATTERY INPUT (+10 v to +15 v)
32 μf 30 v (TANTALUM)
1N1614R
5.6 k
6.8 k

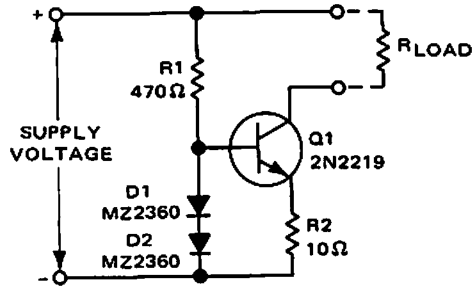
5.5 V AND 170 V FROM 12 V D-C—Extra winding on smoothing inductor of switching regulator drives voltage doubler to provide 150 to 210 V d-c needed for Nixie display tubes. Circuit also provides regulated 5.5 V for TTL logic. Efficiency is about 80%. Uses IC regulator at switching frequency of about 9.8 kHz.—D. B. Newton, Switching Regulator Drives IC's and Nixies Off Battery, *Electronics*, July 6, 1970, p 77.


VIN
(+13V TO +36V)
R6
120k
.001µF
R1
12k
S
G
Q1
2N4382
ID
D
VREF (7V)
(+)
3
7
5000 PF
C2
R5
1.5k
1
D1
FD100
R8
1k
Q2
2N3300
R7
10k
μA709
8
5
6
R2
36k
R3
4.3k
2
4
(−)
C1
39pF
C3
200pF
R9
10k
Q3
2N3300
EOUT
(10V NOM)
R4
10k
R11
10k

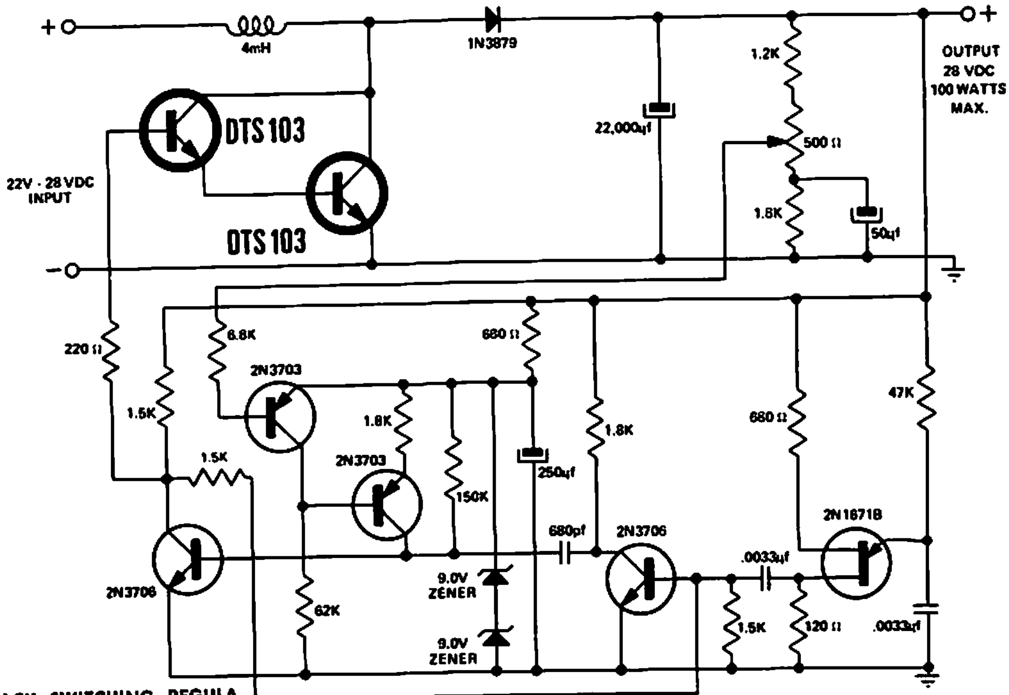
FET CONSTANT-CURRENT REFERENCE—Q1 supplies constant current to R2 to produce voltage drop as reference for d-c voltage regulator. Reference voltage can be much smaller than 6-V lower limit of most zeners. Temperature coefficient is adjustable and can either be set to low value or set to compensate for temperature effects in other circuits. Modified Darlington Q2-Q3 supplies output current up to 250 mA. Temperature coefficient depends on fet drain current.—C. N. Gold, Zenerless Regulator with Adjustable Tempco, *EEE*, Aug. 1967, p 128–129.


(+)
120K
1K
22K
6
1
3
9
6U8A
8
7
2
(+)
UNREGULATED
250 V
INPUT
51K
75 – 150 V
OUTPUT
A057B
100K
(−)
(−)

REGULATION AT LOW POWER—Neon sets reference level and its maintaining voltage establishes lower limit for voltage regulation. Potentiometer permits output voltage to be set at any value between 75 and 150 V.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 88.

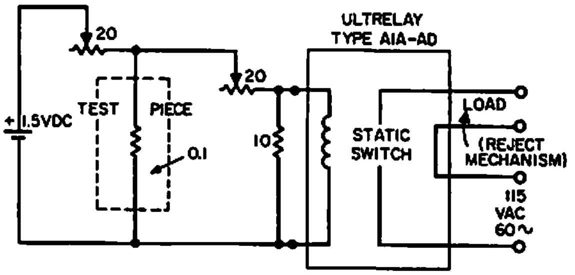

+
R1
470Ω
RLOAD
SUPPLY
VOLTAGE
Q1
2N2219
D1
MZ2360
D2
MZ2360
R2
10Ω
−

70-MA D-C CURRENT REGULATOR WITH BIASING DIODES—Current level at which regulation occurs is equal to 0.7-V drop across D2 divided by value of R2, because base-emitter voltage of Q1 matches drop across D1. Current remains essentially constant over load range of 10 to 100 ohms.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 3–24.

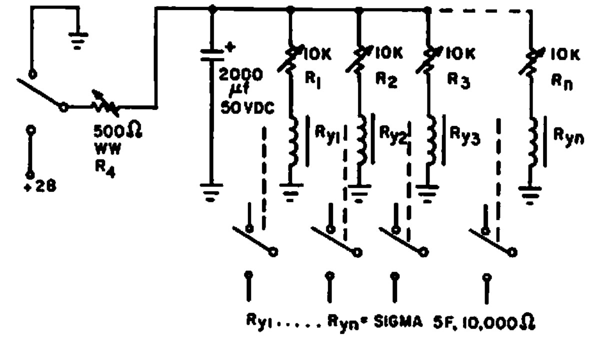

+
4mH
1N3879
+
OUTPUT
28 VDC
100 WATTS
MAX.
DTS103
DTS103
22,000µf
1.2K
500 Ω
1.8K
50µf
22V - 28 VDC
INPUT
−
220 Ω
6.8K
680 Ω
1.5K
2N3703
1.8K
1.8K
680 Ω
47K
1.5K
2N3703
150K
250µf
2N3706
680pf
2N3706
2N1671B
.0033µf
9.0V
ZENER
62K
9.0V
ZENER
1.5K
120 Ω
.0033µf

100-W 28-V FLYBACK SWITCHING REGULATOR—Provides efficient regulation by pulse width modulation at output voltages as high as 6 V above d-c input voltage. Switching rate of 9 kHz is provided by oscillator that triggers monostable mvbr, with mvbr also receiving voltage-sensing signals from output that determine pulse width. Efficiency is 87% at 80 W and better than 80% for other power outputs down to 15 W. Developed for use in aircraft.—28 Volts Flyback Regulator Switching, Delco Radio, Kokomo, Ind., No. 42, 1968.

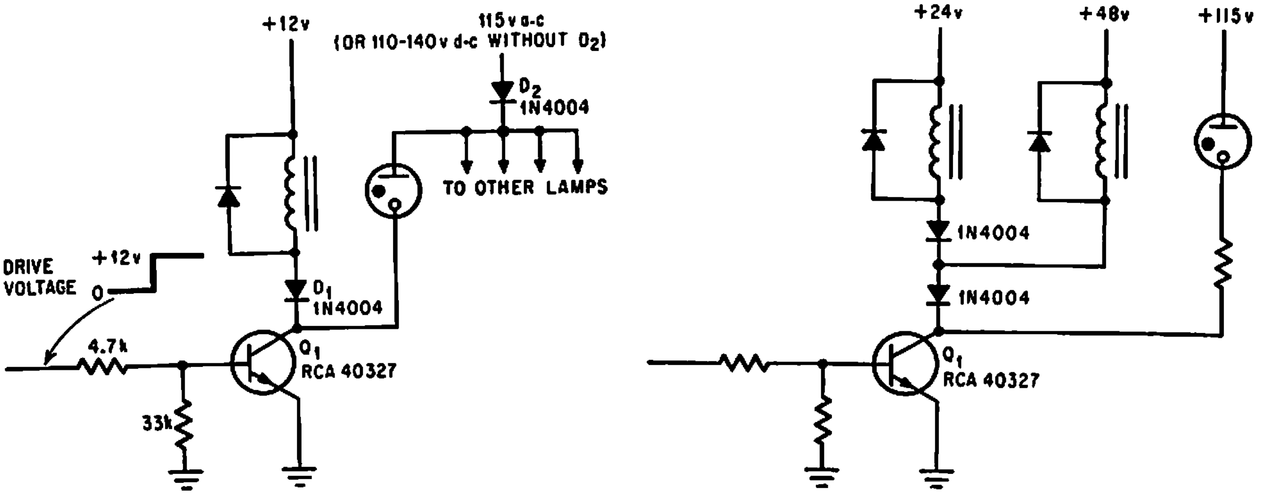
CHAPTER 72
Relay Circuits


ULTRELAY
TYPE AIA-AD
20
20
1.5VDC
TEST
PIECE
0.1
10
STATIC
SWITCH
LOAD
(REJECT
MECHANISM)
115
VAC
60~

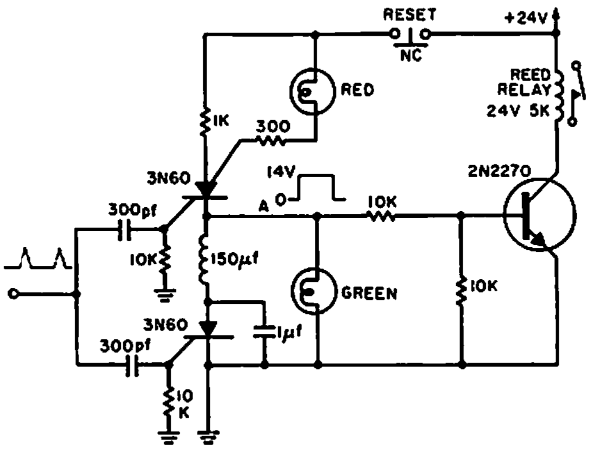
0.1-OHM RESISTANCE CHANGE DETECTOR—Uses Airborne Accessories ultrasensitive static relay in bridge circuit for production testing of components whose resistance value is critical. Static switch contains magamp-driven scr that can be used to activate solenoid reject mechanism that either labels or removes faulty test piece.—Sensitive Static Relay Detects Resistance Limits, *Electronic Design*, Nov. 29, 1965, p 75.


2000
μf
50VDC
10K
R1
10K
R2
10K
R3
10K
Rn
Ry1
Ry2
Ry3
Ryn
500Ω
WW
R4
+28
Ry1..... Ryn = SIGMA 5F, 10,000Ω

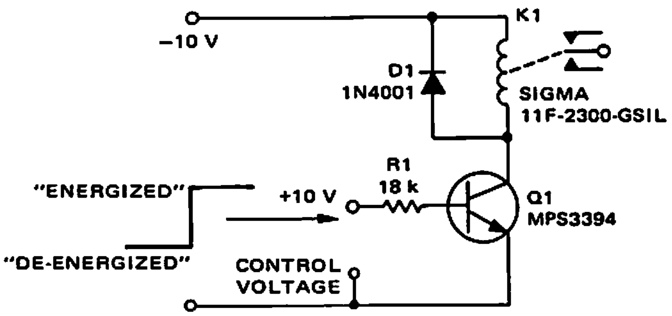
SEQUENCING OF RELAY PULL-INS—Series pot for each relay is set for pull-in voltage desired. When switch is set at 28 V, capacitor charges through R4, and each relay pulls in when capacitor voltage reaches preset value. When switch is released, relays drop out in reverse order of pull-in.—M. E. Swinnen, Relay Arrangement Simplifies Contact Sequencing, *Electronic Design*, Nov. 23, 1964, p 62.


+12v
115v a-c
(OR 110-140v d-c WITHOUT D2)
D2
1N4004
TO OTHER LAMPS
DRIVE
VOLTAGE
+12v
0
D1
1N4004
4.7k
33k
Q1
RCA 40327
+24v
+48v
+115v
1N4004
1N4004
Q1
RCA 40327

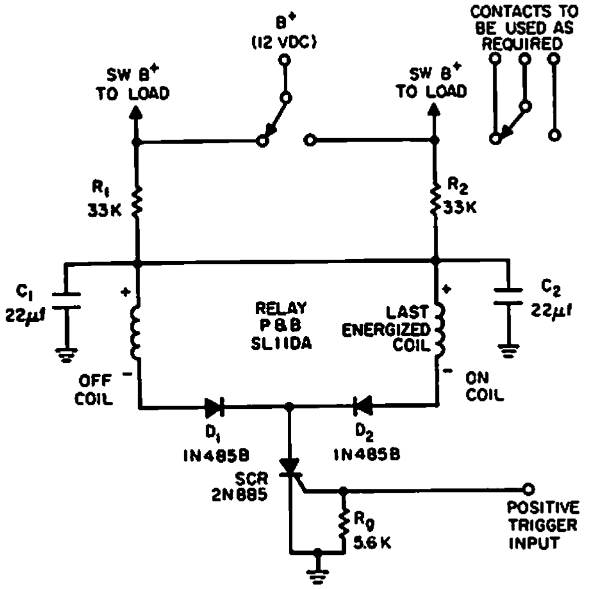
TRANSISTOR DRIVES RELAY AND NEONS—Addition of isolation diode to conventional relay driver permits turning on neon lamps and operating relay with single transistor. Circuit at right shows how to add isolation diodes for driving two or more relays having different supply voltages.—J. H. Silverman, Diode Isolator Combines Relay and Lamp Driver, *Electronics*, May 1, 1967, p 72.


RESET
NC
+24V
RED
REED RELAY 24V 5K
IK
300
3N60
14V
A
10K
2N2270
300pf
10K
150µf
GREEN
10K
3N60
1µf
300pf
10 K

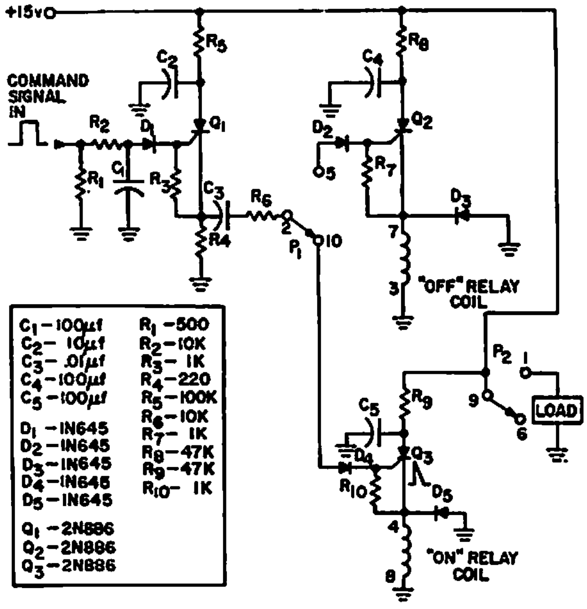
TWO-STEP LOCKOUT—First input pulse produces voltage step at output. Second input pulse makes output return to different level, followed by reed relay lockout. Developed for use in counters. Uses two 3N60 silicon controlled switches in series, lower of which cannot be fired until upper switch is fired. Input pulses must be below 5 V to prevent both switches from firing on first pulse. Lamps show circuit condition. When lower switch fires, on second pulse, transistor pulls in relay and holds it until reset switch is pushed.—B. Soroka, Lockout Circuit Operates With Single Line Input, *Electronic Design*, March 30, 1964, p 72–73.


−10 V
K1
D1
1N4001
SIGMA
11F-2300-GSIL
R1
18 k
"ENERGIZED"
+10 V
Q1
MPS3394
"DE-ENERGIZED"
CONTROL VOLTAGE

TRANSISTOR CONTROL—D-c relay is controlled by 0.5-mA signal current applied to transistor. Diode protects transistor from inductive voltage spike of relay coil.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–37.

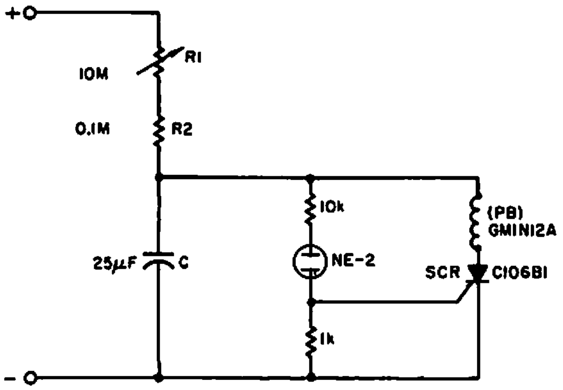

B+
(12 VDC)
CONTACTS TO BE USED AS REQUIRED
SW B+ TO LOAD
SW B+ TO LOAD
R1
33K
R2
33K
C1
22µf
C2
22µf
RELAY P&B SL11DA
LAST ENERGIZED COIL
OFF COIL
ON COIL
D1
1N485B
D2
1N485B
SCR
2N885
R9
5.6K
POSITIVE TRIGGER INPUT

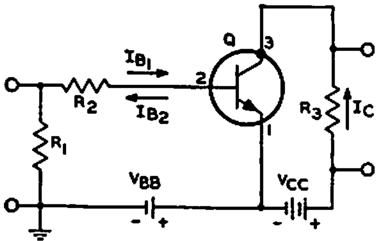
PULSES FLIP LATCHING RELAY—Positive trigger inputs applied to scr serve to alternate contacts of latching relay. Circuit draws very little power and provides current overload protection for coil. Time between successive trigger pulses should be greater than 2RC to give sufficient time for charging of coil capacitor.—J. S. Poole, SCR Pulse-Follower Circuit Alternates Latching Relay, *Electronic Design*, Dec. 20, 1965, p 51–52.


+15v
COMMAND SIGNAL IN
R5
C2
Q1
R2
D1
R1
C1
R3
C3
R6
R4
P1
2
10
R8
C4
Q2
D2
5
R7
D3
7
3
"OFF" RELAY COIL
P2
1
9
LOAD
6
C5
R9
D4
Q3
D5
R10
4
8
"ON" RELAY COIL
C1 – 100µf
C2 – 10µf
C3 – .01µf
C4 – 100µf
C5 – 100µf
D1 – IN645
D2 – IN645
D3 – IN645
D4 – IN646
D5 – IN645
Q1 – 2N886
Q2 – 2N886
Q3 – 2N886
R1 – 500
R2 – 10K
R3 – 1K
R4 – 220
R5 – 100K
R6 – 10K
R7 – 1K
R8 – 47K
R9 – 47K
R10 – 1K

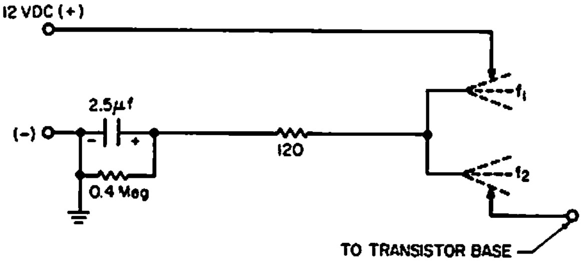
LATCHING WITH PULSES—Load is switched on and off by consecutive command signal pulses, with minimum signal power. Uses three scr's and dpdt magnetic latching relay. Circuit is shown with poles P1 and P2 in position corresponding to energizing of ON relay coil. Filter network R1-R2-C1 desensitizes circuit to random noise spikes.—J. N. Libby and J. C. Schaffert, SCR Relay Flips, Flops on Consecutive Commands, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 110.

TIMER DRIVES STEPPER—With 90-V d-c supply, stepping relay is operated at 5-minute intervals with values shown, with interval determined by R1-C. R2 determines minimum time. With half-wave rectified a-c line power, interval is 10 minutes. Can also be used with ordinary relay or other inductive load. Neon conducts at about 65 V and triggers scr, to make C discharge through relay coil and scr.—L. Eaton, Low-Power Timer Drives Stepping Relay, *Electronic Design*, Aug. 16, 1969, p 238 and 240.

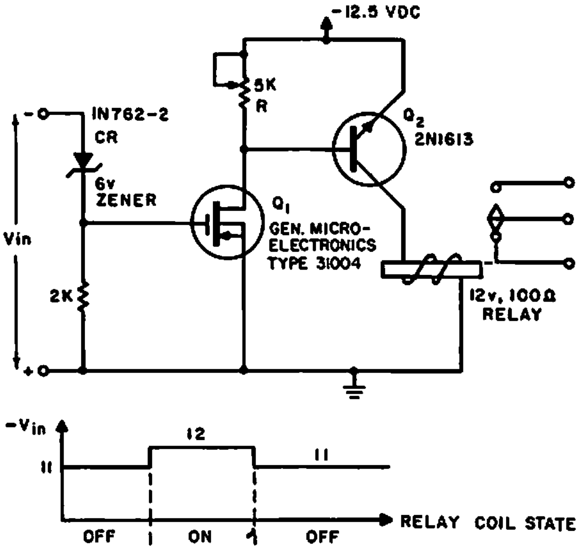

+
10M
R1
0.1M
R2
10k
(PB)
GMIN12A
25µF
C
NE-2
SCR
C106B1
1k
−


Q
3
IB1
2
IB2
R2
R1
R3
IC
1
VBB
VCC
−
+
−
+

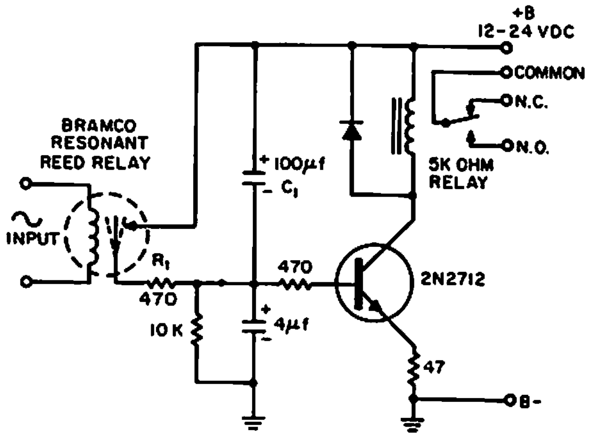
RELAY DRIVER—Uses 2N1483 npn silicon power transistor for energizing solenoid or relay. Delay time is only 0.2 µs and pulse rise and fall times about 1 µs. Values: R1 50; R2 700; R3 59; V-BB 8.5 V; V-CC 12 V. —"Transistor Manual," RCA, Harrison, N.J., SC-13, p 167.


12 VDC (+)
(−)
2.5µf
−
+
120
0.4 Meg
f1
f2
TO TRANSISTOR BASE

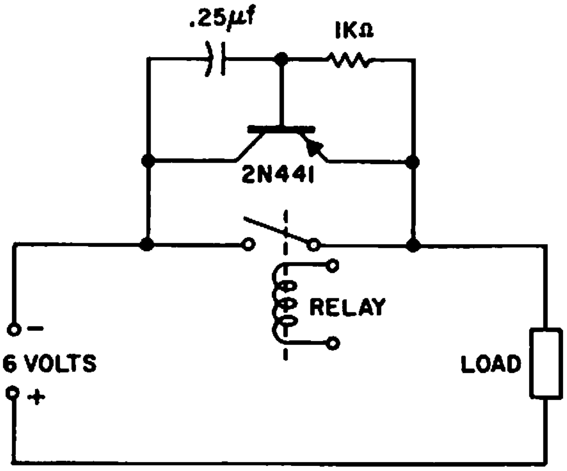
TWO-FREQUENCY AUDIO DECODER—Provides decoding for control function only when the two reeds of Bramco signal-coil relay are activated in sequence by their respective different frequencies. First frequency, f1, charges capacitor. Second frequency, f2, transfers capacitor charge to transistor base (or tube grid) for control action. Bleeder resistor across capacitor prevents switching action by undesired codes.—Multiple-Reed Relay Acts as 2-Frequency Decoder, *Electronic Design*, Nov. 29, 1965, p 71.


−12.5 VDC
5K
R
IN762-2
CR
6v
ZENER
Q2
2N1613
Q1
GEN. MICRO-ELECTRONICS
TYPE 31004
Vin
2K
12v, 100Ω
RELAY
−
+
−Vin
12
11
11
RELAY COIL STATE
OFF
ON
OFF

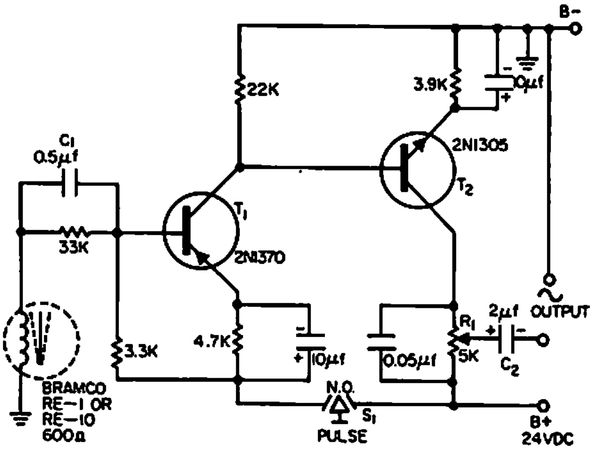
LOW-COST DIFFERENTIAL RELAY—Sharp-turn-on characteristic of mosfet Q1 gives reliable operation of inexpensive common relay on voltage differential less than 1 V. Pull-in and drop-out levels can be changed, to place 1-V differential level at any desired location in range of 1 to 12 V, by appropriate choice of zener and value of R.—L. G. Cowles, MOS Transistor Provides Sharp Differential Relay Switching, *Electronic Design*, March 29, 1965, p 32.


+B
12-24 VDC
COMMON
N.C.
N.O.
BRAMCO
RESONANT
REED RELAY
INPUT
100µf
C1
5K OHM
RELAY
R1
470
470
2N2712
10 K
4µf
47
B−

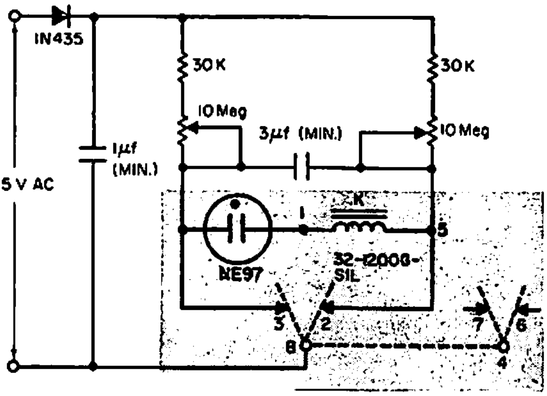
TIMED LOCKUP OF LATCHING CIRCUIT—Contacts of frequency-selective resonant-reed relay discharge C1 through R1 to make transistor conduct and pull in power relay at desired time interval after input signal is applied. When reed stops vibrating after input signal is removed, C1 charges up to transistor cutoff point, and power relay is then released. Lockup time is 5 to 10 s for value of C1 shown.—Resonant Reed Controls Timed Latching Relay, *Electronic Design*, Nov. 29, 1965, p 80.


.25µf
1KΩ
2N441
RELAY
6 VOLTS
−
+
LOAD

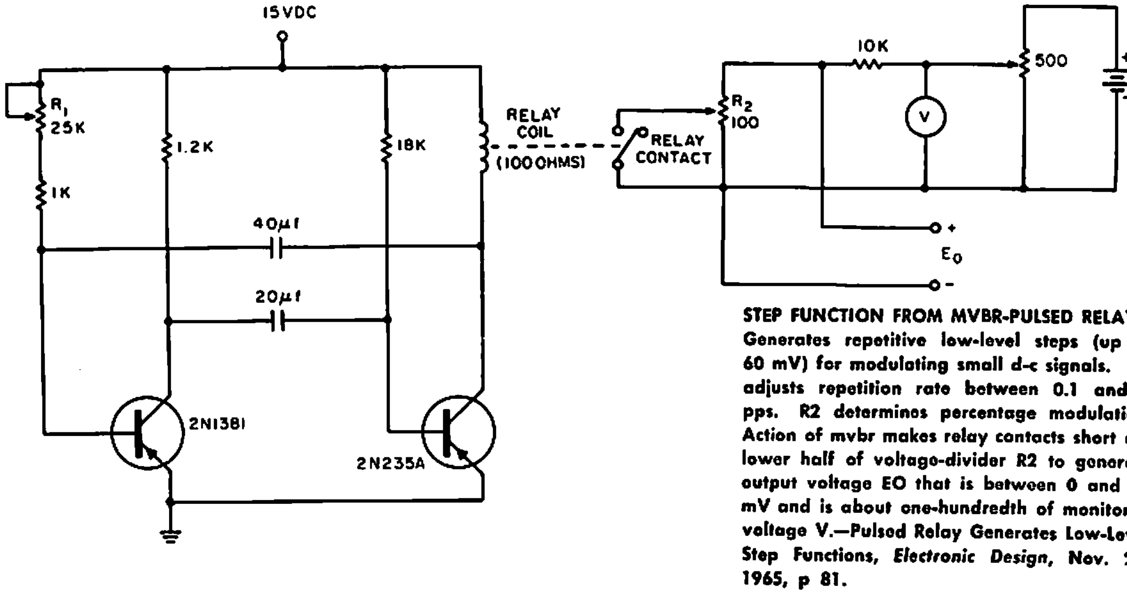
CONTACT ARC SUPPRESSION—Transistor supplements capacitor action in suppressing arc occurring when relay contacts open. With no suppression, peak voltage across opening contacts was 640 V. Capacitor alone reduced this to 340 V, and capacitor-transistor combination brought peak down to 12 V.—M. Dickey, Amplified Capacitor Suppresses Arc More Completely, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 100–101.


B−
22K
3.9K
10µf
2N1305
T2
C1
0.5µf
33K
T1
2N1370
3.3K
4.7K
10µf
0.05µf
R1
5K
2µf
C2
OUTPUT
BRAMCO
RE−1 OR
RE−10
600Ω
N.O.
S1
PULSE
B+
24VDC

DAMPED TONE GENERATOR—Damped audio tone with extremely narrow bandwidth is generated each time reed relay is pulsed. Tone is amplified by T1 and clipped to desired level by T2.—Resonant Reed-Relay Produces Pulsed Tone, *Electronic Design*, Nov. 29, 1965, p 74.

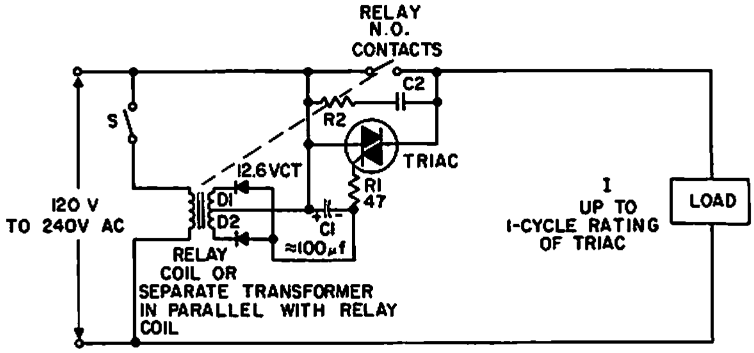

1N435
30K
30K
10Meg
10Meg
3µf (MIN.)
1µf
(MIN.)
115 V AC
NE97
1
5
K
32-12000-
SIL
3
2
8
7
6
4

20-MINUTE FLIP-FLOP—Bistable magnetic-latching polarized relay and neon lamp serve as free-running mvbr having cycling times up to 20 min, depending on settings of pots and size of capacitor used between them.—Polarized Latching Relay Forms Free-Running Flip-Flop, *Electronic Design*, Nov. 29, 1965, p 74.

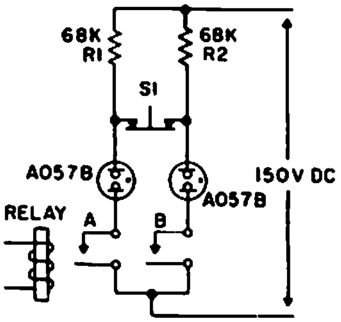

15VDC
R1
25K
1K
1.2K
18K
RELAY
COIL
(100 OHMS)
40µf
20µf
2N1381
2N235A
RELAY
CONTACT
R2
100
10K
500
V
6
+
−
E0

STEP FUNCTION FROM MVBR-PULSED RELAY—Generates repetitive low-level steps (up to 60 mV) for modulating small d-c signals. R1 adjusts repetition rate between 0.1 and 8 pps. R2 determines percentage modulation. Action of mvbr makes relay contacts short out lower half of voltage-divider R2 to generate output voltage EO that is between 0 and 60 mV and is about one-hundredth of monitored voltage V.—Pulsed Relay Generates Low-Level Step Functions, *Electronic Design*, Nov. 29, 1965, p 81.

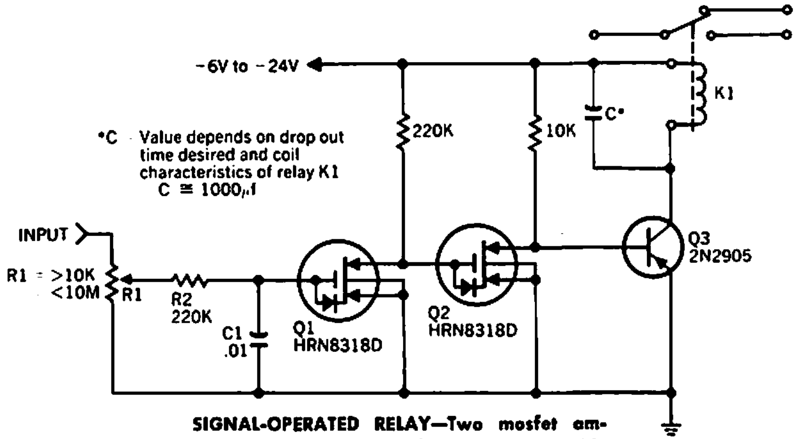
TRIAC CONTACT-PROTECTOR—When switch is closed, relay is energized and triac is fired, sending current through load. Since triac stays on as long as load current flows, there is no arcing of contacts while they bounce. Furthermore, load current flows through contacts when they are closed, rather than through triac, so heat dissipation in triac is negligible. When switch is opened, relay contacts open but triac remains fired long enough to eliminate contact arcing because it opens only at natural current-zero time. Circuit can thus be used for load currents higher than relay or triac could handle alone.—J. H. Galloway, Using the Triac for Control of AC Power, General Electric, Syracuse, N.Y., No. 200.35, 1966, p 13.


RELAY
N.O.
CONTACTS
C2
R2
S
TRIAC
12.6VCT
D1
D2
R1
47
C1
≈100µf
120 V
TO 240V AC
I
UP TO
I-CYCLE RATING
OF TRIAC
LOAD
RELAY
COIL OR
SEPARATE TRANSFORMER
IN PARALLEL WITH RELAY
COIL

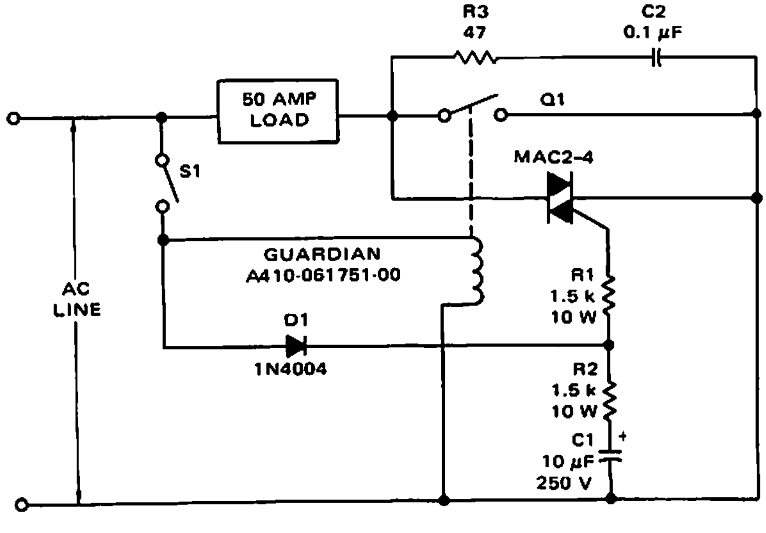
NOTE: FOR INDUCTIVE LOADS USE RC dv/dt SUPPRESSION CIRCUIT IN PARALLEL WITH TRIAC


68K
R1
68K
R2
S1
A057B
A057B
150V DC
RELAY
A
B

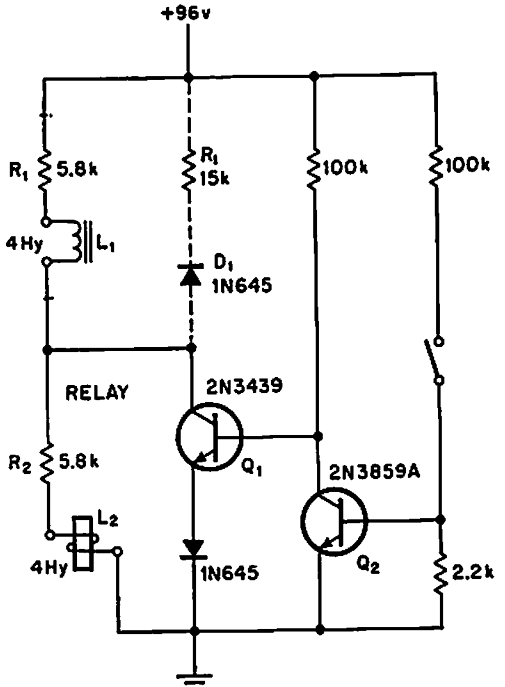
CONTACT-CLOSING SEQUENCE—Both neons should glow when S1 is closed. With S1 open, neon which glows shows which contact closed first. If neither lamp lights, both contacts closed simultaneously.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 144.


-6V to -24V
*C Value depends on drop out time desired and coil characteristics of relay K1
C ≅ 1000µf
220K
10K
C*
K1
INPUT
R1 = >10K
<10M
R1
R2
220K
C1
.01
Q1
HRN8318D
Q2
HRN8318D
Q3
2N2905

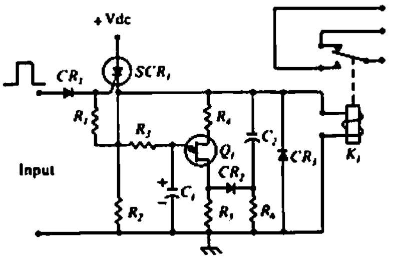
SIGNAL-OPERATED RELAY—Two mosfet amplifier stages ahead of transistor provide sufficient voltage gain for detecting signals as low as 2 V and energizing relay.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 35.


R3
47
C2
0.1 µF
50 AMP
LOAD
Q1
S1
MAC2-4
GUARDIAN
A410-061751-00
AC
LINE
D1
1N4004
R1
1.5 k
10 W
R2
1.5 k
10 W
C1
10 µF
250 V

TRIAC SUPPRESSES CONTACT ARCING—Triac turns on during first positive half-cycle after S1 is closed, and carries load current before relay coil has had time to close its contacts. Similarly, triac conducts for several cycles after relay contacts open, because of energy stored in C2. Maximum voltage across contacts is only about 1 V when they open, permitting use of smaller relay and reducing noise of relay closing. Triac shown will handle loads up to 50 A.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4-7.

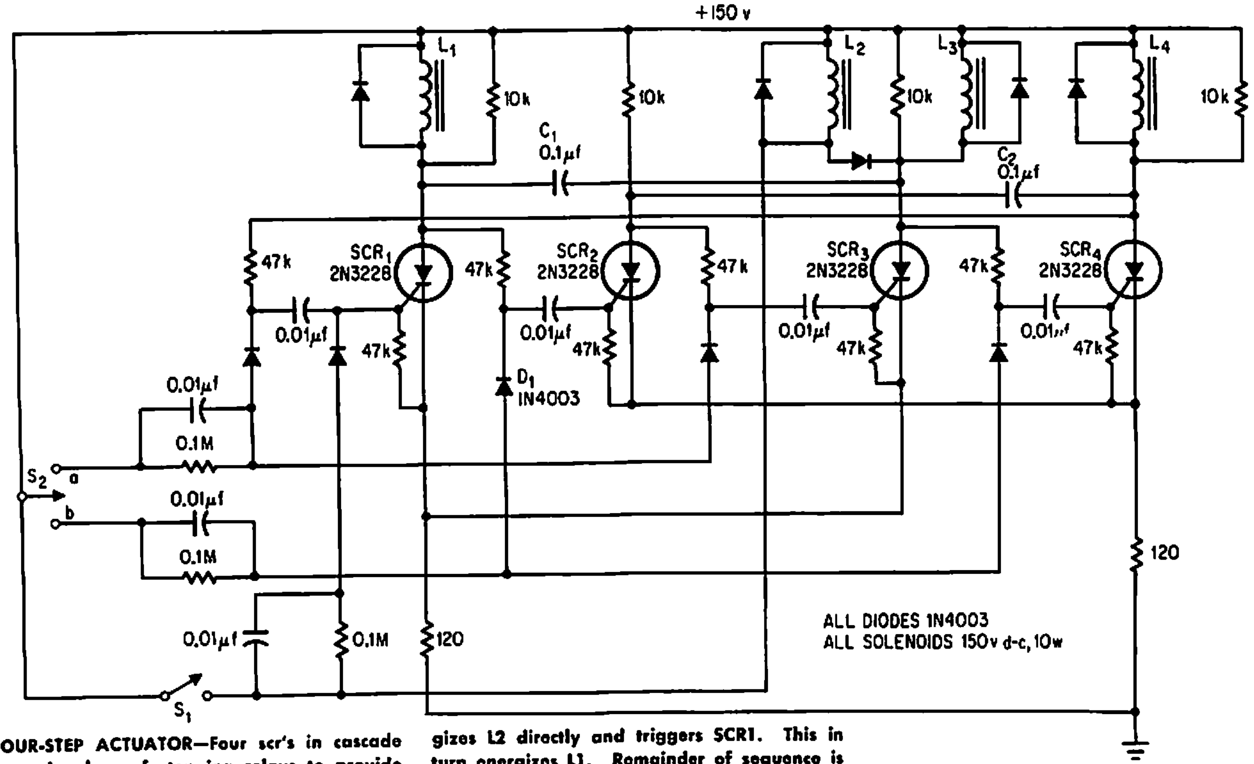

+96v
R1 5.8k
4Hy
L1
R1 15k
D1 1N645
100k
100k
RELAY
2N3439
Q1
R2 5.8k
L2
4Hy
1N645
2N3859A
Q2
2.2k

FASTER RELAY—Shortens pull-in time of industrial control relay or solenoid from normal 16 ms to 5 ms. With switch open, Q2 is on and current flows through inductor L1 (which can be another relay like L2 with armature jammed open). Closing switch turns Q2 off and Q1 on, causing field of L1 to collapse and generate large voltage spike that is integrated by L2-R2 to give fast build-up of current through relay coil. D1 and R1 are optional, for protecting Q1 against collector-emitter breakdown while increasing delay slightly.—J. Gaon, Storage Coil Cuts Relay Pull-In Delay, *Electronics*, Aug. 3, 1970, p 74.

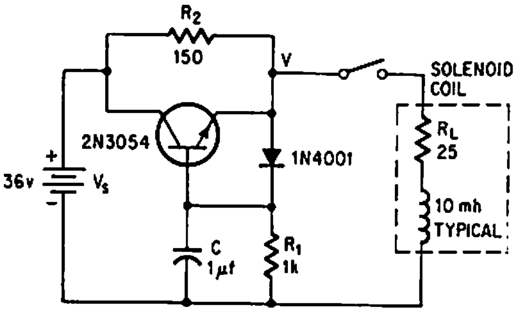

+Vdc
CR1
SCR1
R1
R3
R4
C2
Q1
CR2
CR3
K1
Input
C1
R2
R5
R6

Supply	+ 12 V dc
K_1	220 Ω
SCR_1	3J60
Q_1	2N1671B
CR_1, CR_2, CR_3	1N645
R_1	2.2K
R_2	4.7K
R_3, R_4, R_5	100 Ω
R_6	10K
C_1	100 μF
C_2	1 μF

ONE-SHOT RELAY DRIVER—Will pull in relay for about 50 s out of every minute, with immunity to both positive and negative power supply transients. Initiating trigger pulse must be long enough for relay current through SCR1 to rise above its latching current. Ujt Q1 turns off scr when C1 has been charged through R3 to point where it discharges through Q1 and R5. Circuit was developed at Goddard Space Flight Center, and should be useful for general control applications.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 68.

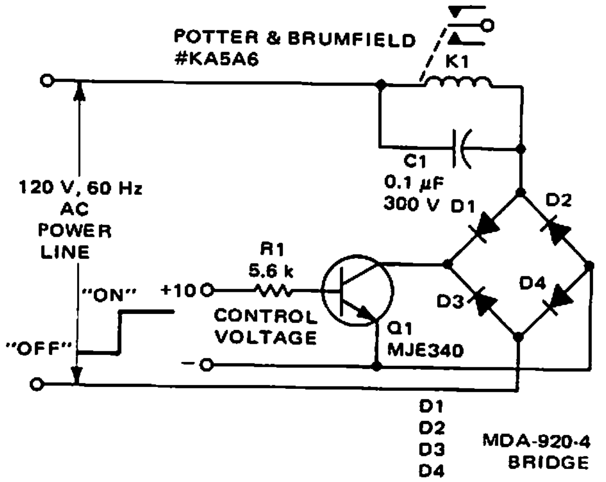

+150 v
L1
L2
L3
L4
10k
10k
10k
10k
C1 0.1μf
C2 0.1μf
SCR1 2N3228
SCR2 2N3228
SCR3 2N3228
SCR4 2N3228
47k
0.01μf
D1 1N4003
S2
a
b
0.1M
0.01μf
120
S1
ALL DIODES 1N4003
ALL SOLENOIDS 150v d-c,10w

FOUR-STEP ACTUATOR—Four scr's in cascade serve in place of stepping relays to provide four-step actuating sequence for four solenoids controlling semiconductor bonding process. Closing momentary switch S1 energizes L2 directly and triggers SCR1. This in turn energizes L1. Remainder of sequence is then obtained by moving S2 alternately to positions b, a, b, a, and b. Continued operation of S2 then repeats entire cycle.—C. H. Harris, SCR Ring Circuit Replaces Stepping Relays, *Electronics*, July 10, 1967, p 80–81.



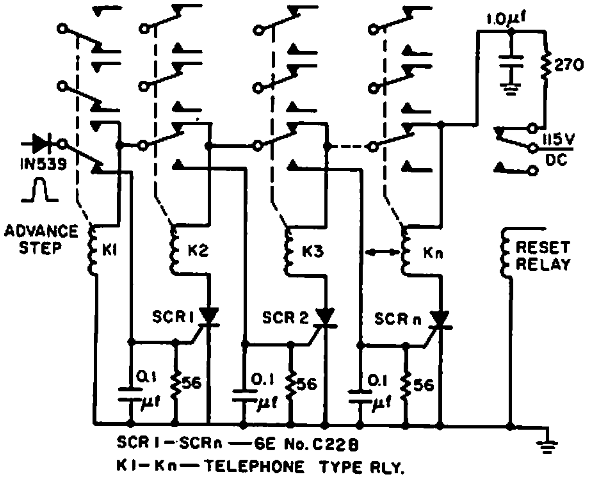
R_2
150
V
SOLENOID COIL
2N3054
1N4001
R_L
25
36v
V_s
10 mh
TYPICAL
C
1μf
R_1
1k

SPEEDING SOLENOID RECOVERY—Use of R-C network to control timing speeds recovery in circuits actuating solenoid-operating devices. Before operating solenoid, switch is opened so C charges to supply voltage. Closing switch makes C discharge through R1 and add to solenoid excitation current.—F. E. Mueller, Pick-Hold Coil Driver Recovers Quickly, *Electronics*, April 14, 1969, p 96–97.



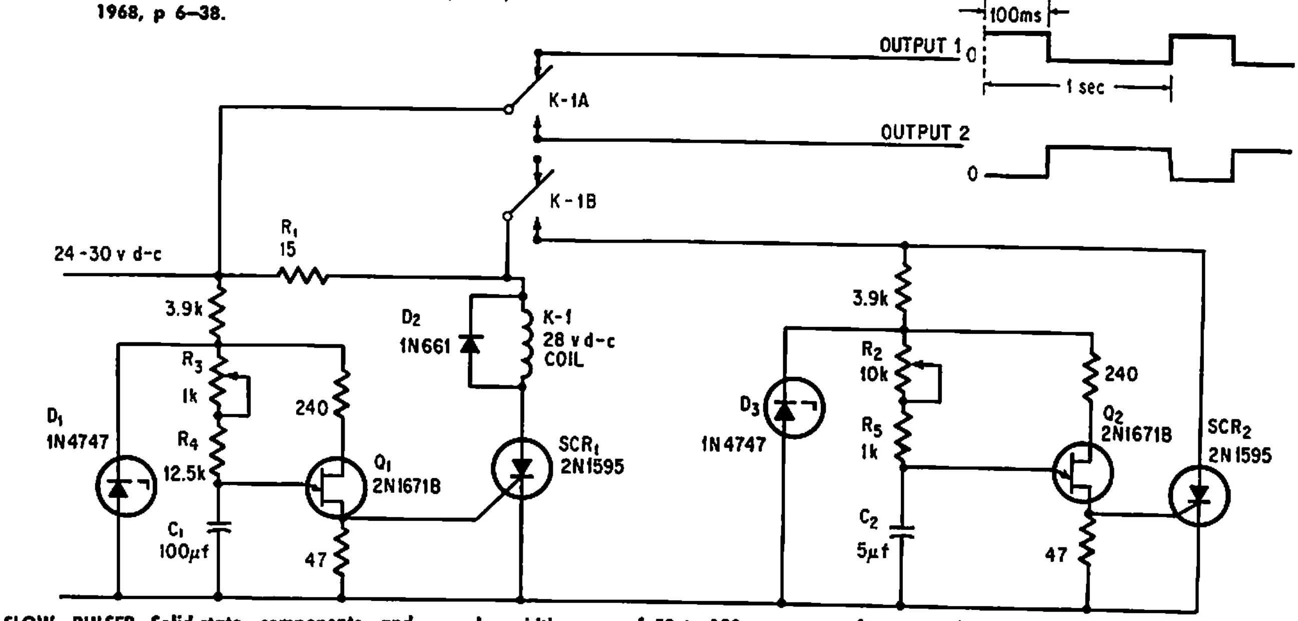
POTTER & BRUMFIELD
#KA5A6
K1
C1
0.1 μF
300 V
D1
D2
120 V, 60 Hz AC POWER LINE
R1
5.6 k
"ON"
+10
CONTROL VOLTAGE
"OFF"
−
Q1
MJE340
D3
D4
D1
D2
D3
D4
MDA-920-4 BRIDGE

A-C RELAY CONTROL—Diode bridge provides d-c for transistor while passing a-c for operation of relay. C1 protects transistor from inductive voltage spikes of relay coil. One drawback is that control signal must be isolated from a-c power line. Control voltage source must provide 1.6 mA to base of transistor having gain of 10, to pull in relay coil requiring 16 mA.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–38.



1.0μf
270
115V DC
1N539
ADVANCE STEP
K1
K2
K3
Kn
RESET RELAY
SCR1
SCR2
SCRn
0.1 μf
56
0.1 μf
56
0.1 μf
56
SCR1—SCRn —GE No. C22B
K1—Kn—TELEPHONE TYPE RLY.

SCR STEPPING AND HOMING—Combination of telephone relays and scr's gives better reliability, faster stepping, and faster homing or resetting than conventional stepping switches.—E. Pacia, Relay Combination Improves Step Switching, Homing, *Electronic Design*, Oct. 26, 1964, p 52.

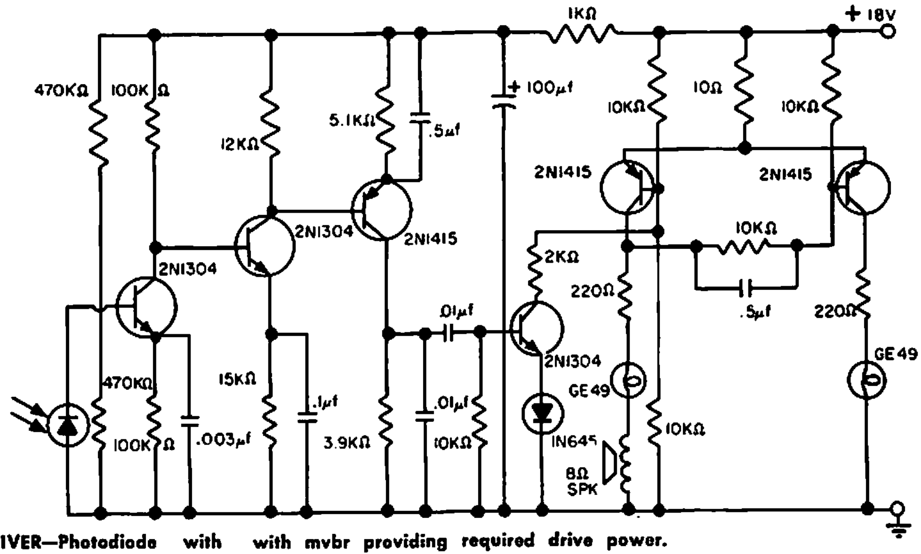


100ms
OUTPUT 1
0
1 sec
K-1A
OUTPUT 2
0
K-1B
24-30 v d-c
R_1
15
3.9k
D_2
1N661
K-1
28 v d-c
COIL
R_3
1k
240
D_1
1N4747
R_4
12.5k
Q_1
2N1671B
SCR_1
2N1595
C_1
100μf
47
3.9k
R_2
10k
240
D_3
1N4747
R_5
1k
Q_2
2N1671B
SCR_2
2N1595
C_2
5μf
47

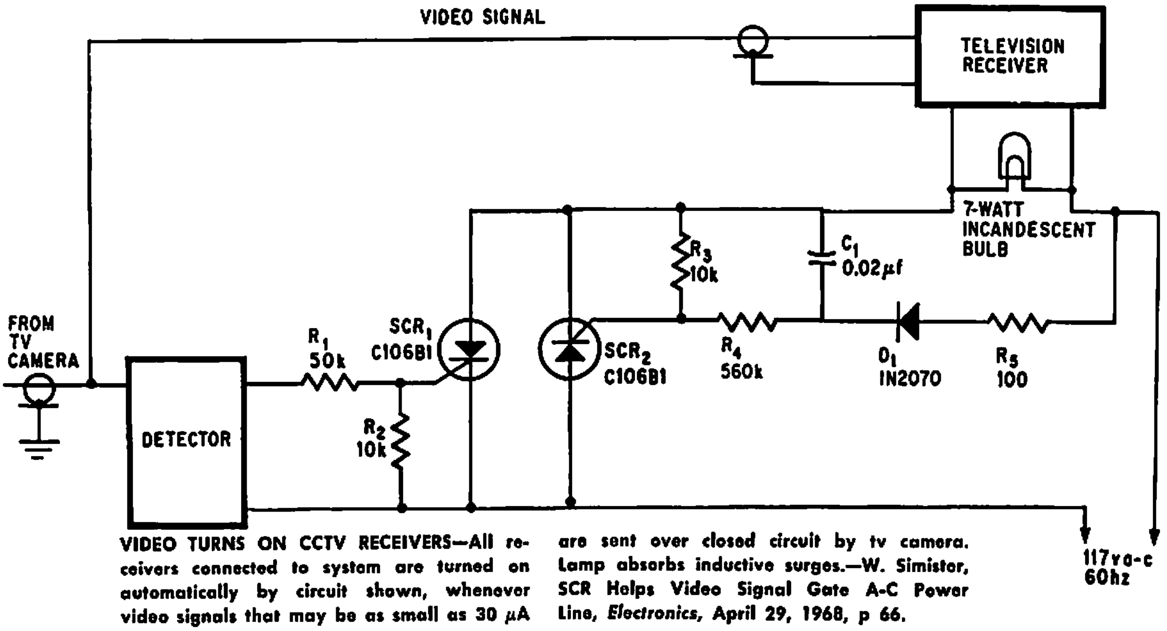
SLOW PULSER—Solid-state components and relay can stretch output pulses over range from 20 ms to one hour, depending on values used for C1 and R3-R4. Values shown give pulse width range of 50 to 150 ms at prr of 1 pps. D1 and D2 (20-V zeners) keep timing circuit voltage constant. Dpdt relay gives complementary outputs.—D. L. Pippen, Relay Actuator Produces One-Hour Pulses, *Electronics*, Nov. 13, 1967, p 100–101.

CHAPTER 73

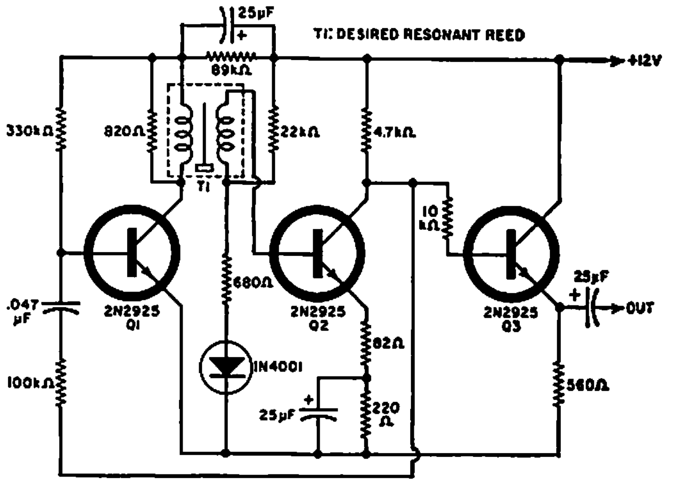
Remote Control Circuits


1KΩ
+ 18V
470KΩ
100KΩ
12KΩ
5.1KΩ
.5μf
+ 100μf
10KΩ
10Ω
10KΩ
2N1415
2N1415
2N1304
2N1415
2N1304
10KΩ
2KΩ
220Ω
.5μf
220Ω
.01μf
GE49
470KΩ
15KΩ
.1μf
.01μf
2N1304
GE49
100KΩ
.003μf
3.9KΩ
10KΩ
1N645
8Ω SPK
10KΩ

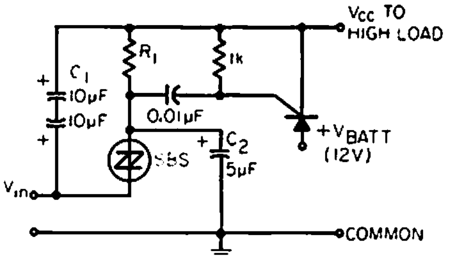
PULSED-LIGHT RECEIVER—Photodiode with simple lens picks up pulsed light from solid-state lamp up to 2 ft away, having one of four different pulsing rates. Speaker gives audible indication of tone being transmitted, with mvbr providing required drive power. Pilot lamps indicate, by intensity, frequency being transmitted. Alternatively, reed relays could be used to provide direct response to each signal. With infrared wavelength, visible ambient light does not affect performance.—L. M. Hertz, Solid State Lamps—Part II, General Electronic, Cleveland, Ohio, No. 3-0121, 1970, p 33.


VIDEO SIGNAL
TELEVISION RECEIVER
7-WATT INCANDESCENT BULB
FROM TV CAMERA
DETECTOR
R1 50k
SCR1 C106B1
R2 10k
SCR2 C106B1
R3 10k
R4 560k
C1 0.02μf
D1 1N2070
R5 100
117va-c 60hz

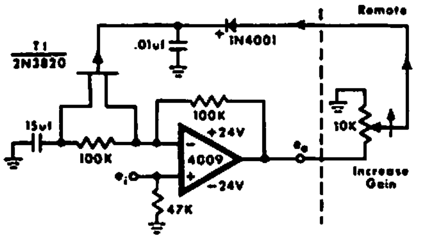
VIDEO TURNS ON CCTV RECEIVERS—All receivers connected to system are turned on automatically by circuit shown, whenever video signals that may be as small as 30 μA are sent over closed circuit by tv camera. Lamp absorbs inductive surges.—W. Simistor, SCR Helps Video Signal Gate A-C Power Line, *Electronics*, April 29, 1968, p 66.


25μF
T1: DESIRED RESONANT REED
+12V
89kΩ
330kΩ
820Ω
22kΩ
4.7kΩ
T1
10 kΩ
680Ω
.047 μF
2N2925 Q1
2N2925 Q2
2N2925 Q3
25μF
OUT
82Ω
1N4001
100kΩ
25μF
220 Ω
560Ω

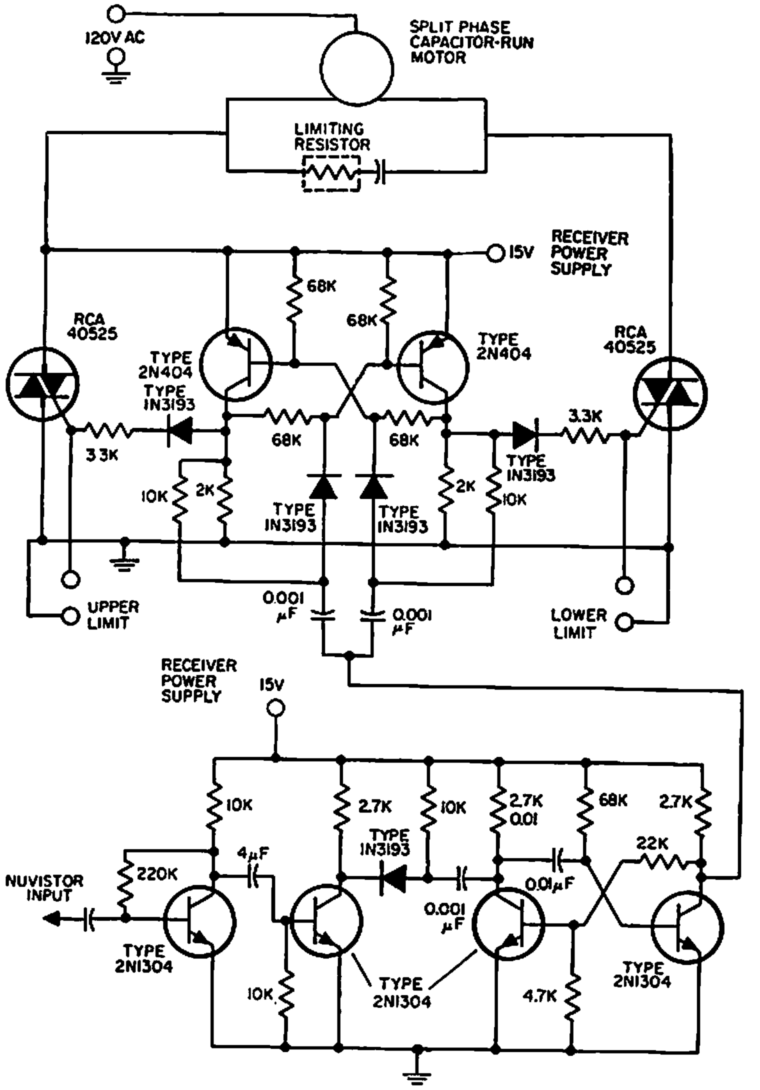
SELECTIVE-SIGNALING TONE GENERATOR—Can be used either with wire line or with modulator of radio transmitter, for radio remote control, selective CB or mobile radio communication, or for operating lamp or latching relay of frequency-selective receiver connected to wire line. Uses Motorola Minitone resonant-reed device capable of operating at any one of 200 preselected frequencies between 67 and 3,150 Hz. Reed unit is connected in feedback oscillator Q1-Q2. Emitter-follower Q3 matches high impedance of oscillator to load.—L. Solomon, Tone-Selective Signaling The New Look, *Electronics World*, Sept. 1967, p 88–90.


Vcc TO HIGH LOAD
R1
1k
C1
10μF
10μF
0.01μF
+VBATT (12V)
C2
5μF
SBS
Vin
COMMON

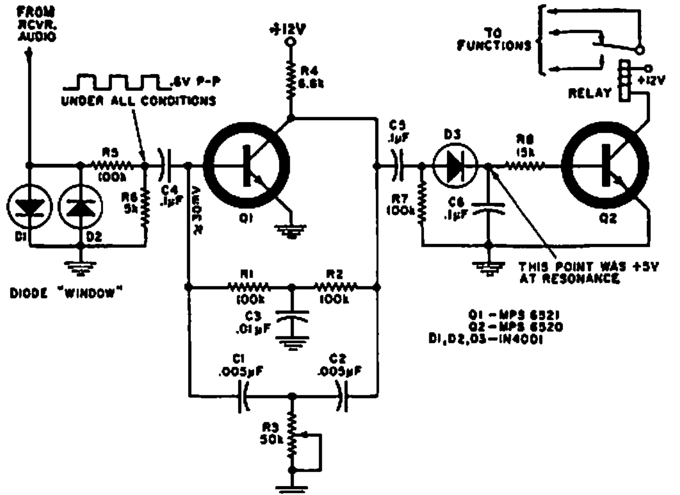
BILATERAL SBS TRIGGER—Provides high input impedance and draws negligible standby current, while providing reliable turn-on and turn-off of scr controlling heavy logic-system load. R1 must be large enough to couple substantial pulse to gate of scr but small enough for quick discharge of C1 and C2 for turn-off; good compromise is 1K. Scr type depends on load, while sbs can be D13E, MPT28, or MPT32. Can easily be driven by simple detector circuit such as Schmitt trigger. —C. H. Davis, Remote-Controlled Solid-State Switch, *EEE*, Nov. 1968, p 142 and 144.


Remote
T1 2N3820
.01uf
1N4001
15uf
100K
100K
+24V
4009
-24V
e_o
e_i
47K
10K
Increase Gain

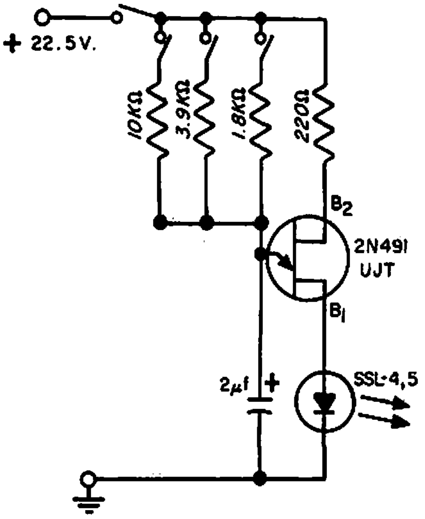
REMOTE AUDIO GAIN CONTROL—Requires only 10K pot at remote control location for adjusting gain of 20-dB audio compressor using IC opamp.—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.


120V AC
SPLIT PHASE CAPACITOR-RUN MOTOR
LIMITING RESISTOR
15V
RECEIVER POWER SUPPLY
68K
68K
RCA 40525
TYPE 2N404
TYPE 1N3193
TYPE 2N404
RCA 40525
3.3K
68K
68K
3.3K
TYPE 1N3193
10K
2K
2K
10K
TYPE 1N3193
TYPE 1N3193
UPPER LIMIT
0.001 μF
0.001 μF
LOWER LIMIT
RECEIVER POWER SUPPLY
15V
10K
2.7K
10K
2.7K
0.01
68K
2.7K
TYPE 1N3193
4μF
22K
220K
0.01μF
NUVISTOR INPUT
0.001 μF
TYPE 2N1304
10K
TYPE 2N1304
4.7K
TYPE 2N1304

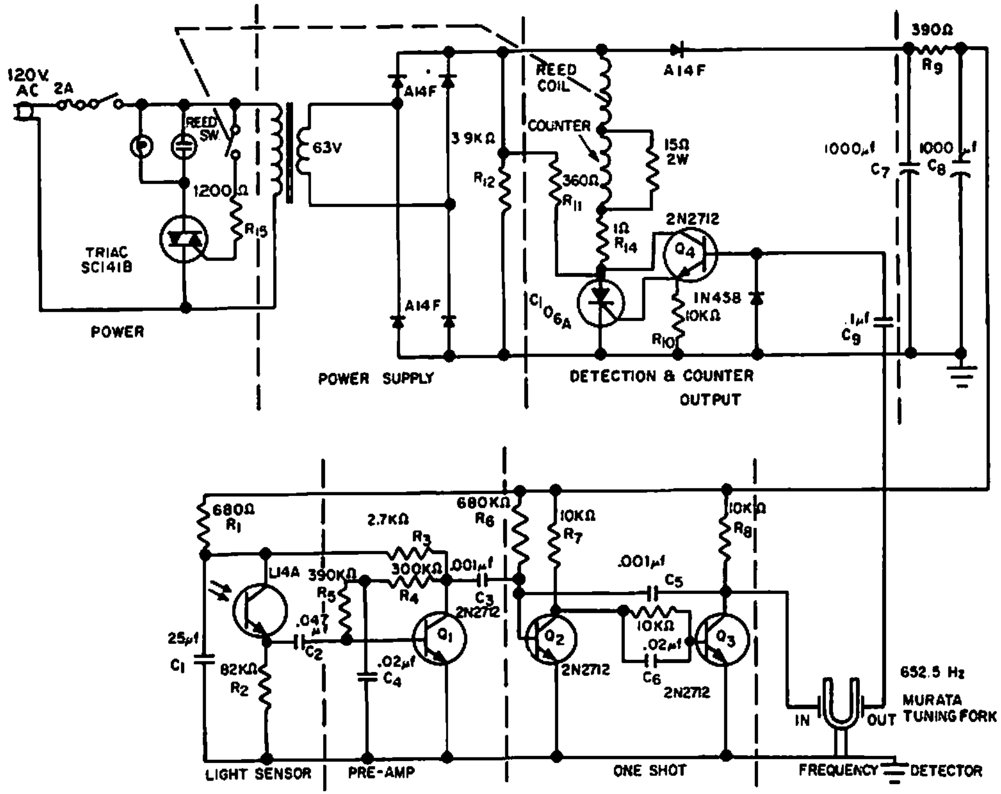
GARAGE-DOOR REVERSING CONTROL—Triacs eliminate arcing problems obtained with relays when reversing split-phase capacitor-run motor commonly used with radio-controlled garage door opener. Circuit includes time-delay mono mvbr. During door travel, transmitter keying will control motor direction independently of motor switches.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 252.


FROM RCVR. AUDIO
.6V P-P
UNDER ALL CONDITIONS
+12V
R4 6.8k
TO FUNCTIONS
RELAY
+12V
R5 100k
R6 5k
C4 .1µF
≈ 30mV
Q1
C5 .1µF
D3
R8 15k
R7 100k
C6 .1µF
Q2
D1
D2
DIODE "WINDOW"
THIS POINT WAS +5V AT RESONANCE
R1 100k
R2 100k
C3 .01µF
Q1 – MPS 6521
Q2 – MPS 6520
D1,D2,D3 – IN4001
C1 .005µF
C2 .005µF
R3 50k

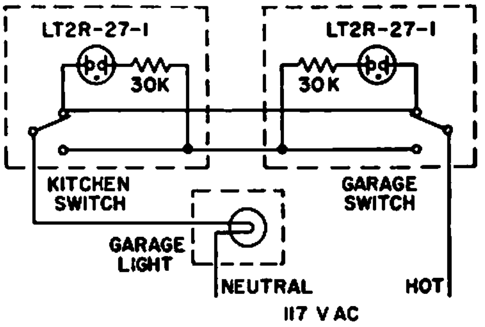
TWIN-T RESONANT AMPLIFIER—Low-power a-m transmitter on 27-MHz CB channel, modulated at 300, 400, and 500 Hz by twin-T oscillators, feeds superhet receiver of experimental radio remote-control system. Demodulated control signals are clipped to 0.6 V by diode window and fed to three twin-T resonant amplifiers, each tuned to one modulation frequency and driving relay (only one is shown). Reliability of system is good. —F. B. Maynard, Twin T's: Designs & Applications, *Electronics World*, Aug. 1968, p 35–37 and 64.


+ 22.5V.
10KΩ
3.9KΩ
1.8KΩ
220Ω
B2
2N491 UJT
B1
2µf
+
SSL-4,5

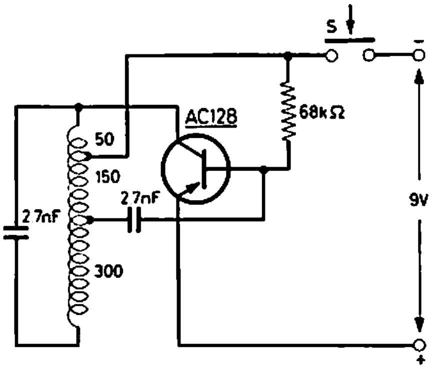
PULSED-LIGHT TRANSMITTER—Ujt oscillator pulses solid-state lamp to produce pulsed light beam for remote control. Range is about 2 ft when using simple lens over photodiode in receiver. Switches give choice of four pulse rates providing four different control functions in receiver. Supply voltage can be as low as 3 V, from pair of D flashlight cells, if low-voltage ujt is used.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 32.


120V AC
2A
REED SW.
1200Ω
R15
TRIAC SC141B
POWER
63V
A14F
A14F
3.9KΩ
R12
POWER SUPPLY
REED COIL
COUNTER
360Ω
R11
15Ω 2W
1Ω
R14
C106A
2N2712
Q4
IN458
10KΩ
R10
DETECTION & COUNTER
OUTPUT
A14F
390Ω
R9
1000µf
C7
1000µf
C8
.1µf
C9
680Ω
R1
2.7KΩ
R3
680KΩ
R6
10KΩ
R7
10KΩ
R8
L14A
390KΩ
R5
300KΩ
R4
.001µf
C3
2N2712
25µf
C1
.047µf
C2
Q1
.02µf
C4
82KΩ
R2
.001µf
C5
Q2
10KΩ
.02µf
C6
Q3
2N2712
2N2712
652.5 Hz
MURATA TUNING FORK
IN
OUT
LIGHT SENSOR
PRE-AMP
ONE SHOT
FREQUENCY DETECTOR

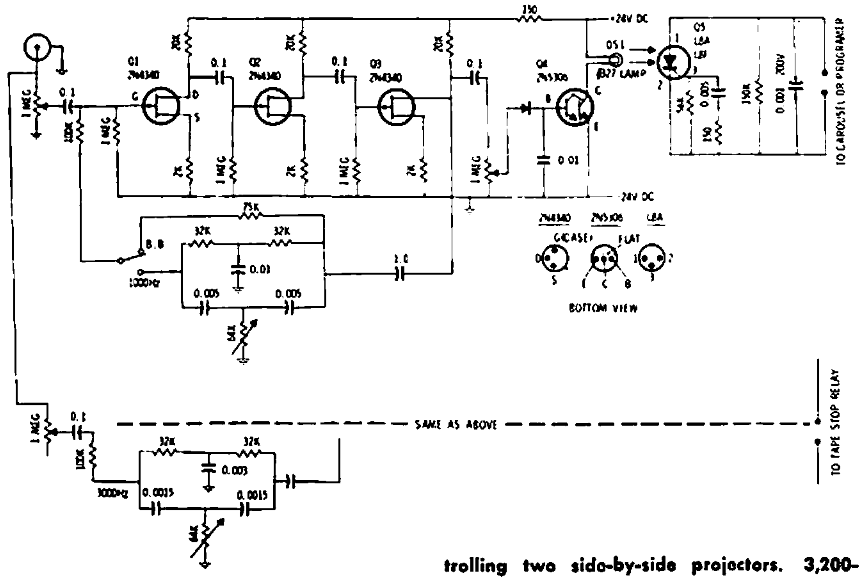
TUNED-RELAY RECEIVER—Silicon photodiode receives pulsed light beam in range of 300–1,200 pps from transmitter up to several hundred feet away. Q1 amplifies output and drives mvbr Q2-Q3 to stretch pulses to about 1 ms for driving tuning fork. When transmitted frequency corresponds to that of fork, fork output triggers gate of scr, to close reed switch and trigger triac that applies power to a-c receptacle for load up to 2 A. Additional channels are required if more than one control frequency is used.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 35.


LT2R-27-1
LT2R-27-1
30K
30K
KITCHEN SWITCH
GARAGE SWITCH
GARAGE LIGHT
NEUTRAL
HOT
117 VAC

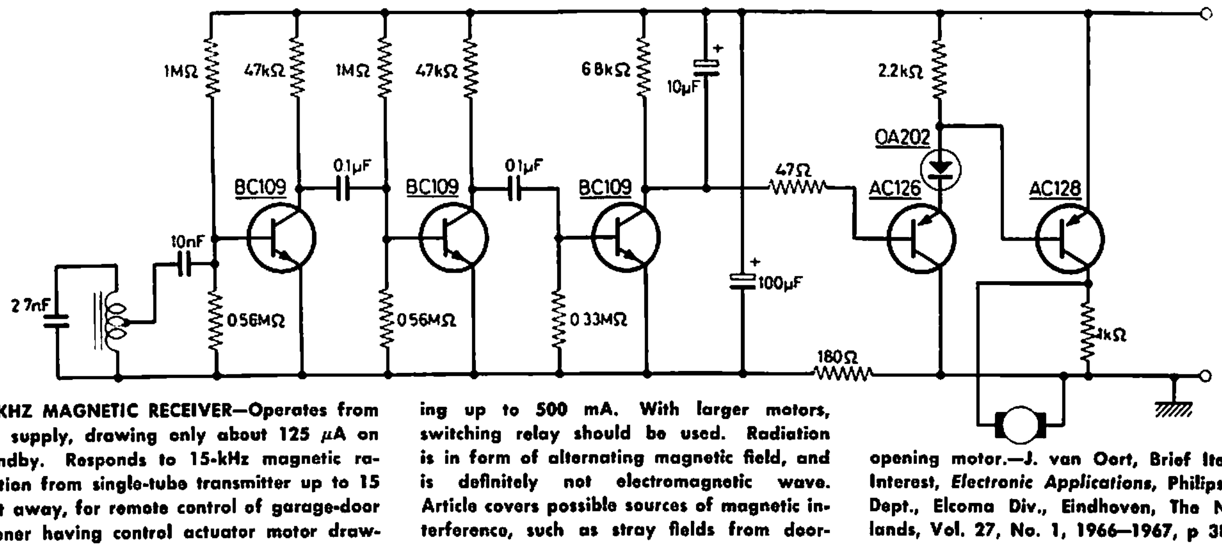
LAMP FAILURE INDICATOR—Neon glows if three-way switch in kitchen does not turn on garage light because it is burned out or removed.—E. Bauman, "Application of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 139.


S
−
AC128
68kΩ
50
150
2.7nF
2.7nF
300
9V
+

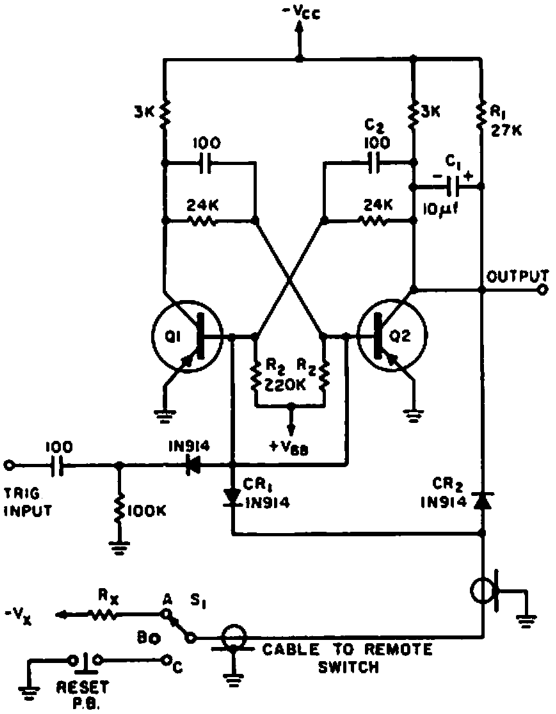
15-KHZ MAGNETIC DOOR OPENER—Developed to solve problem of radio-controlled garage doors that open when jokester drives past with transmitter in car, or photoelectric openers that are opened by boys with flashlights. Inductor wound on 12-mm rod of ferroxcube 4B 12 cm long serves as element of tuned circuit for Hartley oscillator and as magnetic antenna. Will operate in band from 10 to 100 kHz, permitting operation of two or more different systems close together. Control range is about 15 feet. Requires similarly tuned magnetic receiver and control actuator driving garage door motor.—J. van Oort, Brief Items of Interest, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 38–40.


150
+24V DC
Q1 2N4340
Q2 2N4340
Q3 2N4340
Q4 2N5306
Q5 L8A LSI
0.1
0.1
0.1
0.1
20K
20K
20K
G
D
S
1 MEG
100K
1 MEG
2K
1 MEG
2K
1 MEG
2K
1 MEG
OS1
#327 LAMP
B
C
E
0.01
54K
0.005
150
150K
0.001
200V
TO CAROUSEL OR PROGRAMER
-24V DC
75K
32K
32K
B.B
0.01
1000Hz
0.005
0.005
54K
1.0
2N4340
2N5306
L8A
G(CASE)
FLAT
BOTTOM VIEW
SAME AS ABOVE
TO TAPE STOP RELAY
0.003
3000Hz
0.0015
0.0015

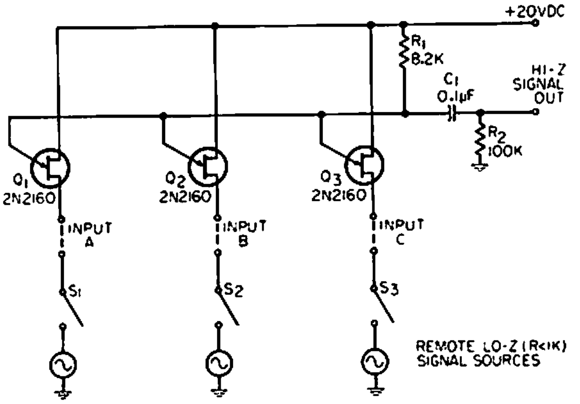
CASSETTE TONE COMMANDS—Dual-channel pulse circuit converts 1,000 and 3,200 Hz tone signals on second track of 150-mil stereo tape cassette to useful control commands, such as for advancing slide projector or controlling two side-by-side projectors. 3,200-Hz tone stops sound tape. Bridged-T network forms feedback loop that passes all frequencies except the one to which it is tuned.—W. Szabo, Control Commands, *A-V Communications*, Dec. 1969, p 6 and 31–33.


1MΩ
47kΩ
1MΩ
47kΩ
6.8kΩ
10μF
2.2kΩ
OA202
BC109
BC109
BC109
0.1μF
0.1μF
47Ω
AC126
AC128
10nF
2.7nF
0.56MΩ
0.56MΩ
0.33MΩ
100μF
180Ω
1kΩ

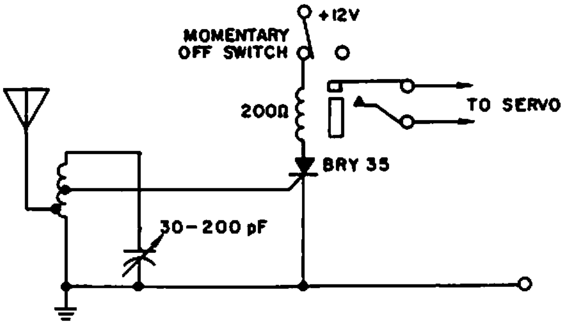
15-KHZ MAGNETIC RECEIVER—Operates from 3-V supply, drawing only about 125 μA on standby. Responds to 15-kHz magnetic radiation from single-tube transmitter up to 15 feet away, for remote control of garage-door opener having control actuator motor drawing up to 500 mA. With larger motors, switching relay should be used. Radiation is in form of alternating magnetic field, and is definitely not electromagnetic wave. Article covers possible sources of magnetic interference, such as stray fields from door-opening motor.—J. van Oort, Brief Items of Interest, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 1, 1966–1967, p 38–40.


-Vcc
3K
100
C2
100
3K
R1
27K
C1
10μf
24K
24K
OUTPUT
Q1
Q2
R2 R2
220K
100
IN914
+VBB
TRIG
INPUT
100K
CR1
IN914
CR2
IN914
-Vx
Rx
A
S1
Bo
C
RESET
P.B.
CABLE TO REMOTE
SWITCH

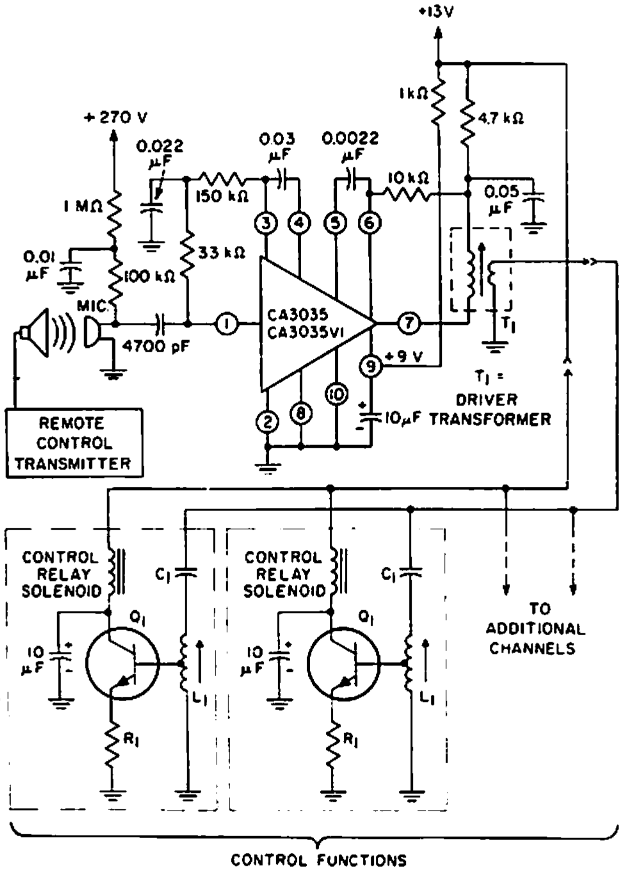
THREE-MODE REMOTE CONTROL—Single shielded wire going to remote control gives choice of three modes of operation: single-shot with minimum ON time; single-shot with ON time determined by C1 and R1; bistable operation with ON time determined by manual preset. Transistor types are not critical. —D. E. Campbell, Three-Mode Multivibrator Uses Single Control Wire, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 192.


+20VDC
R1
8.2K
C1
0.1μF
HI-Z
SIGNAL
OUT
R2
100K
Q1
2N2160
Q2
2N2160
Q3
2N2160
INPUT
A
INPUT
B
INPUT
C
S1
S2
S3
REMOTE LO-Z (R<IK)
SIGNAL SOURCES

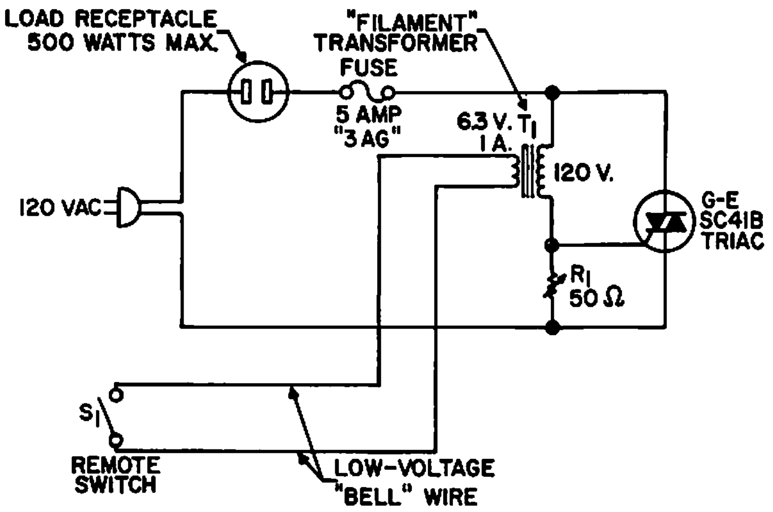
EXCLUSIVE-OR GATES FOR MIKES—Developed for paging and public address systems having many push-to-talk carbon microphones feeding common amplifier from different locations. When switch at any remote location is closed, corresponding ujt gate is triggered. Resulting emitter current makes emitter voltage stabilize below trigger level of other ujt stages, blocking all other mikes.—R. F. Sherwin, Remote-Controlled Exclusive OR Gate, *EEE*, Dec. 1966, p 119.


+12V
MOMENTARY
OFF SWITCH
200Ω
TO SERVO
BRY 35
30-200 pF

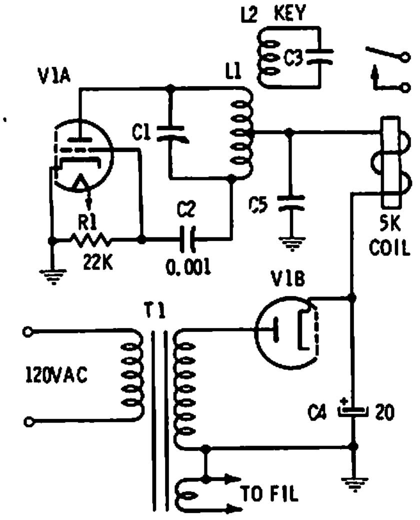
RADIO CONTROL FOR GARAGE DOOR—Simple receiver circuit requires only single scr in high-Q tuned antenna circuit. Signal input of only 30 μW, obtained from whip or wire antenna up to 100 feet from low-power transistor transmitter in auto, will trigger scr and pull in relay.—P. Antoniazzi, Inexpensive Radio-Controlled Door Opener Uses Only One SCR, *Electronic Design*, Nov. 8, 1969, p 109.


+13V
1kΩ
4.7 kΩ
+270 V
0.022 μF
0.03 μF
0.0022 μF
10 kΩ
0.05 μF
1 MΩ
150 kΩ
0.01 μF
33 kΩ
100 kΩ
MIC
4700 pF
CA3035
CA3035V1
+9 V
T1
T1 = DRIVER TRANSFORMER
10μF
REMOTE
CONTROL
TRANSMITTER
CONTROL
RELAY
SOLENOID
C1
Q1
10 μF
L1
R1
TO
ADDITIONAL
CHANNELS
CONTROL FUNCTIONS

ULTRASONIC REMOTE CONTROL—40-kHz acoustic wave from remote ultrasonic transmitter is picked up by microphone and amplified by wideband IC amplifier driving frequency-sensitive control relay. Additional channels are tuned to different frequencies, above or below 40 kHz. May be used for remote tuning and control of color tv set.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 296.

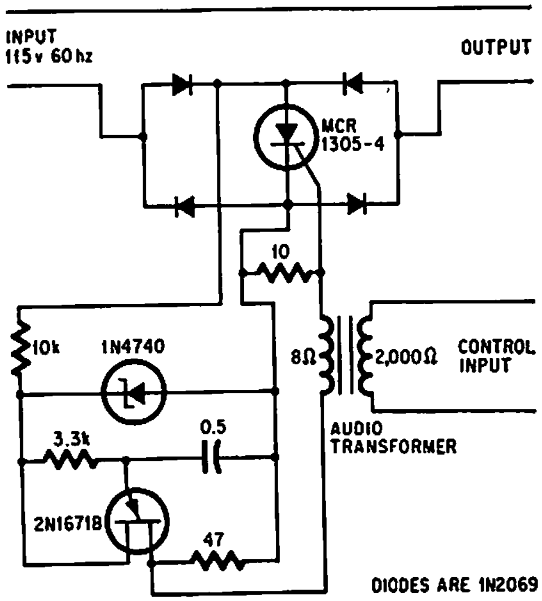

LOAD RECEPTACLE
500 WATTS MAX.
"FILAMENT"
TRANSFORMER
FUSE
5 AMP
"3 AG"
6.3 V. T1
1 A.
120 V.
120 VAC
G-E
SC41B
TRIAC
R1
50 Ω
S1
REMOTE
SWITCH
LOW-VOLTAGE
"BELL" WIRE

ISOLATED REMOTE SWITCH—Requires only bell wire, because switch simply shorts 6.3-V secondary of small filament transformer to make it saturate and thereby trigger triac on. Ideal for controlling outdoor light, lawn-sprinkling systems, irrigation pumps, and similar loads that may be at inconvenient locations.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 9.


L2 KEY
C3
V1A
L1
C1
R1
22K
C2
0.001
C5
5K
COIL
V1B
T1
120VAC
C4
20
TO FIL

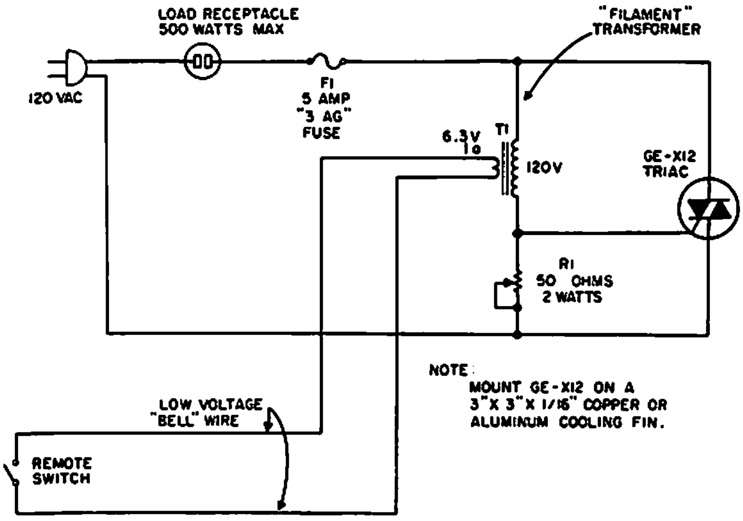
V1A, V1B • 12AU7
T1 • STANCOR PS-8415

ELECTRONIC LOCK—Uses series-fed Hartley oscillator, adjusted to oscillate normally when key L3-C3 is removed. Triode V1A then draws only very low plate current and relay is open. When key is brought near oscillator tank circuit, it absorbs energy and loads oscillator, making its plate current rise and pull in relay that actuates electric door lock. To adjust, place key 0.5 in away from plate end of L1 and slowly adjust C1 until relay energizes. Relay will then drop out when key is removed. Key is small parallel resonant circuit having same frequency as L1-C1.—J. P. Shields, "Novel Electronic Circuits," H. W. Sams & Co., Indianapolis, Ind., 1968, p 83.


INPUT
115 v 60 hz
OUTPUT
MCR
1305-4
10
10k
1N4740
8Ω
2,000Ω
CONTROL
INPUT
3.3k
0.5
AUDIO
TRANSFORMER
2N1671B
47

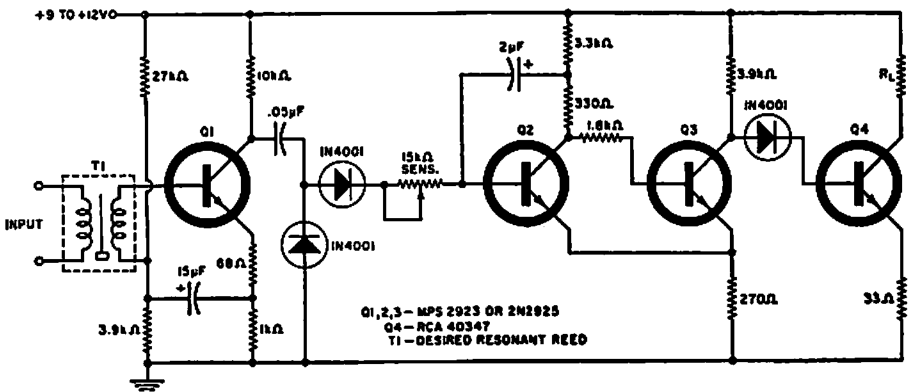
DIODES ARE 1N2069

SOLID-STATE RELAY—Ujt produces pulse after each zero crossing of line voltage, but reactance of transformer prevents gating of pulses to scr when primary winding is open. When primary is shorted at remote control location, gating pulses trigger scr at start of each half-cycle, to give effect of closing switch between a-c line and output.—J. B. Johnson, Line-Operated Relay Uses Isolated Actuating Input, *Electronics*, Feb. 3, 1969, p 78.

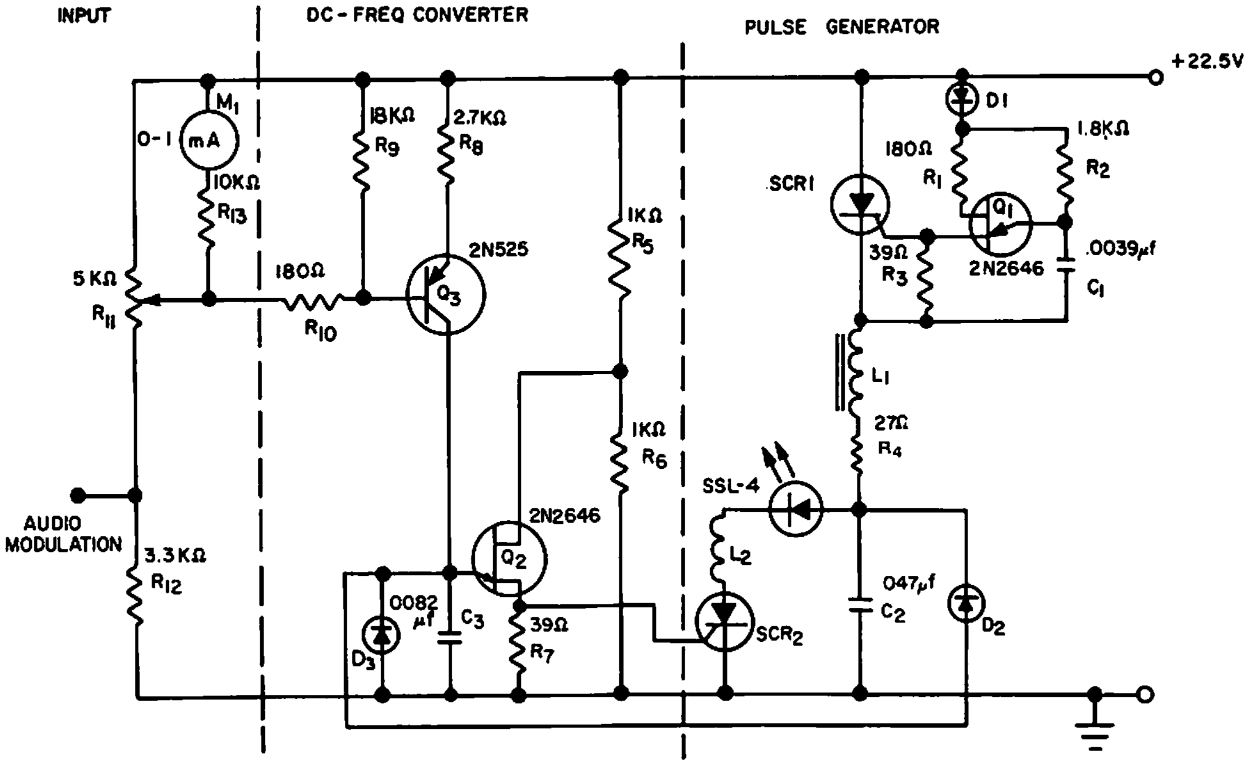

LOAD RECEPTACLE
500 WATTS MAX
"FILAMENT"
TRANSFORMER
120 VAC
F1
5 AMP
"3 AG"
FUSE
6.3V
1a
T1
120V
GE-X12
TRIAC
R1
50 OHMS
2 WATTS
LOW VOLTAGE
"BELL" WIRE
S1
REMOTE
SWITCH

NOTE:
MOUNT GE-X12 ON A 3"X 3"X 1/16" COPPER OR ALUMINUM COOLING FIN.

CONTROLLING 500 W WITH BELL WIRE—Closing remote switch shorts secondary of small filament transformer and triggers triac for turning on load. When triac conducts, it bypasses transformer primary and prevents burning it out. Will handle lamp or appliance loads up to 500 W.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 162.

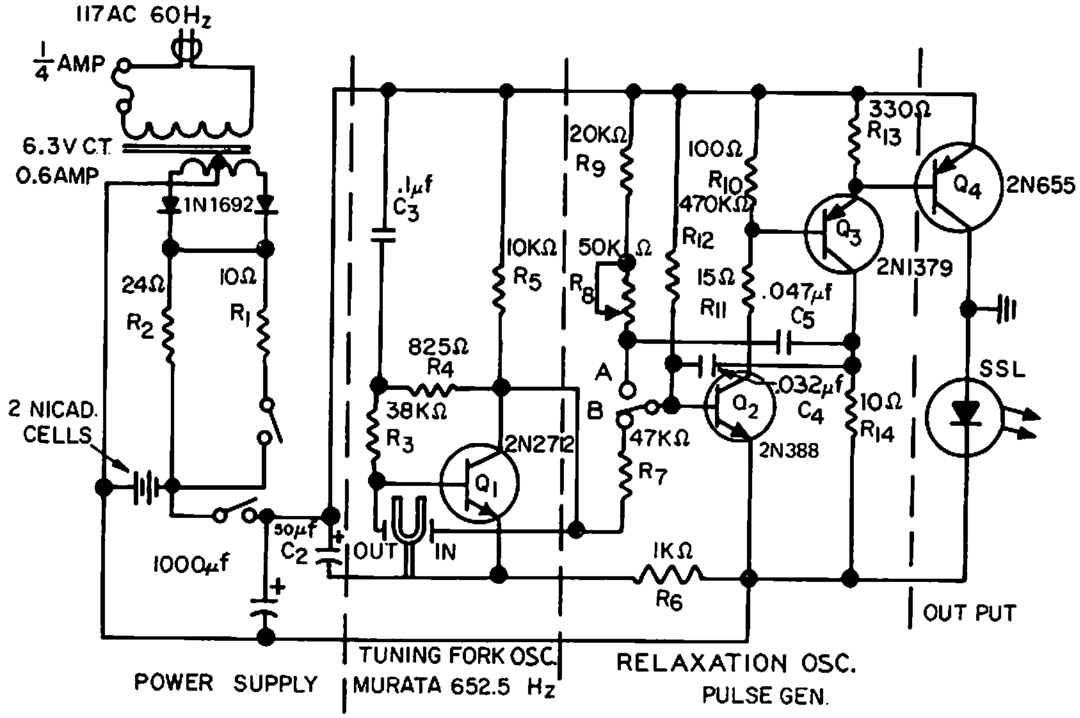

+9 TO +12V
27kΩ
10kΩ
.05μF
2μF
3.3kΩ
330Ω
1.8kΩ
3.9kΩ
RL
Q1
Q2
Q3
Q4
1N4001
1N4001
1N4001
15kΩ SENS.
T1
INPUT
15μF
68Ω
3.9kΩ
1kΩ
270Ω
33Ω
Q1,2,3—MPS 2923 OR 2N2925
Q4—RCA 40347
T1—DESIRED RESONANT REED

FREQUENCY-SELECTIVE RECEIVER—Uses Motorola Minitone resonant-reed device at input, tuned to same frequency between 67 and 3,150 Hz as in companion transmitter. Input can be from wire line or from audio output of radio receiver. Tone signal is amplified by Q1, detected in diodes, and used to activate Schmitt trigger Q2-Q3. This turns on Q4, to send current through load which can be latching relay, signal lamp, or other device.—L. Solomon, Tone-Selective Signaling The New Look, *Electronics World*, Sept. 1967, p 88–90.

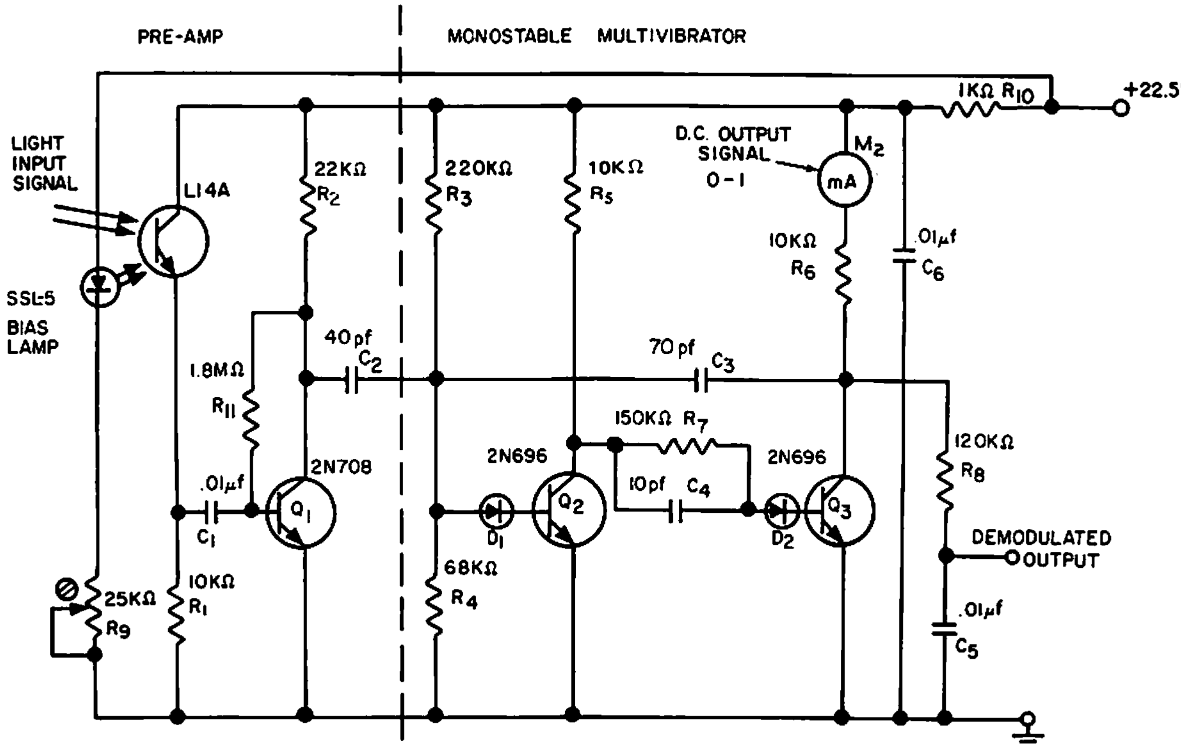

INPUT
DC-FREQ CONVERTER
PULSE GENERATOR
+22.5V
M1
0-1 mA
10KΩ
R13
5KΩ
R11
18KΩ
R9
2.7KΩ
R8
180Ω
R10
2N525
Q3
1KΩ
R5
1KΩ
R6
2N2646
Q2
.0082 μf
C3
39Ω
R7
D3
AUDIO MODULATION
3.3KΩ
R12
D1
1.8KΩ
R2
180Ω
R1
SCR1
Q1
2N2646
39Ω
R3
.0039μf
C1
L1
27Ω
R4
SSL-4
L2
SCR2
.047μf
C2
D2

L_1 = 115μH, 60 turns #24 wire, Genelax Core G59N/30.1
L_2 = ≈ 1μH, 6 turns #26 wire, 3/4" dia. air core
D_1, D_2, and D_3 = glass signal diodes

OPTICAL F-M TRANSMITTER—Used to transmit analog information, with signal voltage being converted into pulse repetition rate that is adjustable from 50 Hz to 50,000 Hz by d-c control voltage. Pulses are 500 ns wide, with peaks of several amperes. Variations in received signal strength do not affect fidelity of transmitted signal. Pulse generator uses solid-state lamp and scr having actual switching time of only 40 ns, to give effective duty factor of about 0.025 at 50 kHz. Analog-frequency converter uses ujt Q2 controlled by adjustable constant-current source Q3. Audio information can be transmitted by frequency-modulating the transmitter. R11 then determines carrier frequency.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 37.


117AC 60Hz
1/4 AMP
6.3V C.T.
0.6AMP
1N1692
24Ω
R2
10Ω
R1
2 NICAD. CELLS
1000μf
50μf
C2
.1μf
C3
825Ω
R4
38KΩ
R3
OUT
IN
Q1
2N2712
10KΩ
R5
20KΩ
R9
50KΩ
R8
A
B
47KΩ
R7
1KΩ
R6
100Ω
R10
470KΩ
R12
15Ω
R11
.047μf
C5
.032μf
C4
Q2
2N388
Q3
2N1379
330Ω
R13
10Ω
R14
Q4
2N655
SSL
OUT PUT
POWER SUPPLY
TUNING FORK OSC.
MURATA 652.5 Hz
RELAXATION OSC.
PULSE GEN.

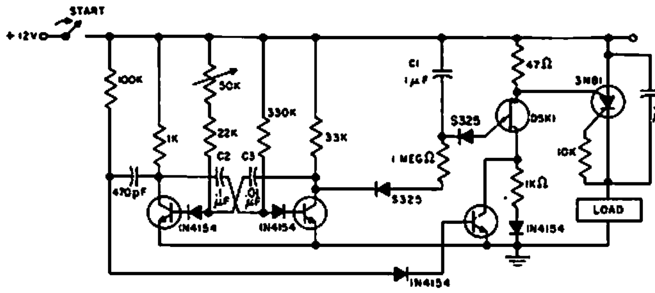
TUNED-RELAY TRANSMITTER—Operates from a-c line and drives solid-state lamp at pulsing rate corresponding to frequency of tuning fork used (switch at B) or at free-running frequency of relaxation oscillator Q2-Q3. R8 covers range of 300 to 1,200 pps. Used with receiver having appropriate tuned relay circuit for each transmitting channel.—L. M. Hertz, Solid State Lamps—Part II, General Electronic, Cleveland, Ohio, No. 3-0121, 1970, p 34.


PRE-AMP
MONOSTABLE MULTIVIBRATOR
LIGHT INPUT SIGNAL
L14A
SSL-5 BIAS LAMP
25KΩ
R9
22KΩ
R2
1.8MΩ
R11
.01μf
C1
10KΩ
R1
2N708
Q1
40pf
C2
220KΩ
R3
68KΩ
R4
D1
2N696
Q2
10KΩ
R5
150KΩ R7
10pf C4
70pf C3
D2
2N696
Q3
D.C. OUTPUT SIGNAL 0-1
M2
mA
10KΩ
R6
.01μf
C6
1KΩ R10
+22.5V
120KΩ
R8
DEMODULATED OUTPUT
.01μf
C5

OPTICAL F-M RECEIVER—Detects pulse-frequency-modulated light beam and converts prr back to analog output. Mvbr Q2-Q3 generates one pulse for each detected light pulse. M2 averages these pulses for visual output, while d-c output is obtained across C5. System gives highly intelligible voice communication at maximum prr of 50 kHz and minimum of about 100 Hz.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, p 38.

CHAPTER 74

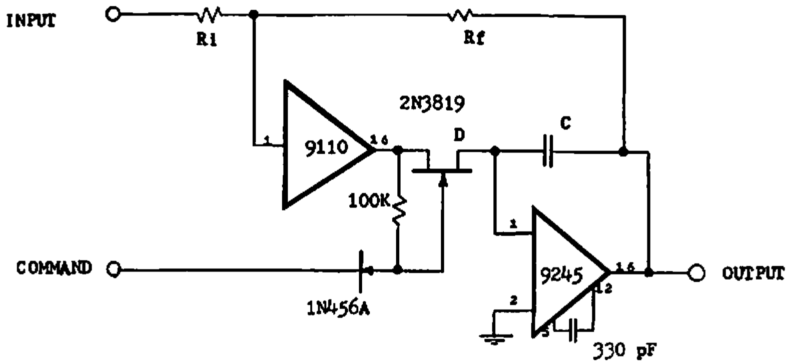
Sampling Circuits



START
+12V
100K
1K
50K
22K
C2
.1 µF
C3
.01 µF
330K
33K
470pF
1N4154
1N4154
C1
1 µF
S325
1 MEGΩ
S325
47Ω
D5K1
3N81
.1 µF
10K
1KΩ
1N4154
LOAD
1N4154

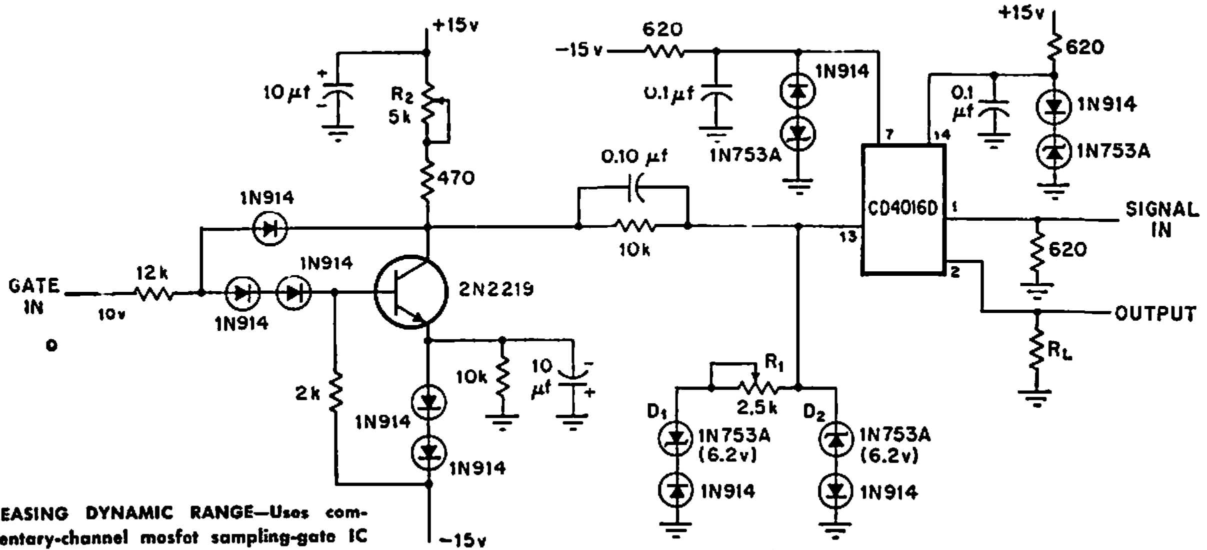
C1 GE POLYCARBONATE 74F51A105
C2 GE BLUE JAY AA14A104
C3 GE BLUE JAY AA11A103
TRANSISTORS - GE 2N2924

R-C MULTIPLICATION AND SAMPLING—Free-running mvbr with very low duty cycle applies timing voltage through diode S325 to 1-meg 1-µF R-C timing combination, to produce chopped exponential waveform like staircase. At end of each mvbr charging cycle, negative pulse is applied to base of sampling transistor through 470-pF capacitor and diode, to give about 10-µs sample period.—W. R. Spofford, Jr., Complementary Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.72, 1968, p 13.



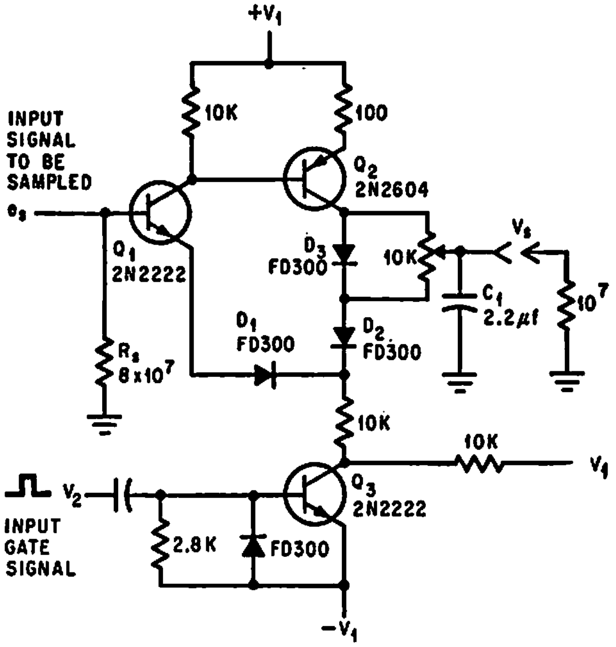
INPUT
R1
Rf
9110
1
16
2N3819
D
C
100K
COMMAND
1N456A
1
2
9245
5
12
16
330 pF
OUTPUT

LONG HOLD—Command signal of 0 V initiates sampling, and −10 V gives hold. Report discusses frequency limitations of arrangement.—A Wide Band, Long Hold Sample and Hold Circuit, Optical Electronics, Tucson, Ariz., No. 10131.

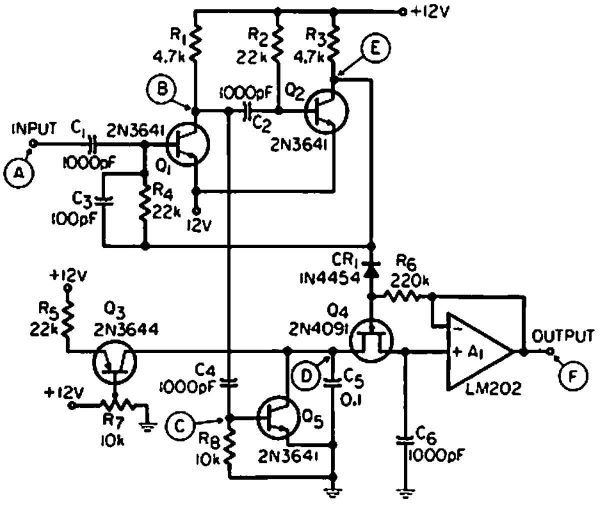


+15v
10 µf
R2 5k
470
1N914
GATE IN
12k
10v
0
1N914
1N914
2N2219
2k
10k
10 µf
1N914
1N914
−15v
−15 v
620
0.1 µf
1N914
1N753A
0.10 µf
10k
7
14
13
CD4016D
1
2
+15v
620
0.1 µf
1N914
1N753A
SIGNAL IN
620
OUTPUT
RL
R1
2.5k
D1
D2
1N753A (6.2v)
1N914
1N753A (6.2v)
1N914

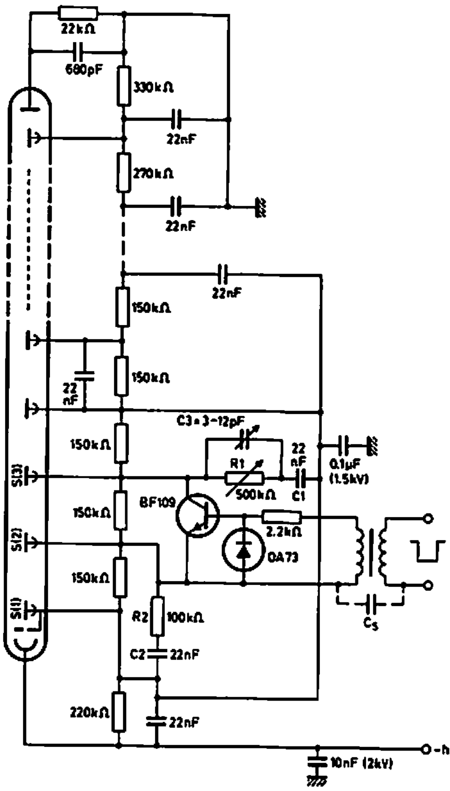
INCREASING DYNAMIC RANGE—Uses complementary-channel mosfet sampling-gate IC to increase dynamic range of sample-and-hold circuit. Keeps transient peaks in load 46 dB down from maximum gating amplitude. Zeners with series resistances soften sharp edges of drive waveform applied to IC, to reduce transients and thereby increase dynamic range of switch.—R. J. Turner, Zeners Cut Corners in MOS Gate Driver, *Electronics*, June 22, 1970, p 82.


+V1
INPUT SIGNAL TO BE SAMPLED
es
10K
100
Q2 2N2604
Q1 2N2222
D3 FD300
10K
Vs
C1 2.2µf
10^7
D1 FD300
D2 FD300
Rs 8x10^7
10K
10K
V1
V2
INPUT GATE SIGNAL
2.8K
FD300
Q3 2N2222
-V1

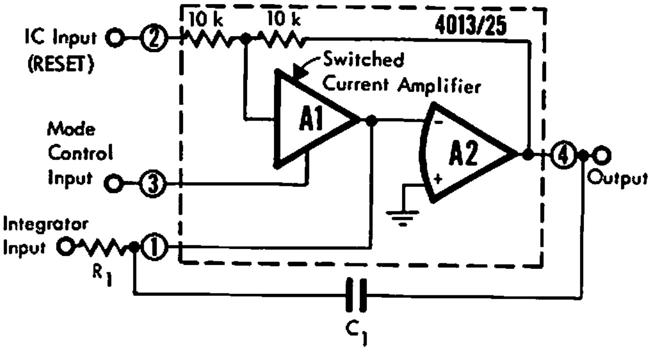
DATA SYSTEM PULSES—Will sample pulse input signal and hold for up to 1 min. Transistor beta of 100 gives signal transfer ratio of 10,000, making high-beta transistors unnecessary.—R. S. Culkay, Circuit Samples A Signal, Holds It Up To 1 Minute, *Electronics*, Oct. 3, 1966, p 106–107.


+12V
R1 4.7k
R2 22k
R3 4.7k
E
B
1000pF
Q2
C2
2N3641
INPUT
C1
2N3641
A
1000pF
Q1
C3 100pF
R4 22k
12V
+12V
R5 22k
Q3 2N3644
CR1 1N4454
R6 220k
Q4 2N4091
OUTPUT
A1
LM202
F
C4 1000pF
D
C5 0.1
+12V
R7 10k
C
R8 10k
Q5 2N3641
C6 1000pF

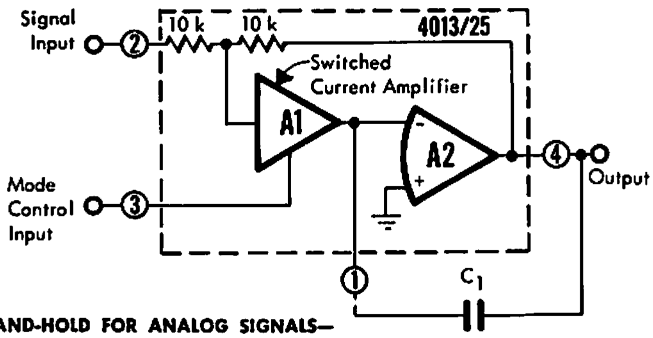
PERIOD-VOLTAGE CONVERTER—Allows sampling at rates approaching input frequency, without introducing excessive ripple. Instantaneous output voltage is proportional to input signal period or frequency. Consists of mono mvbr Q1-Q2, linear ramp generator Q3-Q5, and sample-and-hold circuit Q4-A1. Sample-hold allows accurate tracking of rapid changes in period, because each step is independent of preceding changes.—J. M. Kasson, Linear Period-to-Voltage Converter with Low Ripple, *EEE*, Jan. 1969, p 117–118.


22kΩ
680pF
330kΩ
22nF
270kΩ
22nF
22nF
150kΩ
22 nF
150kΩ
C3=3-12pF
150kΩ
R1
500kΩ
22 nF
C1
0.1µF (1.5kV)
S(3)
150kΩ
BF109
2.2kΩ
OA73
S(2)
150kΩ
S(1)
R2 100kΩ
Cs
C2 22nF
220kΩ
22nF
-h.t.
10nF (2kV)

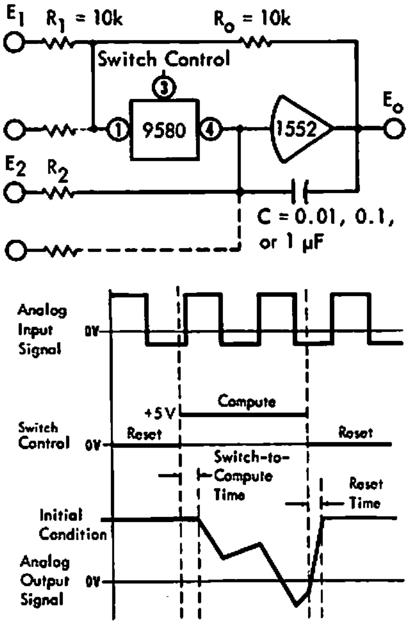
GATING PHOTOMULTIPLIER—Negative-going pulse applied through transformer makes transistor short bleeder resistor between dynodes S2 and S3, dropping voltage between them and reducing gain of photomultiplier by factor of about 100, which is usually enough for sampling applications such as are used in spectrometry.—J. M. Schenkeren, "Photomultipliers," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1970, p 99.


IC Input (RESET)
2
10 k
10 k
4013/25
Switched Current Amplifier
A1
A2
Mode Control Input
3
4
Output
Integrator Input
R1
1
C1

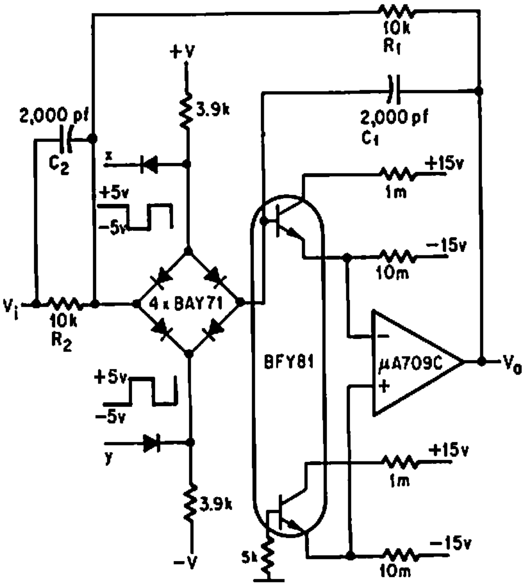
SWITCHED INTEGRATOR—Uses Burr-Brown 4013/25 sample-hold module, with input signal applied through external summing resistor R1 as shown. When switched current amplifier in module is gated off, input signal is integrated with integrator gain of 1/R1C1. In repetitive operation, initial value of time integral is set by IC (initial-condition) input voltage used for switching to reset mode.—Sample/Hold Modules, Burr-Brown Research, Tucson, Ariz., PDS-211, 1969.


Signal Input
2
10 k
10 k
4013/25
Switched Current Amplifier
A1
A2
-
+
4
Output
Mode Control Input
3
1
C1

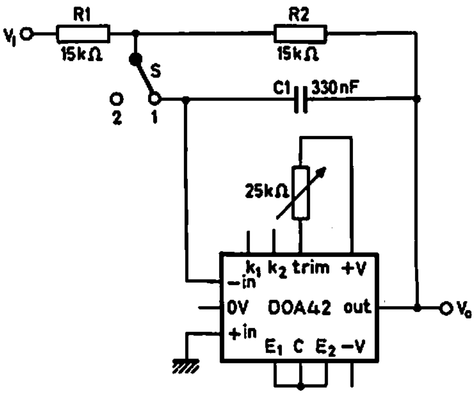
SAMPLE-AND-HOLD FOR ANALOG SIGNALS—Used to acquire and track analog input signal and hold its instantaneous value when commanded to do so by mode control logic input. Can be used in analog-digital converters, pulse amplitude detectors, measurement of time intervals, and conversion of pulse height to pulse width. C1 is holding capacitor, and should be low-leakage polystyrene.—Sample/Hold Modules, Burr-Brown Research, Tucson, Ariz., PDS-211, 1969.


E1
R1 = 10k
Ro = 10k
Switch Control
3
1
9580
4
1552
Eo
E2
R2
C = 0.01, 0.1, or 1 μF
Analog Input Signal
0V
Switch Control
0V
+5V
Reset
Compute
Reset
Switch-to-Compute Time
Reset Time
Initial Condition
Analog Output Signal
0V

SWITCHED INTEGRATOR—Burr-Brown 9580 sample-hold electronic switch gives choice of reset and compute modes of operation for opamp.—Sample/Hold Electronic Switch, Burr-Brown Research, Tucson, Ariz., PDS-188A, 1968.

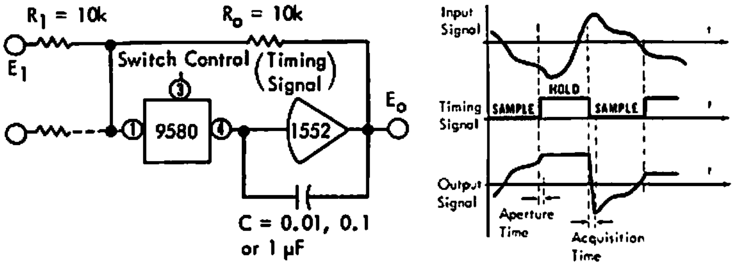

10k
R1
+V
2,000 pf
C2
3.9k
2,000 pf
C1
x
+5v
-5v
+15v
1m
-15v
10m
Vi
10k
R2
4 x BAY71
BFY81
μA709C
-
+
Vo
+5v
-5v
y
+15v
1m
3.9k
-V
5k
-15v
10m

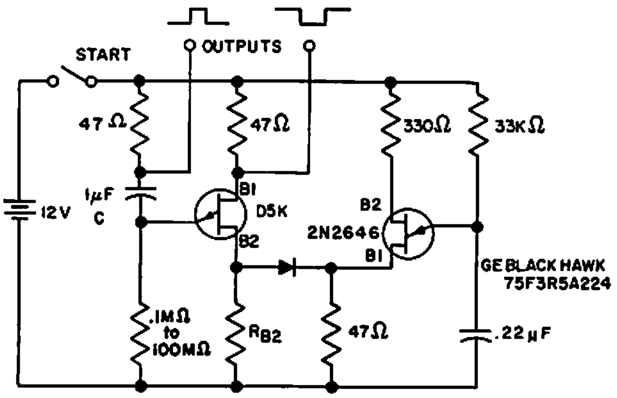
BETTER TRACKING—Accuracy of sample-and-hold circuit is increased by placing dual transistor at input of opamp to limit discharge current of feedback capacitor and thereby decrease holding error at output. Static and dynamic accuracy is better than 0.1% full scale, with a holding error of 1 to 2 mV, for input voltage range of 10 V for either polarity, frequencies from d-c to 1 kHz, and temperature range of 0 to 50 C. Circuit values shown give track and hold time of 200 μs.—G. Koch and U. Mocci, Dual Transistor Reduces Error of Track and Hold Circuit, *Electronics*, March 17, 1969, p 94–95.


Vi
R1
15kΩ
R2
15kΩ
S
2
1
C1
330nF
25kΩ
-in
k1 k2 trim +V
0V DOA42 out
+in
E1 C E2 -V
Vo

MEASURING MOMENTARY VALUE—Simple hold circuit using Philips DOA42 block charges R2-C1 network to hold information, after which switch is changed to position 2 so input signal can be removed.—Hold Circuit Using a DOA42 Block, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 71.

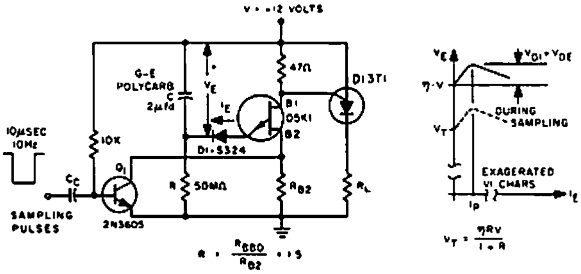
SAMPLE-HOLD—Uses Burr-Brown 9580 sample-hold electronic switch to give choice of track and hold modes of operation with opamp. When 9580 is switched off by applying positive 5–15 V control signal, circuit switches from track mode to hold mode in about 200 ns.—Sample/Hold Electronic Switch, Burr-Brown Research, Tucson, Ariz., PDS-188A, 1968.


R1 = 10k
Ro = 10k
E1
Switch Control
(Timing Signal)
3
1
9580
4
1552
Eo
C = 0.01, 0.1 or 1 μF
Input Signal
Timing Signal
SAMPLE
HOLD
SAMPLE
Output Signal
Aperture Time
Acquisition Time


START
OUTPUTS
47 Ω
47Ω
330Ω
33KΩ
12V
1μF
C
B1
D5K
B2
B2
2N2646
B1
GE BLACK HAWK
75F3R5A224
.1MΩ
to
100MΩ
R_{B2}
47Ω
.22μF

C=GE BLUE JAY AA18A105C

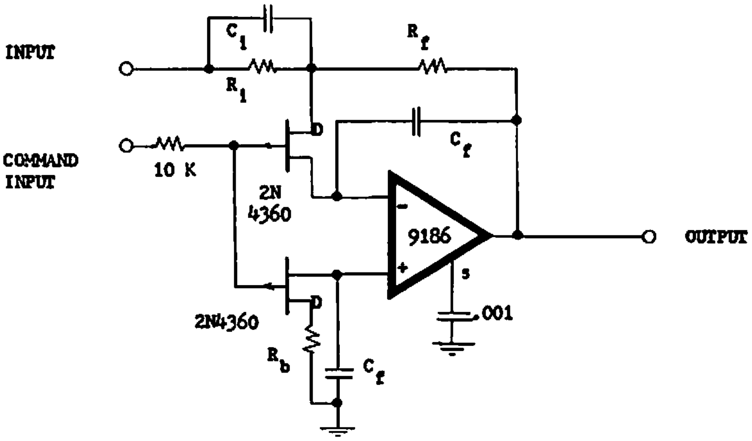
LOW-COST SAMPLER—Uses inexpensive ujt such as 2N2646 or D13T1 in oscillator configuration. When 0.22-μF capacitor discharges, voltage across 47-ohm resistor is lifted positive for few microseconds, back-biasing diode and allowing interbase voltage of complementary ujt D5K to reach its normal value.—W. R. Spofford, Jr., Complementary Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.72, 1968, p 12.

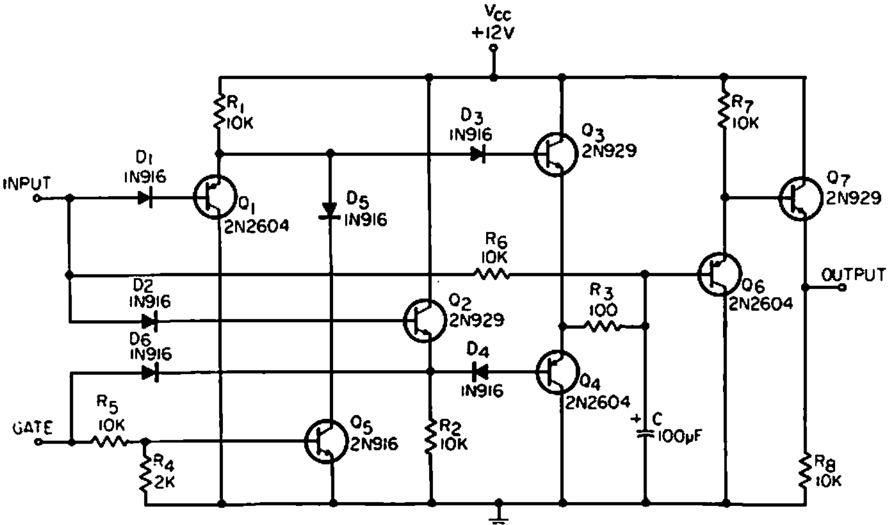

V = +12 VOLTS
G-E
POLYCARB
C
2μfd
V_E
I_E
47Ω
B1
D5K1
B2
D13T1
D1-5324
10μSEC
10Hz
10K
C_C
Q_1
R
50MΩ
R_{B2}
R_L
SAMPLING
PULSES
2N3605
$R = \frac{R_{BBO}}{R_{B2}} = 15$
V_E
$V_{D1} + V_{DE}$
η·V
V_T
DURING
SAMPLING
EXAGERATED
VI CHARS
I_P
I_E
$V_T = \frac{\eta RV}{1+R}$

C= GE POLYCARBONATE 74F01B-205

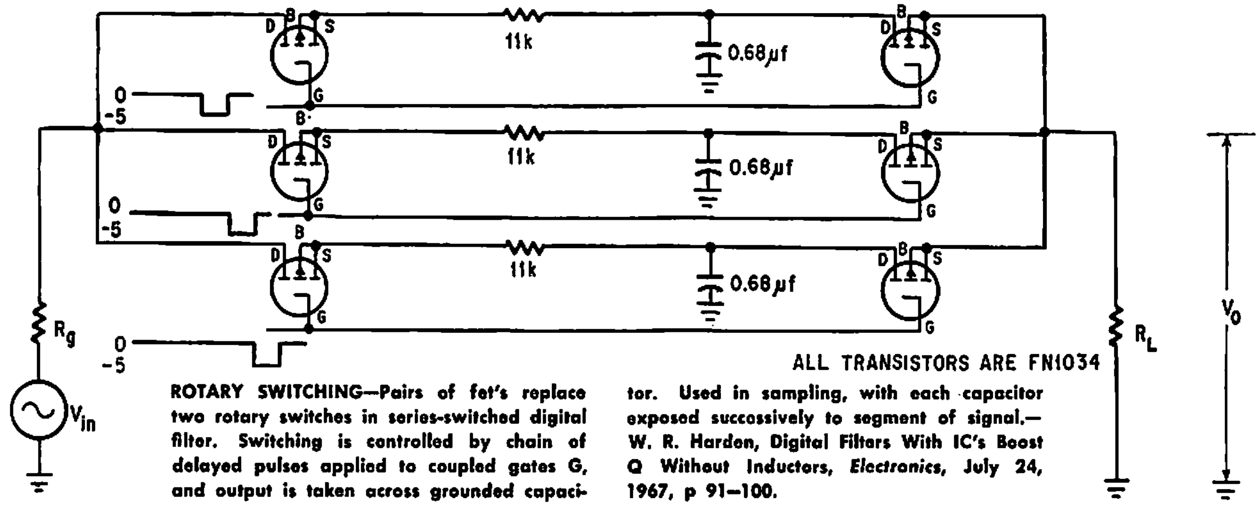
80-SEC TIMER WITH SAMPLING—Threshold sampling is achieved with complementary-ujt 80-s timer by turning Q1 off for 10 μs at 10-Hz rate with external sampling pulses. When capacitor voltage becomes large enough to fire the ujt, D13T1 programmable ujt is triggered into conduction.—W. R. Spofford, Jr., Complementary Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.72, 1968, p 12.

INTEGRATOR WITH SAMPLE & HOLD—Uses OEI Model 9186 uhf opamp having high slewing rate and very wide bandwidth at unity gain. In integrating mode, amplifier has integrating capacitor between output and inverting input, while noninverting input is at signal ground. During integrating mode, fet switches are on and not in circuit. When placed back in circuit and opened by sampling command input, output equals value at moment before switches were opened. For 20-V p-p swing, maximum frequency is 800 kHz. —A High Speed Integrator and Sample & Hold Circuit, Optical Electronics, Tucson, Ariz., No. 10079.


INPUT
C_1
R_1
R_f
COMMAND
INPUT
10 K
D
C_f
2N
4360
-
+
9186
5
.001
OUTPUT
2N4360
D
R_b
C_f


Vcc
+12V
R_1
10K
D_3
1N916
Q_3
2N929
R_7
10K
D_1
1N916
INPUT
Q_1
2N2604
D_5
1N916
Q_7
2N929
R_6
10K
OUTPUT
D_2
1N916
R_3
100
Q_6
2N2604
Q_2
2N929
D_6
1N916
D_4
1N916
Q_4
2N2604
R_5
10K
GATE
R_4
2K
Q_5
2N916
R_2
10K
C
100μF
R_8
10K

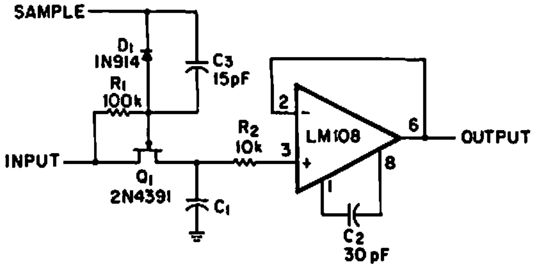
FILTER WITH SAMPLE-HOLD—Circuit functions as unity-gain amplifier having two different time constants that are selected by grounding or opening gate terminal, for use as gated low-pass filter operating in range of 0.1 to 1,000 Hz. Removing R6 converts it to sample-hold circuit functioning as amplifier when gate is grounded. When gate is opened, output is held at last voltage level. —R. S. Hughes, Gated Filter and Sample-Hold Circuit, *EEE*, Nov. 1966, p 154–155.

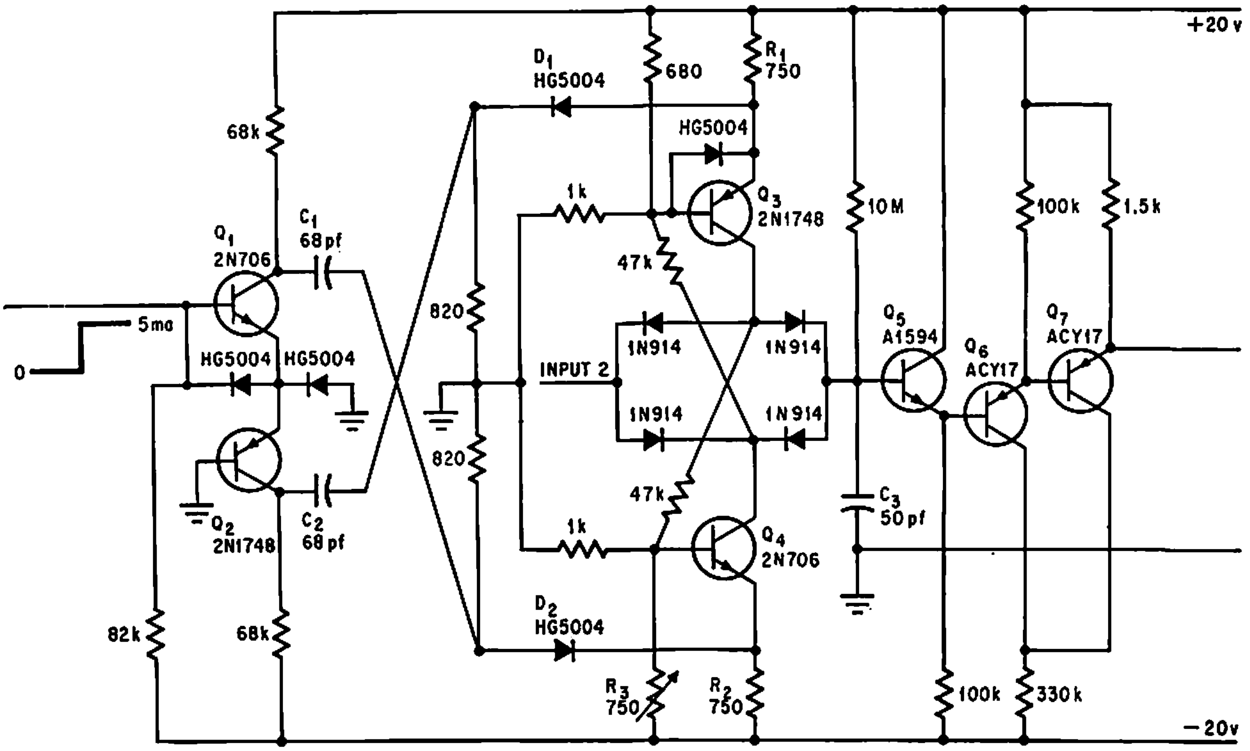

D
B
S
G
11k
0.68μf
0
-5
Rg
Vin
RL
V0

ALL TRANSISTORS ARE FN1034

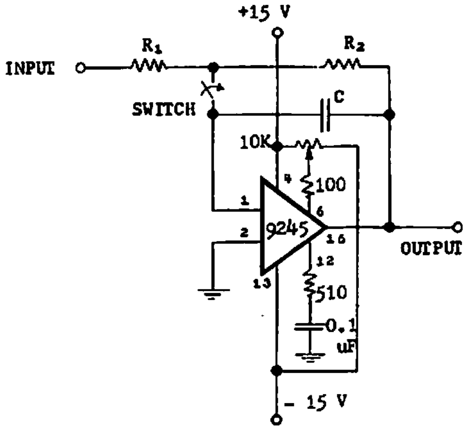
ROTARY SWITCHING—Pairs of fet's replace two rotary switches in series-switched digital filter. Switching is controlled by chain of delayed pulses applied to coupled gates G, and output is taken across grounded capacitor. Used in sampling, with each capacitor exposed successively to segment of signal.—W. R. Harden, Digital Filters With IC's Boost Q Without Inductors, *Electronics*, July 24, 1967, p 91–100.

LOAD-INDEPENDENT HOLDING—Opamp using super-gain transistors provides improved holding accuracy by minimizing error currents. Opamp buffers holding capacitor C1 to prevent it from being discharged by any output loading.—R. J. Widlar, Designing with Super-Beta Transistor Op-Amp ICs, *EEE*, Dec. 1969, p 70–73.

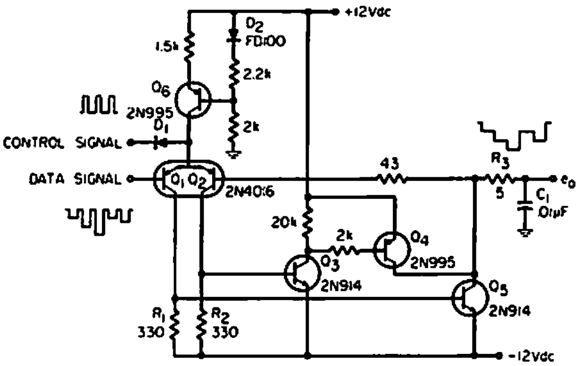

SAMPLE
D1
1N914
C3
15pF
R1
100k
R2
10k
INPUT
Q1
2N4391
C1
LM108
2
3
6
8
1
OUTPUT
C2
30 pF


+20 v
−20v
68k
Q1
2N706
C1
68pf
5ma
0
HG5004
HG5004
Q2
2N1748
C2
68 pf
82k
68k
D1
HG5004
820
820
680
R1
750
HG5004
1k
Q3
2N1748
47k
1N914
1N914
1N914
1N914
INPUT 2
47k
1k
Q4
2N706
D2
HG5004
R3
750
R2
750
10M
C3
50 pf
Q5
A1594
Q6
ACY17
Q7
ACY17
100k
1.5k
100k
330k

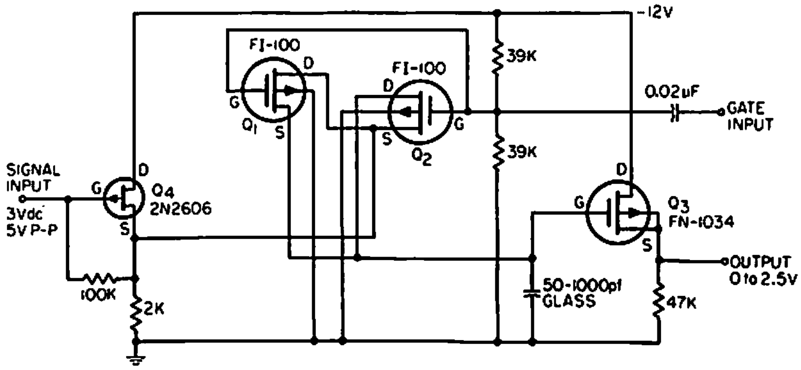
SAMPLING 10-V SIGNALS—Modification of conventional sampler uses balanced drive to diode bridge, in place of pulse transformer drive. Arrangement permits sampling of signal amplitudes comparable to power supply voltage. Ideal for progressive signal sampling, as in sampling oscilloscope.—D. J. Grover, Large-Signal Sampling Without a Transformer, *Electronics*, Nov. 27, 1967, p 80.


+15 V
INPUT
R1
R2
SWITCH
C
10K
4
100
1
6
9245
2
16
12
OUTPUT
13
510
0.1 uF
- 15 V

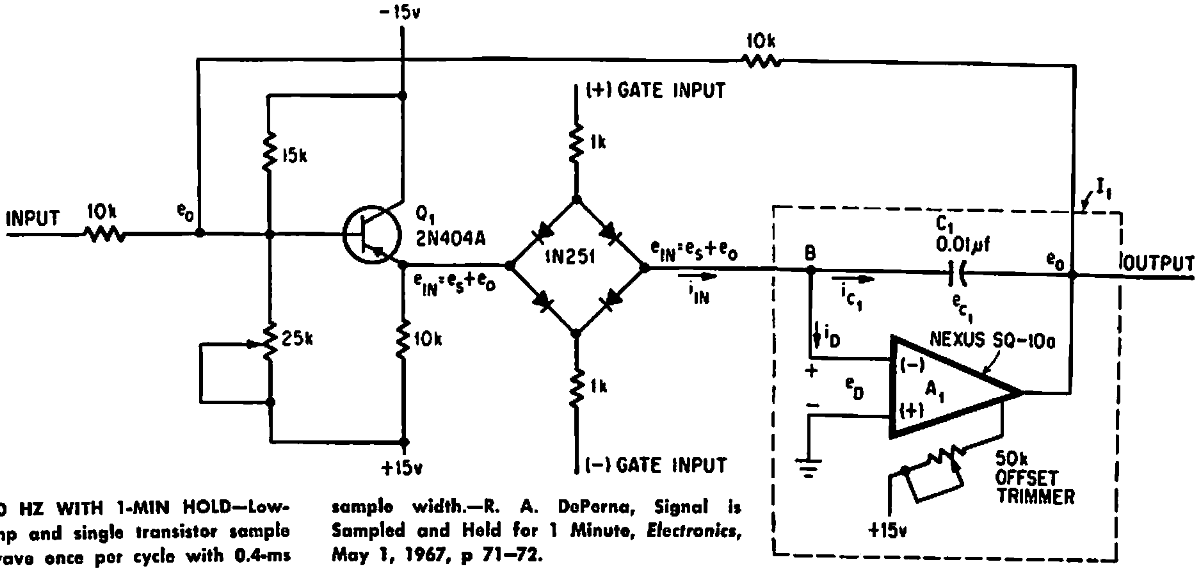
HIGH-SPEED SAMPLING & HOLD—When switch is opened, OEI Model 9245 opamp becomes unity-gain amplifier having same output voltage as that across C. When switch is closed, circuit is in sample mode and behaves as augmented integrator. If C is 150 pF, bandwidth for 3 dB down is 10 MHz.—The 9245 As A High Speed Sample and Hold, Optical Electronics, Tucson, Ariz., No. 10117.


+12Vdc
1.5k
D2
FD100
2.2k
Q6
2N995
2k
D1
CONTROL SIGNAL
DATA SIGNAL
Q1 Q2
2N4016
43
R3
5
eo
C1
.01μF
20k
2k
Q4
2N995
Q3
2N914
Q5
2N914
R1
330
R2
330
-12Vdc

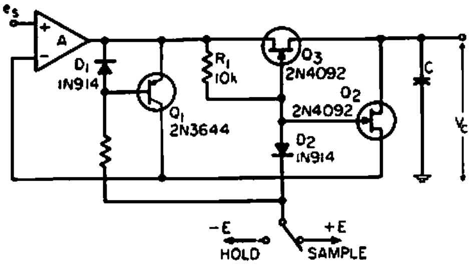
FASTER SAMPLE-HOLD—Matched transistors Q1-Q2 give low offset between sample data input and hold output, to give 300-ns output response to step input level and 0.1% accuracy. Logic input applied to D1 controls state of circuit.—J. Downey, Sample-and-Hold Circuit is Fast Yet Accurate, *EEE*, March 1968, p 125.


-12V
FI-100
D
G
Q1
S
FI-100
D
S
G
Q2
39K
0.02μF
GATE INPUT
39K
SIGNAL INPUT
3Vdc
5V P-P
G
D
Q4
2N2606
S
D
G
Q3
FN-1034
S
OUTPUT
0 to 2.5V
100K
2K
50-1000pf GLASS
47K

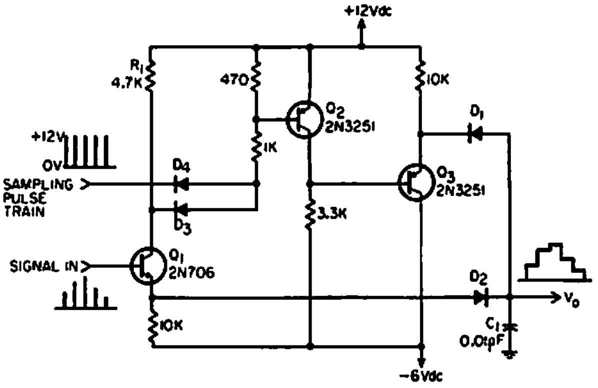
FET BOXCAR SAMPLE-AND-HOLD—Will sample either d-c or a-c signals at repetition rates from 200 to 250 kHz, and store sample voltages having width of only 0.5 μs. Q1 and Q2 form cross-coupled series switch that conducts in both directions for transferring either increasing or decreasing input signals to glass storage capacitor during conduction. Gate input for fet's is −12 V switching pulse lasting 0.5 to 20 μs.—J. J. Contus, Boxcar Circuit Uses FETs, *EEE*, April 1967, p 136.


-15v
10k
(+) GATE INPUT
15k
1k
INPUT
10k
e0
Q1
2N404A
1N251
eIN=es+e0
eIN=es+e0
iIN
I1
C1
0.01μf
B
e0
OUTPUT
iC1
eC1
iD
NEXUS SQ-10a
+
eD
(-)
A1
(+)
−
25k
10k
1k
+15v
(-) GATE INPUT
50k
OFFSET TRIMMER
+15v

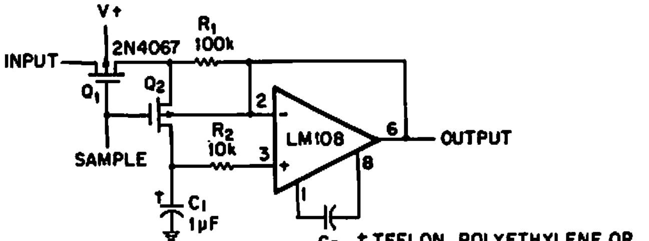
SAMPLING 30 HZ WITH 1-MIN HOLD—Low-cost IC opamp and single transistor sample 30-Hz sine wave once per cycle with 0.4-ms sample width.—R. A. DeParna, Signal is Sampled and Held for 1 Minute, *Electronics*, May 1, 1967, p 71–72.


e_s
A
D_1
1N914
Q_1
2N3644
R_1
10k
Q_3
2N4092
Q_2
2N4092
D_2
1N914
C
V_C
−E
HOLD
+E
SAMPLE

ERROR REDUCTION—Modification of conventional fet sample-and-hold circuit reduces errors caused by ON resistance of fet. During sampling interval, both fet's are on and Q1 is cut off. During hold interval, situation is reversed. With fet's inside feedback loop of high-gain opamp such as μA709C, ON resistance is reduced by open-loop gain, so charging speed is essentially limited only by output current capability of voltage follower. —I. Cohen and D. Clark, An Improved FET Sample-and-Hold Circuit, *EEE*, Sept. 1968, p 104 and 106.


+12Vdc
R_1
4.7K
470
10K
+12V
0V
SAMPLING PULSE TRAIN
D_4
D_3
Q_2
2N3251
1K
D_1
Q_3
2N3251
3.3K
SIGNAL IN
Q_1
2N706
10K
D_2
V_o
C_1
0.01μF
−6Vdc

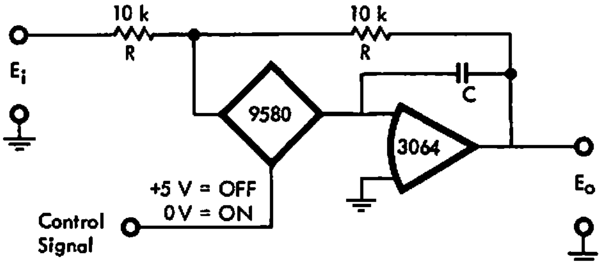
HIGH SPEED WITH SIMPLICITY—Charge and discharge cannot occur simultaneously in simplified circuit shown, and therefore no speed-inhibiting current-limiting resistor is needed. Sampling periods can be as short as 1 μs. Between pulses, sampling pulse train is at ground potential, holding Q2 in saturation. Article describes operation in detail.—B. Pearl, Sample-Hold Circuit, *EEE*, Dec. 1966, p 121–122.


V+
INPUT
2N4067
Q_1
Q_2
R_1
100k
R_2
10k
2
3
6
8
1
LM108
OUTPUT
SAMPLE
†
C_1
1μF
C_2
30pF

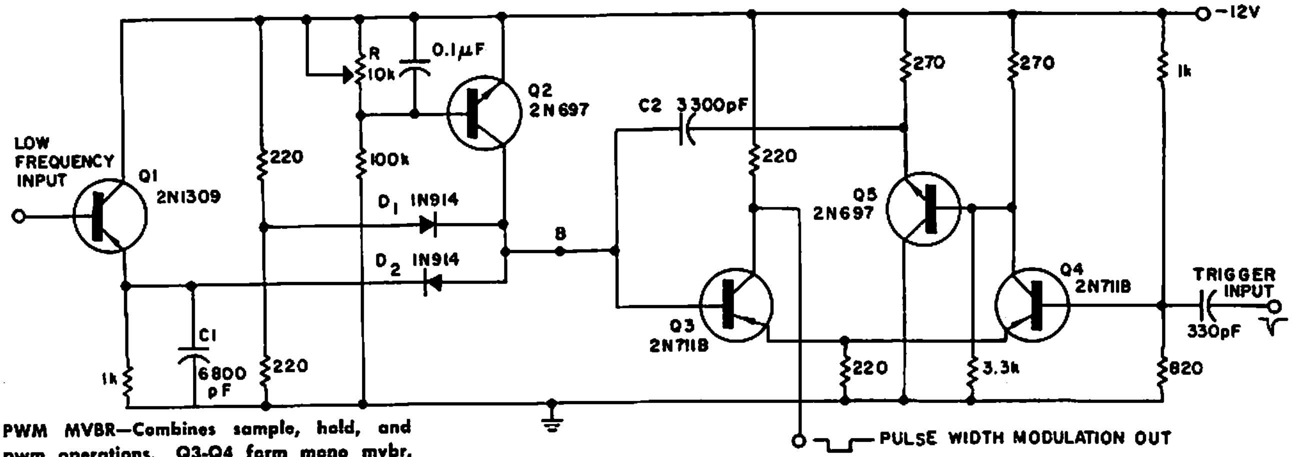
* WORST CASE DRIFT LESS THAN 3mV/SEC

† TEFLON, POLYETHYLENE OR POLYCARBONATE DIELECTRIC CAPACITOR

HIGH-ACCURACY HOLD—Error-producing leakage current across substrate-drain junction is routed to output of high-gain opamp through R1 to prevent it from contributing to residual error current that affects accuracy of sample-and-hold circuit. Hold capacitor must have low leakage and be free from dielectric polarization. For sample interval under 100 μs, use faster IC such as LM102A.—R. J. Widlar, Designing with Super-Beta Transistor Op-Amp ICs, *EEE*, Dec. 1969, p 70–73.


10 k
R
10 k
R
E_i
9580
C
3064
E_o
+5 V = OFF
0V = ON
Control Signal

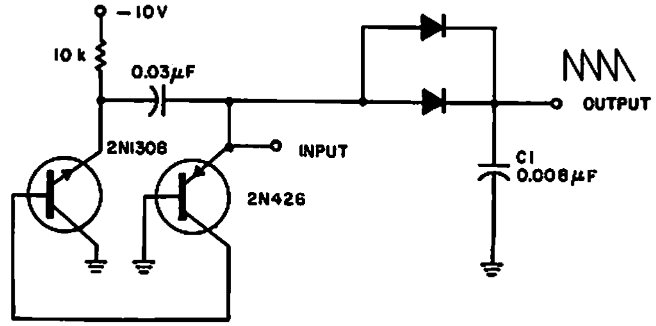
INVERTING SAMPLE-HOLD—Burr-Brown 3064 fet-input opamp module, used with 9580 switch having current amplification factor of 1,000, gives inverting unity-gain amplifier performance when switch is on and set to sample or track mode. Time constant of circuit is short.—Operational Amplifiers, Burr-Brown Research, Tucson, Ariz., LI-227, 1969, p 43.


−12V
R
10k
0.1μF
Q2
2N697
C2 3300pF
270
270
1k
LOW FREQUENCY INPUT
Q1
2N1309
220
100k
220
Q5
2N697
D_1 1N914
D_2 1N914
B
Q4
2N718
Q3
2N718
TRIGGER INPUT
330pF
C1
6800 pF
1k
220
220
3.3k
820
PULSE WIDTH MODULATION OUT

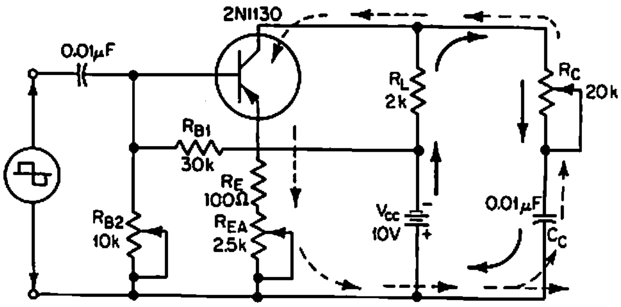
PWM MVBR—Combines sample, hold, and pwm operations. Q3-Q4 form mono mvbr, with C2 as charging capacitor. Positive peak of voltage at B is limited to instantaneous value of low-frequency input to achieve modulation. Maximum prr is 45 kHz and range of output pulse widths is 1 to 20 μs. Linearity is excellent.—A. Shah, Linear Pulse-Width Modulator Uses Monostable Multivibrator, *Electronic Design*, Nov. 8, 1969, p 103 and 105.

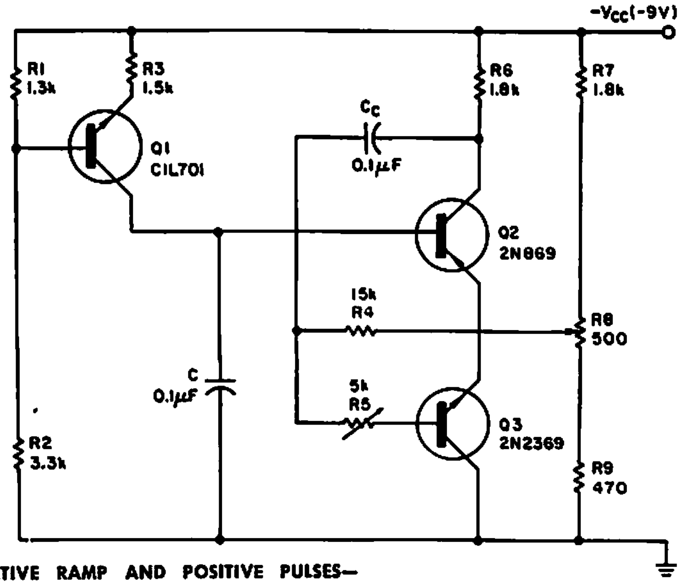
CHAPTER 75
Sawtooth Generator Circuits

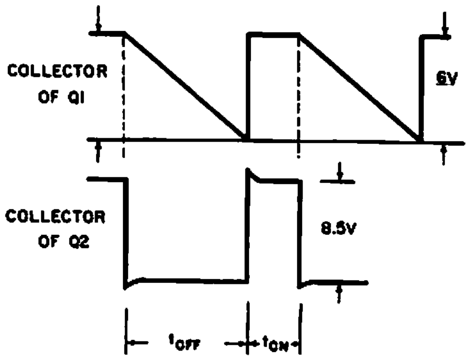
UNIVERSAL SAWTOOTH—Converts 4-V p-p sine, square, or triangular waveform in range of 80 to 800 Hz to 0.3 V sawtooth at lower frequency and 1.5 V sawtooth at higher frequency. Diode can be any type, such as 1N457. Circuit is easily set up, even though not highly accurate.—C. Eddy, Simple Circuit Converts Any Waveform Into a Sawtooth, *Electronic Design*, Dec. 20, 1967, p 110.


−10V
10 k
0.03μF
2N1308
INPUT
2N426
OUTPUT
C1
0.008μF

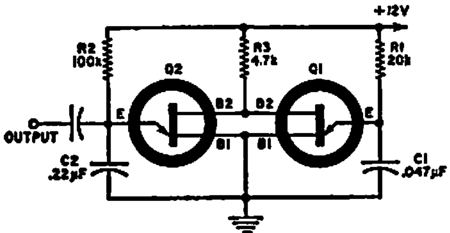
TRAPEZOIDAL VOLTAGE SWEEP—Transistor serves as switch for two wave-shaping networks, one shown by broken arrows and the other by solid arrows. When input pulse swings negative, transistor turns on and CC discharges over broken-arrow path. Output waveform is trapezoidal.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 277.


2N1130
0.01μF
R_L 2k
R_C 20k
V_i
R_{B1} 30k
R_E 100Ω
R_{EA} 2.5k
R_{B2} 10k
V_{CC} 10V
0.01μF
C_C


$-V_{CC}$(−9V)
R1 1.3k
R3 1.5k
Q1 CIL701
R6 1.8k
R7 1.8k
C_C 0.1μF
Q2 2N869
15k R4
R8 500
C 0.1μF
5k R5
Q3 2N2369
R2 3.3k
R9 470

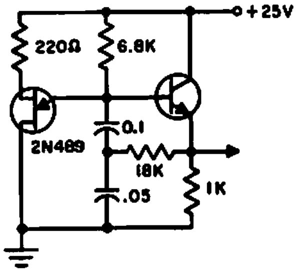

COLLECTOR OF Q1
6V
COLLECTOR OF Q2
8.5V
t_{OFF}
t_{ON}

NEGATIVE RAMP AND POSITIVE PULSES—Provides 200-μs positive pulses with 15 ms OFF time for use in measuring transistor parameters, along with negative-going ramp having excellent linearity. Consumes very little power. Sawtooth can be as narrow as 1 μs, with ramp starting accurately at zero voltage and with no step. Pulses can also be as narrow as 1 μs. Q1 is constant-current source for emitter-coupled complementary pair Q2-Q3.—U. S. Singh, Circuit Generates Linear Ramp and Short Duty Cycle Pulses, *Electronic Design*, May 10, 1969, p 134.

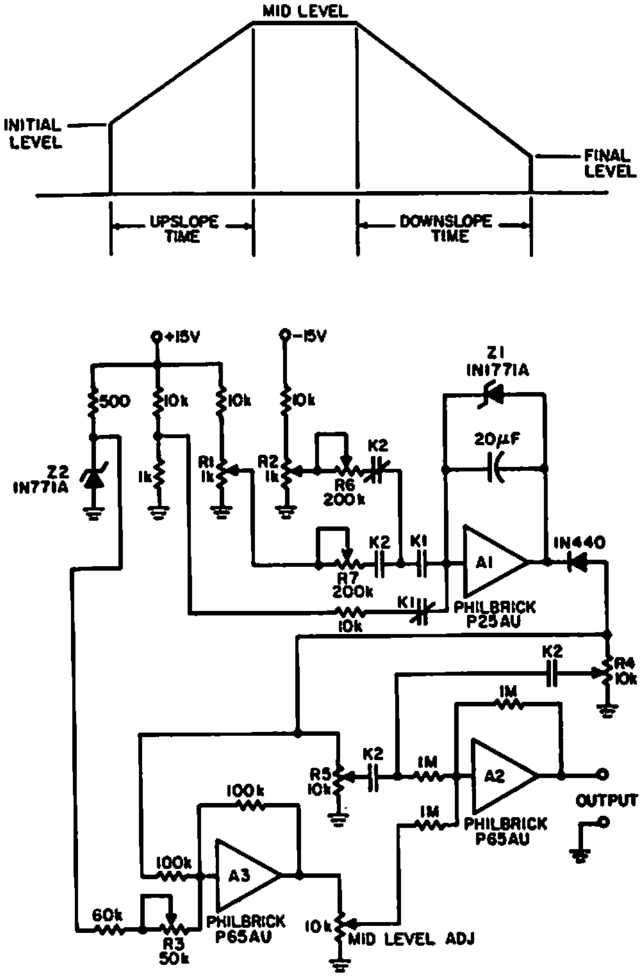

+12V
R2 100k
R3 4.7k
R1 20k
Q2
Q1
B2
B2
E
E
B1
B1
OUTPUT
C2 .22µF
C1 .047µF

Q1,Q2—TIS43—TEXAS INSTRUMENTS UNIJUNCTION TRANSISTOR

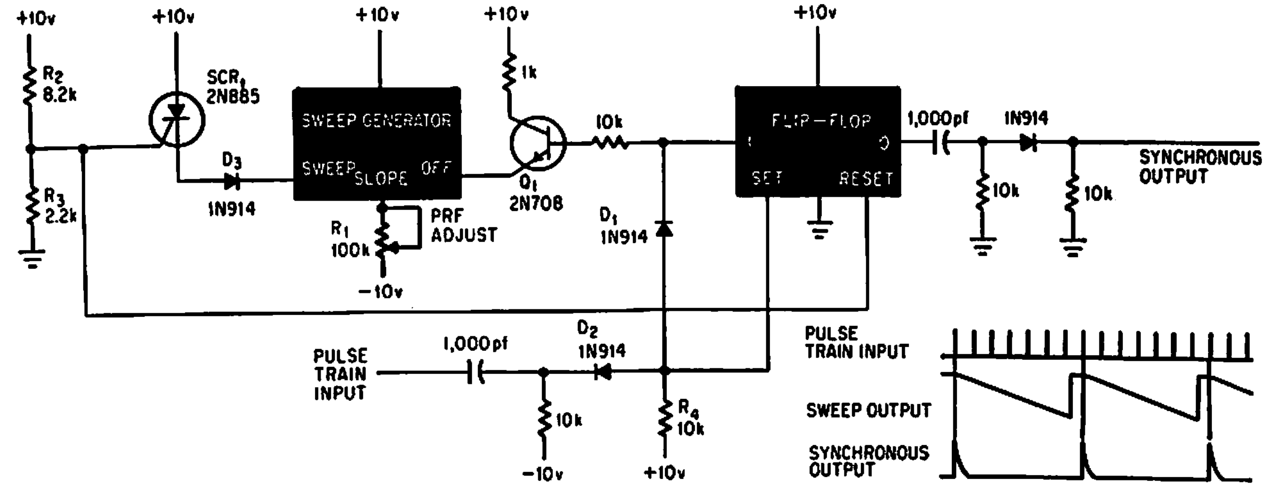
IMPROVING LINEARITY—Instead of feeding timing capacitor from constant-current source, circuit uses two ujt sawtooth oscillators operating independently except for sharing common base-2 resistor R3. The two ujt's now fire in unison, with the fastest ujt determining repetition rate, which is about 500 Hz for values shown and 375-mV output signal. Increasing ratio of time constant R2C2 to R1C1 improves linearity.—F. H. Tooker, Improving Sawtooth Linearity, *Electronics World*, Feb. 1969, p 84.


+25V
220Ω
6.8K
2N489
0.1
18K
.05
1K

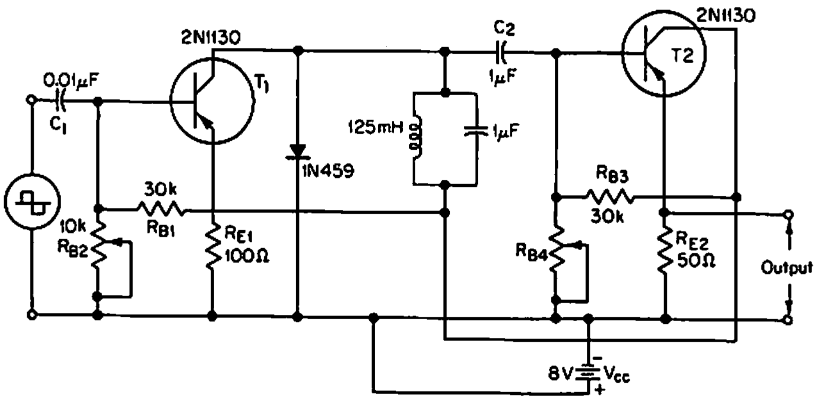
NONLINEARITY COMPENSATION—Addition of 18K-0.05 µF integrating network provides second-order compensation for nonlinearity of bootstrap sawtooth generator. Output stage can be any npn emitter-follower transistor.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 48.


MID LEVEL
INITIAL LEVEL
FINAL LEVEL
UPSLOPE TIME
DOWNSLOPE TIME
+15V
-15V
500
10k
10k
10k
Z1 1N771A
20µF
Z2 1N771A
1k
R1 1k
R2 1k
R6 200k
K2
K2
K1
A1
1N440
R7 200k
K1
PHILBRICK P25AU
10k
K2
R4 10k
1M
R5 10k
K2
1M
A2
OUTPUT
1M
PHILBRICK P65AU
100k
100k
A3
60k
R3 50k
PHILBRICK P65AU
10k
MID LEVEL ADJ

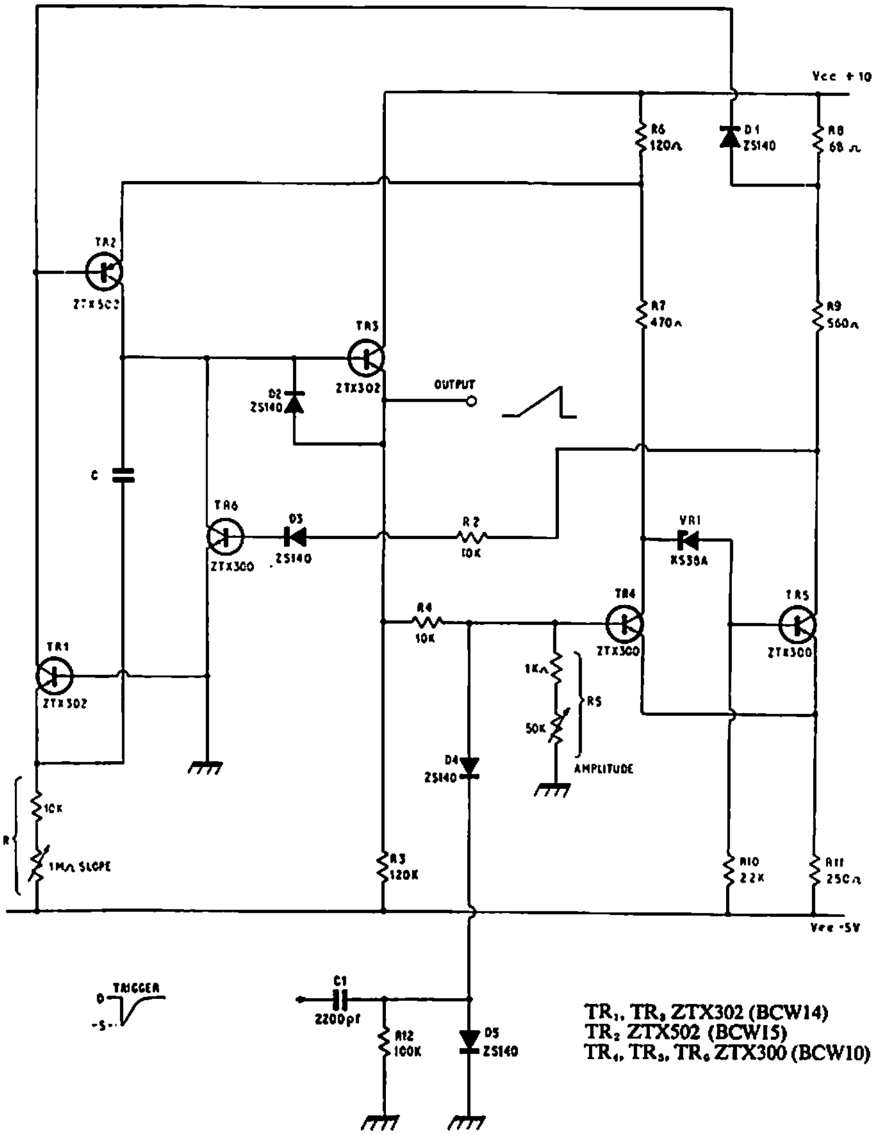
SERVO CONTROLS RAMP—Produces ramp that rises from initial level to mid-level in independently adjustable time, remains at constant level for adjustable time, then drops to preset final level in adjustable downslope time, as required in many industrial control systems. Program is initiated by activating relay K1 and terminated by activating K2 (coils not shown) manually. R6 determines upslope time.—G. E. Cook, Servo Programmer Generates Linear On and Off Ramps, *Electronic Design*, Nov. 8, 1967, p 118 and 120.


+10v
+10v
+10v
+10v
+10v
R2 8.2k
R3 2.2k
SCR1 2N885
D3 1N914
SWEEP GENERATOR
SWEEP SLOPE
OFF
R1 100k
PRF ADJUST
-10v
1k
Q1 2N708
10k
D1 1N914
FLIP-FLOP
1
0
SET
RESET
1,000pf
1N914
10k
10k
SYNCHRONOUS OUTPUT
PULSE TRAIN INPUT
1,000pf
D2 1N914
10k
-10v
R4 10k
+10v
PULSE TRAIN INPUT
SWEEP OUTPUT
SYNCHRONOUS OUTPUT

SWEEP IN FREQUENCY DIVIDER—Generates output pulses in synchronism with input pulse train, for pulse or digital systems. Permits using one variable-frequency generator in place of several fixed-frequency dividers. With values shown and 1-µF capacitor for C1 in linear sweep, output frequency can be varied from 10 to 1,000 Hz for input of 10 kHz. Input-to-output ratios can be as high as 1,000:1.—S. Weisman, One Transistor Sweeps Clean, *Electronics*, June 12, 1967, p 106–109.

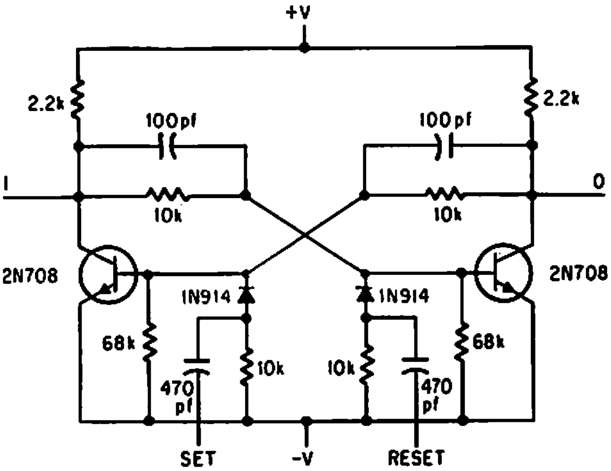

2N1130
0.01μF
C1
T1
1N459
125mH
1μF
C2
1μF
2N1130
T2
30k
RB1
10k
RB2
RE1
100Ω
RB3
30k
RB4
RE2
50Ω
Output
8V
Vcc

COMMON-COLLECTOR OUTPUT—Uses basic transistor current sweep coupled into class A common-collector amplifier serving also as buffer.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 273.

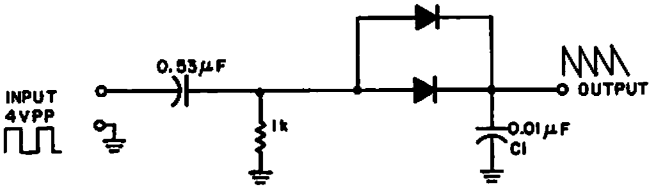

Vcc +10
R6
120Ω
D1
ZS140
R8
68 Ω
TR2
ZTX502
TR3
ZTX302
D2
ZS140
OUTPUT
R7
470Ω
R9
560Ω
C
TR6
ZTX300
D3
ZS140
R2
10K
VR1
KS38A
TR4
ZTX300
TR5
ZTX300
R4
10K
TR1
ZTX302
1KΩ
50K
RS
AMPLITUDE
D4
ZS140
R
10K
1MΩ SLOPE
R3
120K
R10
22K
R11
250Ω
Vee -5V
TRIGGER
0
-5
C1
2200pf
R12
100K
D5
ZS140

TR_1, TR_3 ZTX302 (BCW14)
TR_2 ZTX502 (BCW15)
TR_4, TR_5, TR_6 ZTX300 (BCW10)

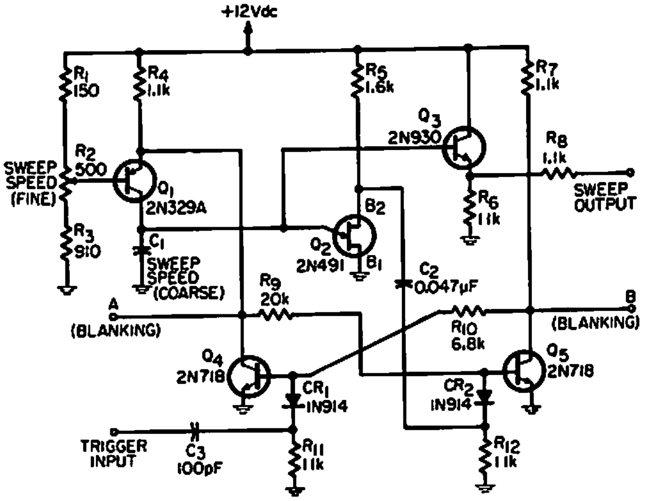
1-MINUTE LINEAR RAMP—Provides adjustable ramp times up to 1 min and adjustable output amplitude up to 8 V. Separate discharge transistor gives rapid flyback and recovery. TR1 and TR2 form constant-current source, TR3 is buffer, and TR4-TR5 form Schmitt trigger. TR6 discharges C rapidly.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 24.


+V
2.2k
2.2k
100pf
100pf
1
0
10k
10k
2N708
2N708
1N914
1N914
68k
68k
10k
10k
470 pf
470 pf
SET
-V
RESET

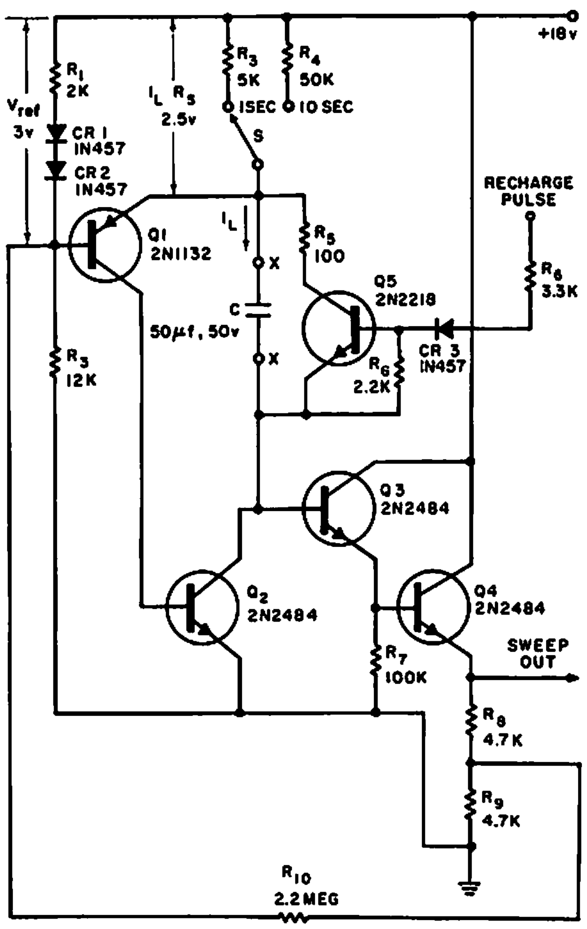
SWEEP-DRIVING FLIP-FLOP—Conventional flip-flop changes state from binary 1 to 0 when positive trigger is applied to set input, and reverses state when positive trigger is applied to reset input. Can be used to drive linear sweep circuit.—S. Waisman, One Transistor Sweeps Clean, *Electronics*, June 12, 1967, p 106–109.


INPUT 4VPP
0.53μF
1k
OUTPUT
0.01μF C1

SQUARE TO SAWTOOTH—Two-diode circuit provides quick means of obtaining sawtooth from 80–800 Hz square wave. Accuracy is fair.—C. Eddy, Simple Circuit Converts Any Waveform Into a Sawtooth, *Electronic Design*, Dec. 20, 1967, p 110.

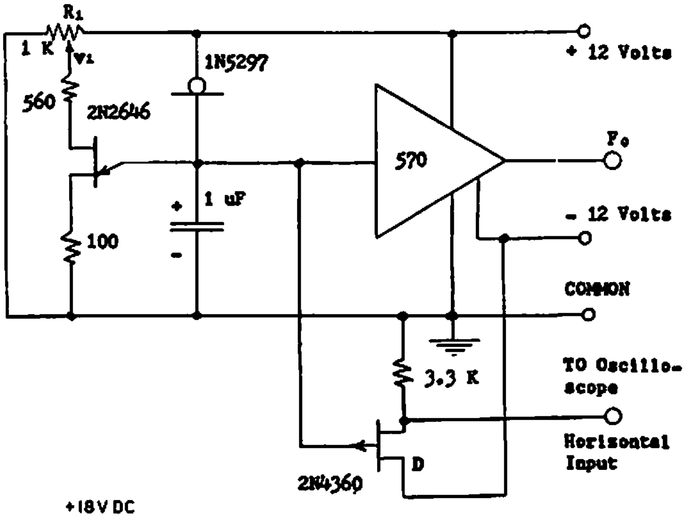

+12Vdc
R1 150
R4 1.1k
R5 1.6k
R7 1.1k
Q3 2N930
R8 1.1k
SWEEP OUTPUT
SWEEP SPEED (FINE)
R2 500
Q1 2N329A
R3 910
C1 SWEEP SPEED (COARSE)
Q2 2N491
B2
B1
R6 1k
C2 0.047μF
R9 20k
A (BLANKING)
B (BLANKING)
R10 6.8k
Q4 2N718
Q5 2N718
CR1 1N914
CR2 1N914
TRIGGER INPUT
C3 100pF
R11 1k
R12 1k

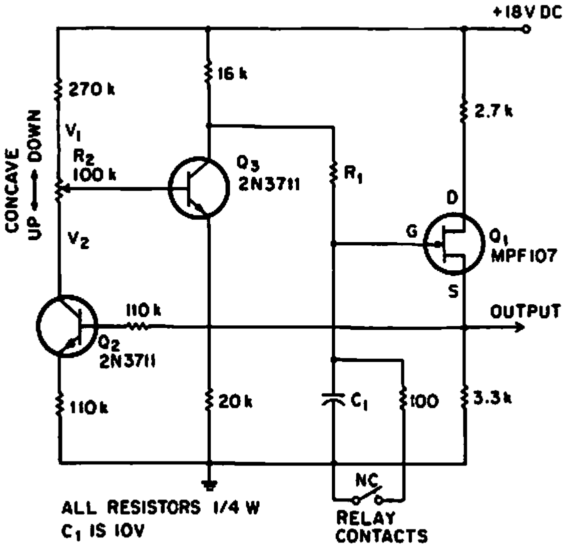
LINEAR RAMP—Changing value of coarse sweep speed capacitor C1 gives sweep frequencies from 0.1 to 500 Hz, along with positive and negative blanking pulses synchronized with output. Reliable triggering is achieved for sweep durations ranging from 2 μs to 10 s. Sweep output is 6 V p-p.—P. M. Solomon, Unijunction Transistor Simplifies Trigger Sweep Generator, *EEE*, March 1968, p 128–129.


+18v
R1 2K
Vref 3v
CR 1 1N457
CR 2 1N457
IL R5 2.5v
R3 5K
R4 50K
1SEC
10 SEC
S
RECHARGE PULSE
Q1 2N1132
IL
R5 100
X
C
50μf, 50v
X
Q5 2N2218
R6 3.3K
CR 3 1N457
R6 2.2K
R3 12K
Q3 2N2484
Q2 2N2484
Q4 2N2484
SWEEP OUT
R7 100K
R8 4.7K
R9 4.7K
R10 2.2 MEG

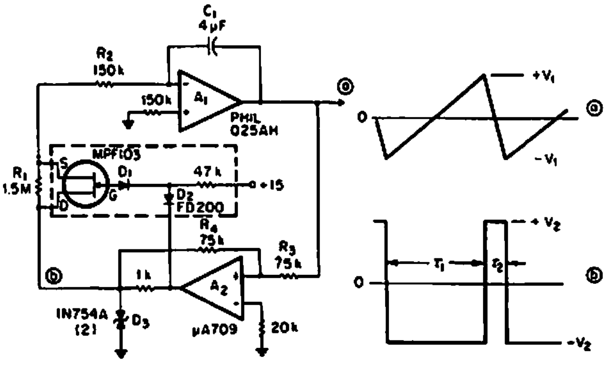
10-S SWEEP—Generates negative-going highly linear sweep with adjustable duration of from 1 to 10 s and sweep speed error under 0.5%. Polarity is easily changed to get positive-going sweep. Q1-Q2 charge C. Sweep output is buffered by Q3—Q4, and Q5 discharges C, which is polystyrene type.—D. Breslow, Infinite Z-out Current Source Generates Long, Linear Sweeps, *Electronic Design*, July 19, 1965, p 28–31.

VOLTAGE-FREQUENCY SWEEP—Circuit delivers sawtooth sweep waveform to horizontal input of cro, with linearity of sawtooth ramp assured by current-limiting diode, and sweep width determined by setting of R1. Center frequency of sweep depends on OEI Model 70 IC voltage-frequency transducer which delivers sinusoidal output whose frequency is directly proportional to d-c input voltage. Fet follower provides low output impedance for cro. Used in testing networks inserted in vertical feed from sweep generator to cro.—Sweep Generator Using a Voltage-To-Frequency Transducer, Optical Electronics, Tucson, Ariz., No. 10059.

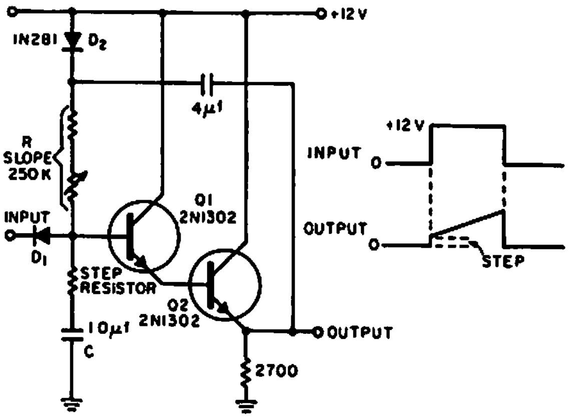

R1
1 K
V1
560
2N2646
100
1N5297
+
1 uF
-
570
+ 12 Volts
Fo
- 12 Volts
COMMON
3.3 K
TO Oscilloscope Horizontal Input
2N4360
D


+18V DC
270 k
16 k
2.7 k
CONCAVE UP ⟷ DOWN
V1
R2
100 k
V2
Q3
2N3711
R1
D
G
Q1
MPF107
S
110 k
Q2
2N3711
OUTPUT
110k
20k
C1
100
3.3k
NC
ALL RESISTORS 1/4 W
C1 IS 10V
RELAY CONTACTS

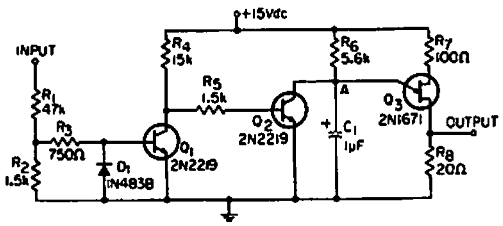
VERSATILE RAMP—R2 adjusts shape of ramp from concave upward through linear to concave downward. Different values for R1 and R2 give ramp durations ranging from 0.1 μs to several hours.—L. S. McLaughlin, Long Duration Variable Linearity Ramp Generator, *EEE*, Jan. 1970, p 127.


C1
4μF
R2
150k
150k
A1
PHIL
025AH
ⓐ
MPF103
S
D1
47 k
+15
R1
1.5M
G
D
D2
FD200
R4
75k
R3
75k
ⓑ
1k
A2
IN754A
(2)
D3
μA709
20k
+V1
0
ⓐ
-V1
+V2
τ1
τ2
0
ⓑ
-V2

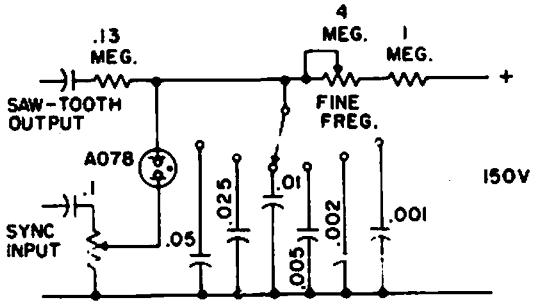
TRIANGULAR-SAWTOOTH CONVERTER—Triangular wave generated by opamps A1 and A2 is converted to sawtooth output by fet and two diodes connected as shown. Used to sweep voltage-controlled oscillator in phase-locked loop as part of automatic acquisition system. Output of sawtooth is symmetrical with respect to zero voltage.—E. F. Prozeller, FET Converts a Triangle Generator to a Sawtooth Generator, *EEE*, Dec. 1969, p 92–93.


+12V
IN281
D2
4μf
R
SLOPE
250K
INPUT
D1
Q1
2N1302
STEP RESISTOR
Q2
2N1302
10μf
C
OUTPUT
2700
+12V
INPUT
0
OUTPUT
0
STEP

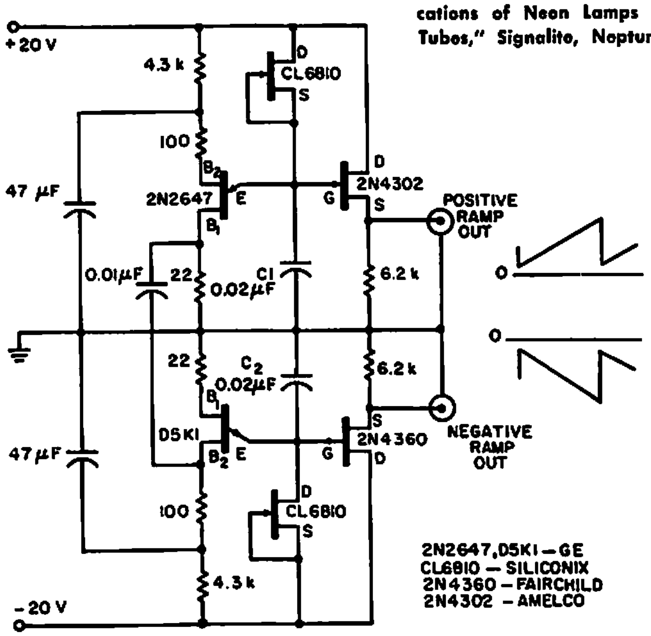
RAMP GENERATOR—Duration of rectangular initiating pulse determines width of highly linear ramp or sawtooth sweep generated by simple two-transistor circuit that is bootstrapped through blocking capacitor. Linearity of ramp is better than 0.25%.—J. Porter, Input Pulse Width Controls Simple Ramp Generator, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., p 189.


+15Vdc
INPUT
R1 47k
R2 1.5k
R3 750Ω
D1 1N4838
R4 15k
Q1 2N2219
R5 1.5k
Q2 2N2219
R6 5.6k
A
C1 1μF
R7 100Ω
Q3 2N1671
OUTPUT
R8 20Ω

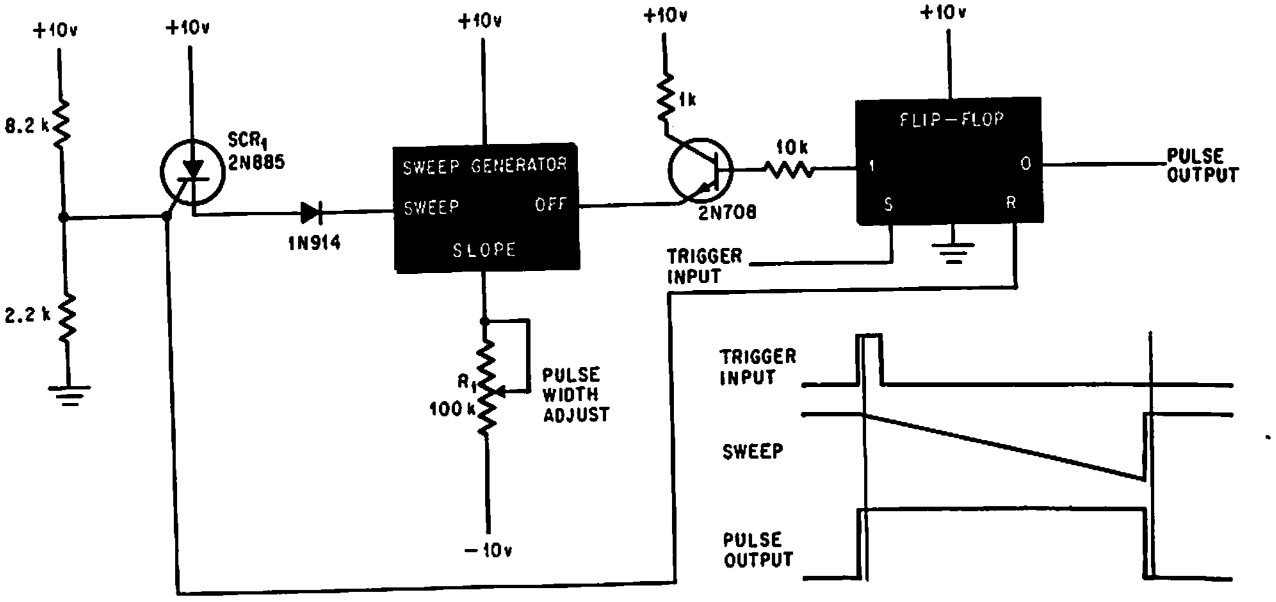
SYNC TO 60 HZ—Developed for scr control circuits requiring sawtooth generator synchronized with a-c line. Q1 and Q2 form switch that is periodically opened and closed under control of 115-V a-c voltage applied to input. When input voltage has peak value above 22 V, Q1 is turned on and Q2 off, allowing ujt oscillator Q3 to generate one output pulse for each cycle of line voltage. Applying positive full-wave-rectified line voltage to input gives one output pulse every 8.3 ms. If R6 is made variable, charging time of C1 can be varied to change time delay of output pulse with respect to zero crossing of power line, to control scr firing angle.—C. L. Wilson, Unijunction-Transistor Oscillator Locks to Line Frequency, *EEE*, Dec. 1967, p 93–94.


.13 MEG.
4 MEG.
1 MEG.
+
SAW-TOOTH OUTPUT
FINE FREQ.
A078
.1
SYNC INPUT
.05
.025
.01
.005
.002
.001
150V

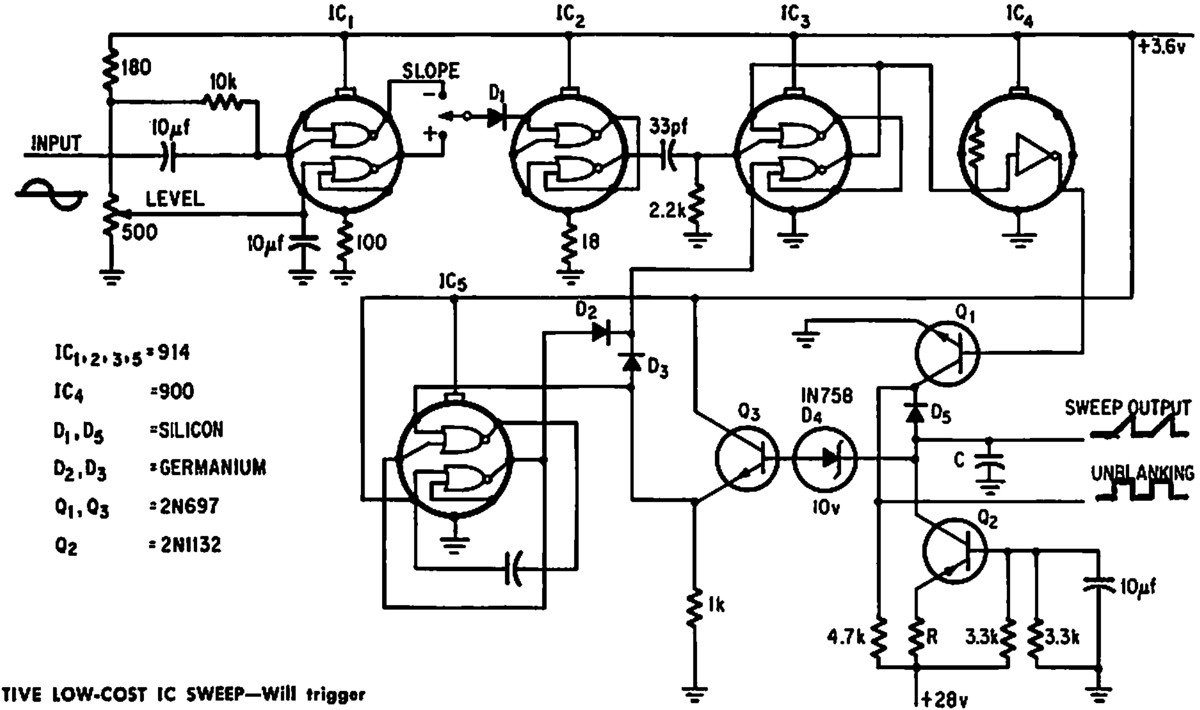
TIME-BASE VOLTAGE SOURCE—Covers range of 5 to 1,500 Hz for inexpensive moderately linear time bases. Used as horizontal sweep for small oscilloscopes.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 34.


+20 V
4.3 k
D
CL6810
S
100
B2
2N2647
E
B1
D
2N4302
G
S
POSITIVE RAMP OUT
47 μF
0.01μF
22
C1 0.02μF
6.2 k
0
0
22
C2 0.02μF
6.2 k
B1
D5K1
B2
E
S
2N4360
G
D
NEGATIVE RAMP OUT
47 μF
100
D
CL6810
S
4.3 k
-20 V
2N2647,D5K1—GE
CL6810 — SILICONIX
2N4360 — FAIRCHILD
2N4302 — AMELCO

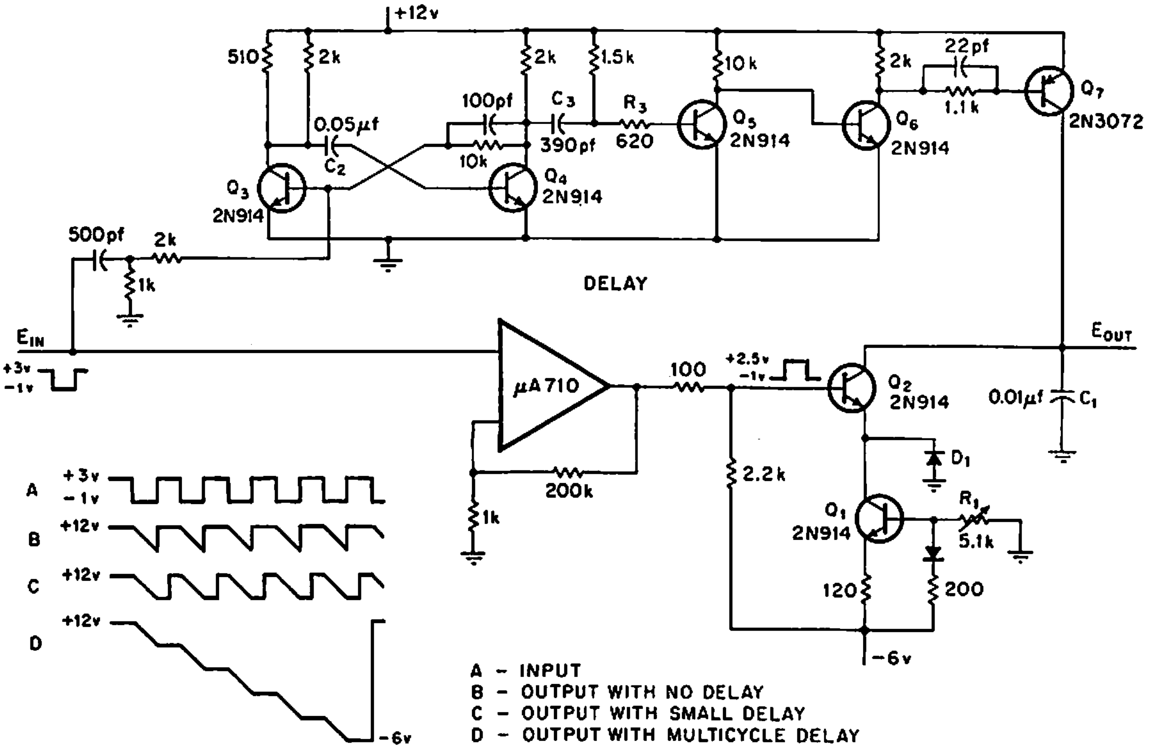
BIDIRECTIONAL RAMPS—Each ramp starts near 0 V and departs linearly, one in positive direction, and the other negative. Uses GE D5K1 complementary ujt and Siliconix CL6810 field-effect diodes to achieve symmetry.—H. Olson, Symmetrical Ramp Generator Uses New Devices, *Electronic Design*, Nov. 8, 1967, p 114.


+10v
+10v
+10v
+10v
+10v
8.2 k
SCR1 2N885
2.2 k
1N914
SWEEP GENERATOR
SWEEP
OFF
SLOPE
R1 100 k
PULSE WIDTH ADJUST
-10v
1k
2N708
10k
FLIP-FLOP
1
0
S
R
PULSE OUTPUT
TRIGGER INPUT
TRIGGER INPUT
SWEEP
PULSE OUTPUT

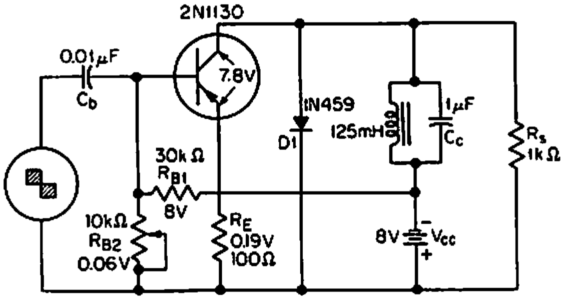
SWEEP GIVES VARIABLE-WIDTH PULSES—With calibrated multiturn linear pot for R1, and 1-μF charging capacitor in sweep generator, pulse width can be linearly changed from 1 to 100 ms. Circuits in boxes appear elsewhere in this chapter under headings LINEAR SWEEP and SWEEP-DRIVING FLIP-FLOP.—S. Weisman, One Transistor Sweeps Clean, *Electronics*, June 12, 1967, p 106–109.


IC1
IC2
IC3
IC4
+3.6v
180
10k
SLOPE
INPUT
10µf
LEVEL
500
10µf
100
D1
33pf
2.2k
18
IC5
D2
D3
Q1
IN758
D4
10v
Q3
D5
SWEEP OUTPUT
C
UNBLANKING
Q2
10µf
1k
4.7k
R
3.3k
3.3k
+28v
IC1,2,3,5 = 914
IC4 = 900
D1, D5 = SILICON
D2, D3 = GERMANIUM
Q1, Q3 = 2N697
Q2 = 2N1132

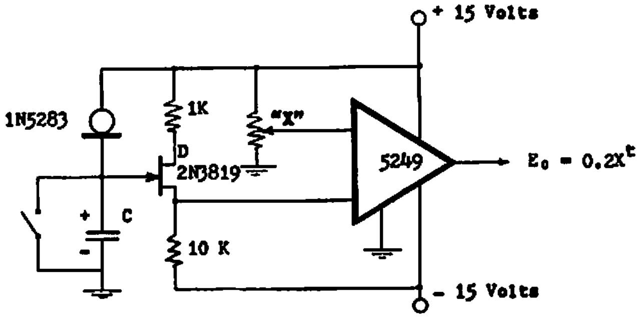
SENSITIVE LOW-COST IC SWEEP—Will trigger on as little as 200 mV from d-c to over 10 MHz. Input stage IC1 serves as preamp and phase inverter to allow selection of positive- or negative-slope triggering. Schmitt trigger IC2 supplies fast-rising positive pulse to R-S flip-flop IC3. Buffer IC4 drives Q1 at inputs above 1 MHz. Resultant sawtooth has good linearity, with sweep speed of 0.5 µs when C is 100 pF and R is 3K. When sawtooth reaches 10 V, zener breaks down and initiates retrace.—E. Feuer, Sweep Circuit Triggers On Only 200 Millivolts, *Electronics*, March 3, 1969, p 96–97.


+12v
510
2k
2k
1.5k
10k
2k
22pf
1.1k
Q7
2N3072
0.05µf
C2
100pf
10k
C3
390pf
R3
620
Q5
2N914
Q6
2N914
Q3
2N914
Q4
2N914
500pf
2k
1k
DELAY
EIN
+3v
-1v
µA710
200k
1k
100
+2.5v
-1v
Q2
2N914
EOUT
0.01µf
C1
2.2k
D1
Q1
2N914
R1
5.1k
120
200
-6v
A +3v -1v
B +12v
C +12v
D +12v
-6v
A - INPUT
B - OUTPUT WITH NO DELAY
C - OUTPUT WITH SMALL DELAY
D - OUTPUT WITH MULTICYCLE DELAY

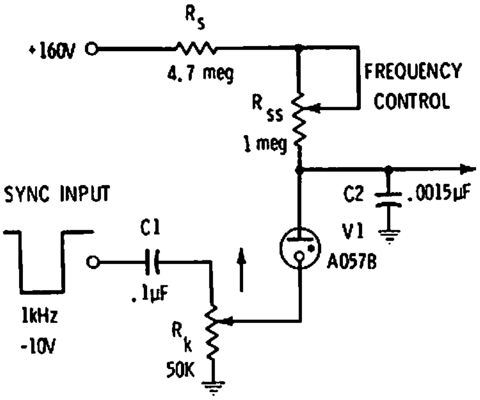
RAMP SLOPE CONTROL—Complex ramp function generator for multiple-axis cro scanning provides 50:1 range of slope adjustment for ramp segments without affecting their linearity. Ramp duration can be varied from several hundred ns to several hundred µs, by changing duration of input pulse. Uses constant-current generator Q1-Q2 for discharging C1 at rate set by R1, to control slope.—J. Downey, Capacitor Discharge Sets Shape of Ramp Function, *Electronics*, Dec. 8, 1969, p 90.


2N1130
0.01μF
C_b
7.8V
1N459
D1
125mH
1μF
C_c
R_s
1kΩ
30kΩ
R_{B1}
8V
10kΩ
R_{B2}
0.06V
R_E
0.19V
100Ω
8V
V_{cc}
-
+

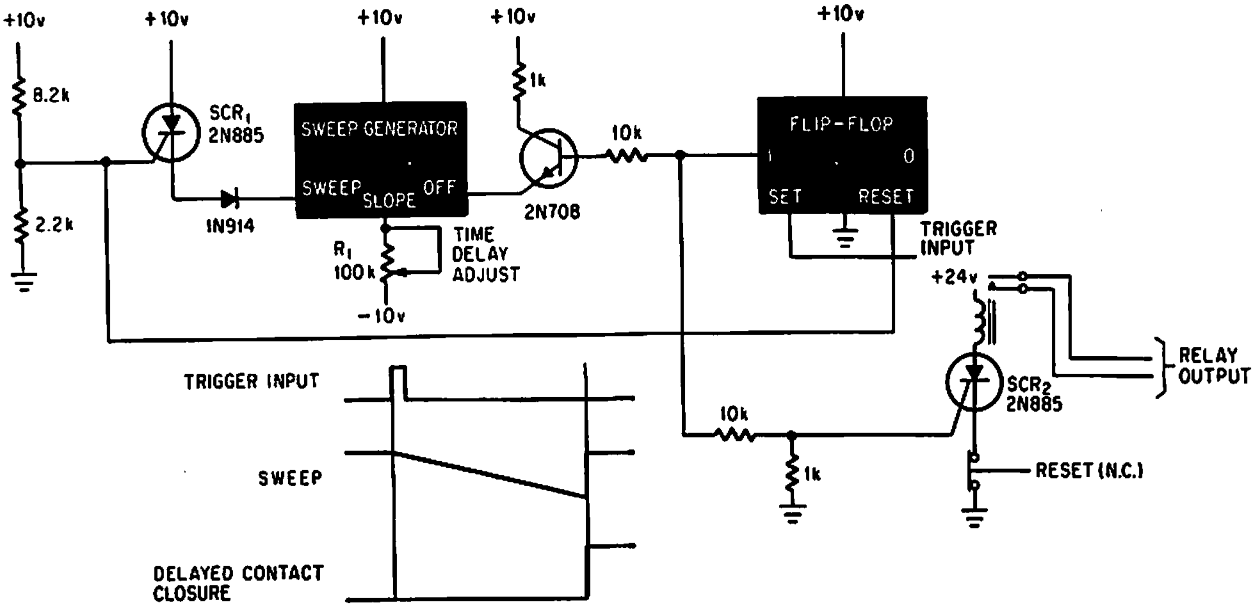
CURRENT SWEEP—Chief function of transistor is that of switch. When transistor is on, current flows from battery through inductor into collector. Current increases with maximum linearity at about 2,500 pps for values shown. Transistor opens during flyback time of sawtooth output. Book gives design procedure for obtaining maximum linearity.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 268.


+ 15 Volts
1N5283
1K
"X"
D
2N3819
5249
$E_o = 0.2X^t$
+
C
-
10 K
- 15 Volts

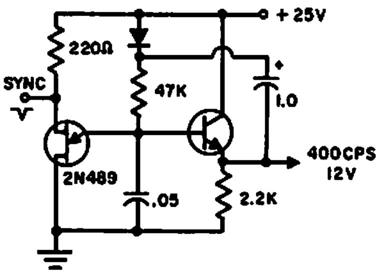
TIME RAMP—Generates ramp to simulate time as Y input, to give output voltage that is equal to constant multiplied by X input having time (Y) as exponent. Ramp begins when switch is opened and ends when switch is closed to discharge C. Switching transistor may be used instead of actual switch contacts.—Time as an Exponent, Optical Electronics, Tucson, Ariz., No. 10101.


R_S
+160V
4.7 meg
FREQUENCY
CONTROL
R_{SS}
1 meg
SYNC INPUT
C1
.1μF
C2
.0015μF
V1
A057B
1kHz
-10V
R_k
50K

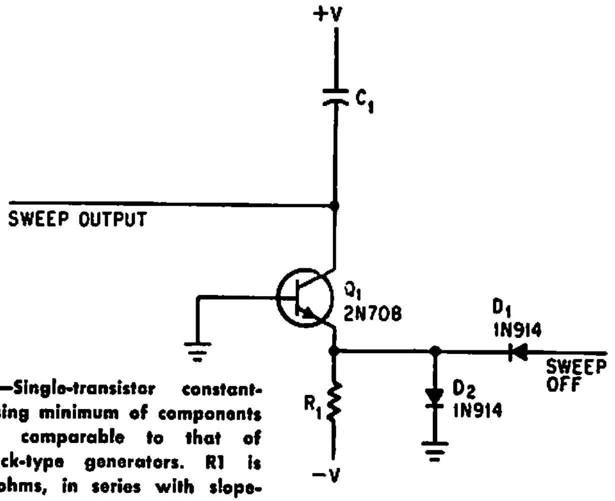
1-KHZ SYNCHRONIZED NEON—Adjust 50K control for proper synchronization with 50-μs input pulse.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 41.


+10v
+10v
+10v
+10v
+10v
8.2k
2.2k
SCR_1
2N885
1N914
SWEEP GENERATOR
SWEEP
SLOPE
OFF
R_1
100k
TIME
DELAY
ADJUST
-10v
1k
2N708
10k
FLIP-FLOP
1
0
SET
RESET
TRIGGER
INPUT
+24v
RELAY
OUTPUT
SCR_2
2N885
10k
1k
RESET (N.C.)
TRIGGER INPUT
SWEEP
DELAYED CONTACT
CLOSURE

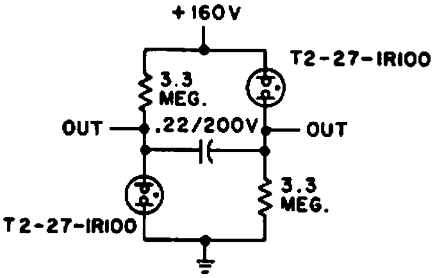
SWEEP CONTROLS RELAY TURN-ON TIME—Length of generated sweep determines turn-on time of time-delay relay with excellent repeatability. With values shown and 50-μF charging capacitor in sweep generator, relay delay can be varied from 50 ms to 5 s plus fixed relay turn-on-time.—S. Weisman, One Transistor Sweeps Clean, *Electronics*, June 12, 1967, p 106–109.


+25V
220Ω
SYNC
47K
+
1.0
2N489
400CPS
12V
.05
2.2K

BOOTSTRAP WITH CAPACITOR FEEDBACK—Eliminates need for negative supply, makes frequency largely independent of supply voltage, and improves linearity of sawtooth output.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 48.

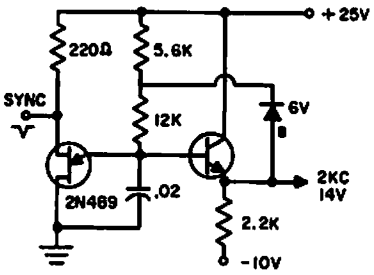

+V
C1
SWEEP OUTPUT
Q1
2N708
D1
1N914
SWEEP OFF
R1
D2
1N914
−V

LINEAR SWEEP—Single-transistor constant-current sweep using minimum of components provides output comparable to that of complex feedback-type generators. R1 is typically 1,000 ohms, in series with slope-adjusting potentiometer of around 10K. Supply voltages can be 10 V. Article gives design equations and five examples of other circuits using this versatile basic sweep.—S. Weisman, One Transistor Sweeps Clean, *Electronics*, June 12, 1967, p 106–109.

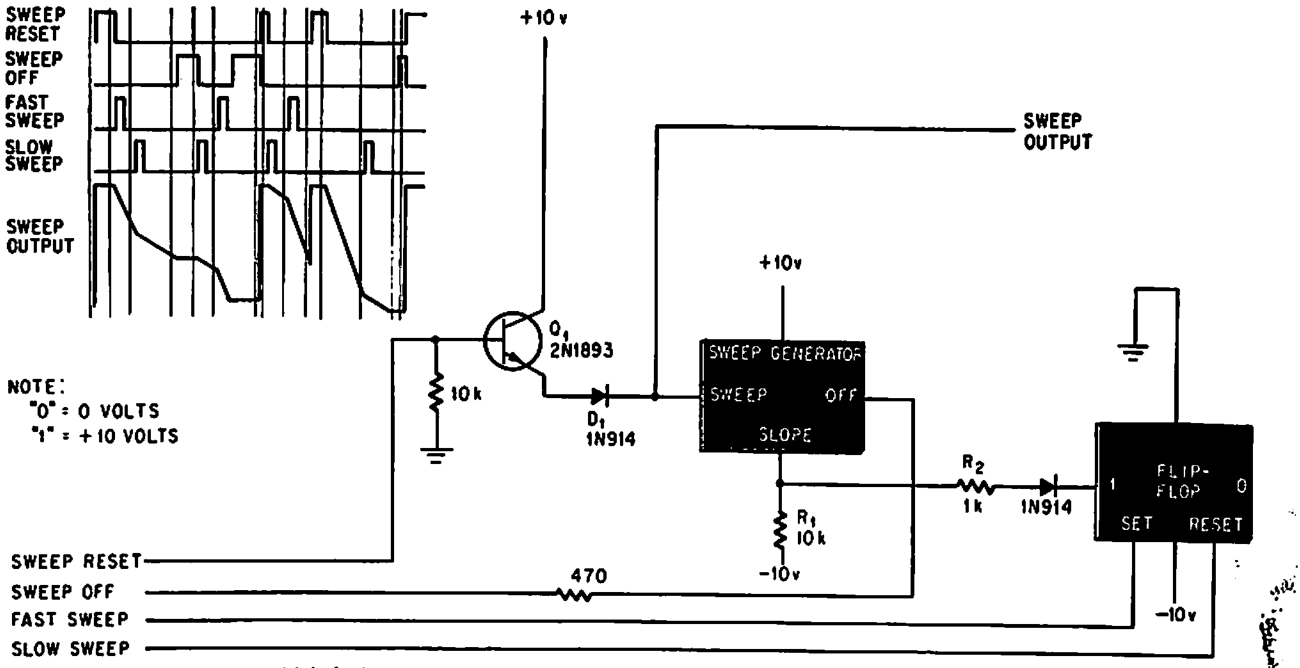

+160V
T2-27-1R100
3.3 MEG.
OUT
.22/200V
OUT
3.3 MEG.
T2-27-1R100

SAWTOOTH FROM TWO NEONS—Symmetrical output from dual-neon relaxation oscillator reduces power supply ripple and noise, and gives twice the voltage of single neon circuit.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 36.

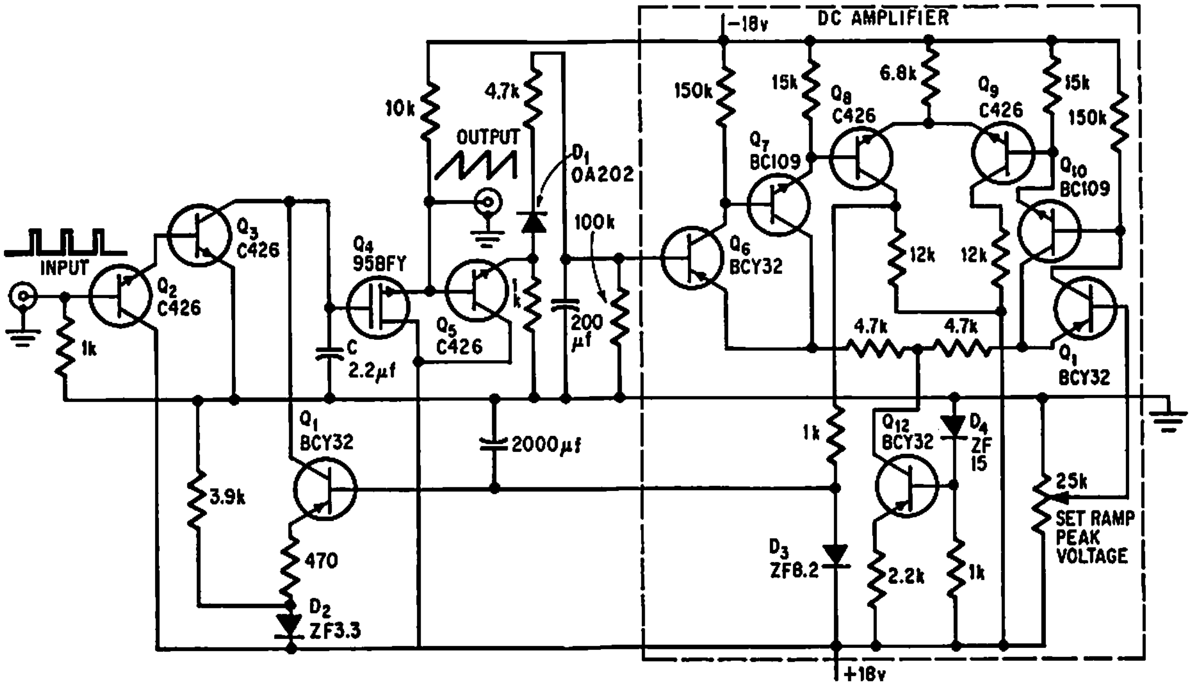
BOOTSTRAP WITH ZENER FEEDBACK—Arrangement improves linearity of ujt sawtooth generator that drives any npn emitter-follower output stage. Capacitor charging current is held constant over complete cycle. Output transistor also serves as driver for bootstrap circuit.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 48.


+25V
220Ω
5.6K
SYNC
12K
6V
2N489
.02
2KC
14V
2.2K
-10V

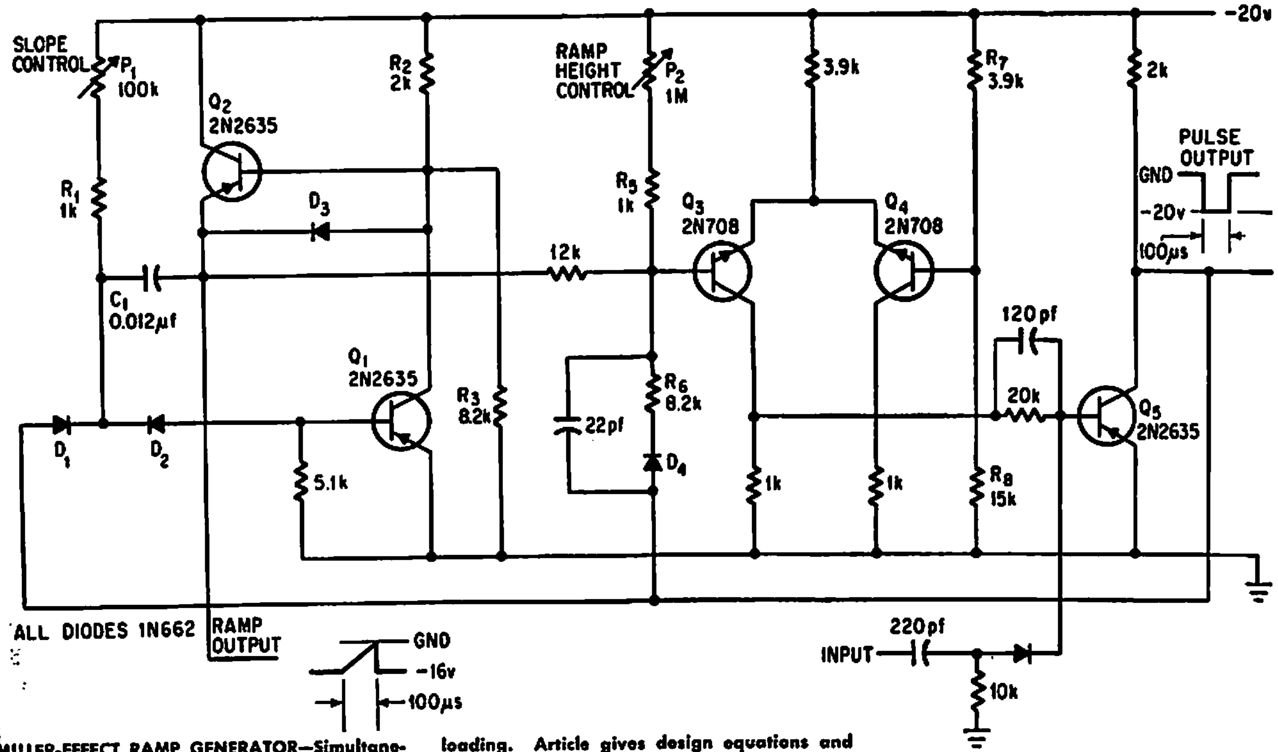
(D) BOOTSTRAP CIRCUIT WITH ZENER DIODE FEEDBACK


SWEEP RESET
SWEEP OFF
FAST SWEEP
SLOW SWEEP
SWEEP OUTPUT
NOTE:
"0" = 0 VOLTS
"1" = +10 VOLTS
+10 v
Q1
2N1893
10 k
D1
1N914
SWEEP OUTPUT
+10v
SWEEP GENERATOR
SWEEP
OFF
SLOPE
R1
10 k
-10v
R2
1 k
1N914
FLIP-FLOP
1
0
SET
RESET
-10v
470
SWEEP RESET
SWEEP OFF
FAST SWEEP
SLOW SWEEP

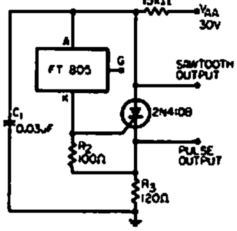
DIGITALLY CONTROLLED SWEEP—Digital signals can reset linear sweep, change its slope, or turn it off at any level. With 1-μF charging capacitor in sweep, slow sweep is 10 ms and fast sweep is 1 ms. Sweep slopes can be changed to form complex timing and control signals.—S. Weisman, One Transistor Sweeps Clean, *Electronics*, June 12, 1967, p 106–109.


DC AMPLIFIER
-18v
INPUT
Q2 C426
1k
Q3 C426
Q4 958FY
C 2.2μf
Q5 C426
10k
4.7k
OUTPUT
1k
D1 OA202
100k
200 μf
2000μf
Q1 BCY32
3.9k
470
D2 ZF3.3
150k
15k
Q6 BCY32
Q7 BC109
Q8 C426
6.8k
Q9 C426
15k
150k
Q10 BC109
Q11 BCY32
12k
12k
4.7k
4.7k
1k
Q12 BCY32
D4 ZF 15
D3 ZF8.2
2.2k
1k
25k
SET RAMP PEAK VOLTAGE
+18v

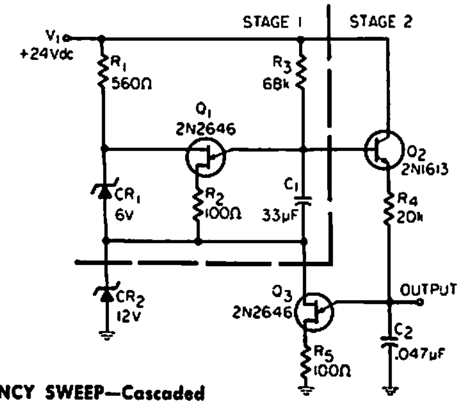
CONSTANT AMPLITUDE—Feedback amplifier compares peak voltage of ramp with reference set by 25K pot and uses error to control charging current. Ramp height is thus kept constant regardless of variations in trigger frequency. For values shown, frequency range is 10 Hz to 1 kHz for constant output within 5%. When combined with comparator set between 0 and 100% of ramp amplitude, can also serve as frequency-compensated phase delay.—P. R. Adby, Sawtooth Generator Delivers Constant Peak Voltage, *Electronics*, March 3, 1969, p 97.


-20v
SLOPE CONTROL
P1 100k
R1 1k
C1 0.012μf
Q2 2N2635
R2 2k
D3
12k
Q1 2N2635
R3 8.2k
5.1k
D1
D2
RAMP HEIGHT CONTROL
P2 1M
R5 1k
R6 8.2k
22pf
D4
Q3 2N708
Q4 2N708
3.9k
R7 3.9k
1k
1k
120pf
20k
R8 15k
2k
Q5 2N2635
PULSE OUTPUT
GND
-20v
100μs
ALL DIODES 1N662
RAMP OUTPUT
GND
-16v
100μs
220pf
INPUT
10k

MILLER-EFFECT RAMP GENERATOR—Simultaneously generates train of positive-going waveforms and train of negative-going square waves. Ramp is linear to within 0.5%, requires no clipping, and is not distorted by loading. Article gives design equations and describes circuit operation in detail. Q1-Q2 are in Miller-effect ramp generator, and other transistors are in differential Schmitt trigger that can terminate ramp at any point, reset circuit, and put out gating pulses as by-product.—G. Marosi, Gain-Multiplied Capacitance Generates Ramp Waveform, *Electronics*, March 6, 1967, p 130–131.

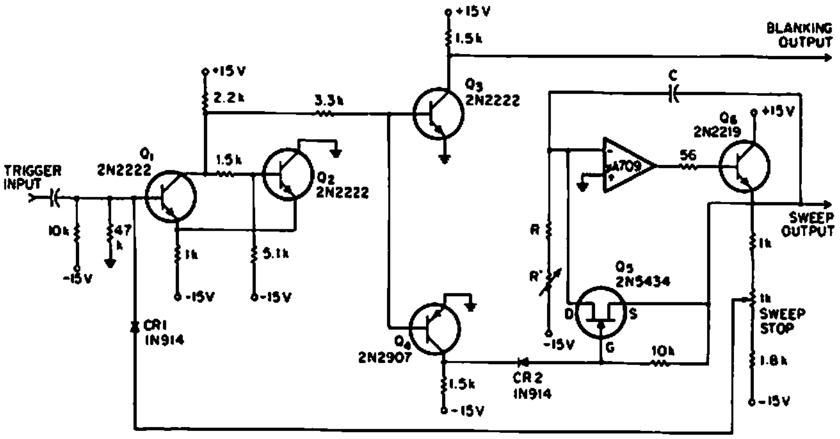

R1
15kΩ
VAA
30V
A
FT 805
G
K
SAWTOOTH OUTPUT
2N4108
C1
0.03μF
R2
100Ω
PULSE OUTPUT
R3
120Ω

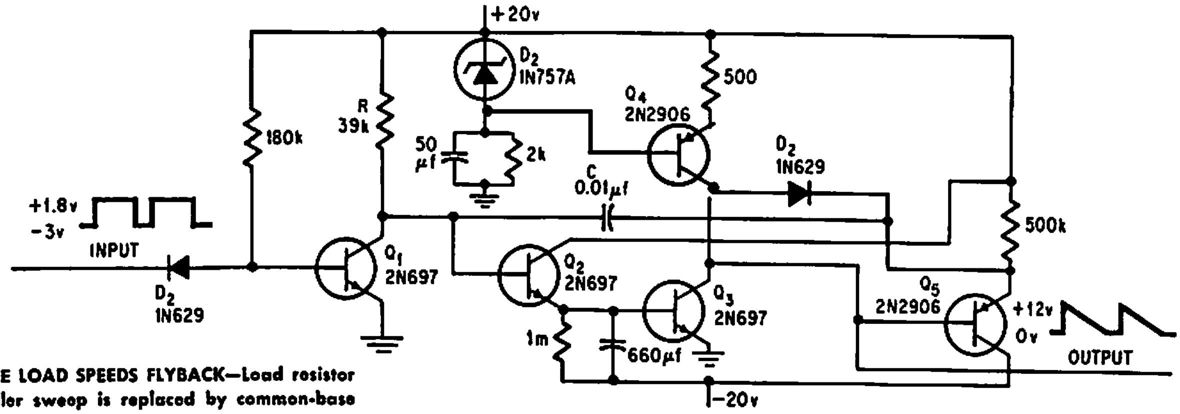
10 KHZ WITH REGENERATIVE TRIGGER DIODE—Allows use of relatively low supply voltages, to reduce circuit dissipation and lower voltage rating of capacitor. Fairchild FT805 trigger diode in scr relaxation oscillator gives high efficiency in comparison with circuits using three-layer triggers. May be synchronized with external reference frequency by feeding positive sync pulses directly to gate of trigger diode. Gives either pulse or sawtooth output.—M. Cottrell, Trigger-Diode Simplifies Efficient Generation of Sawtooths and Pulses, *EEE*, March 1968, p 130.


STAGE 1
STAGE 2
V1
+24Vdc
R1
560Ω
R3
68k
Q1
2N2646
Q2
2N1613
CR1
6V
R2
100Ω
C1
33μF
R4
20k
CR2
12V
Q3
2N2646
OUTPUT
R5
100Ω
C2
.047μF

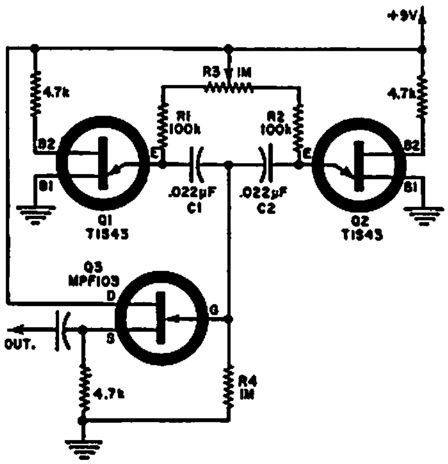
500–2,000 HZ FREQUENCY SWEEP—Cascaded ujt relaxation oscillators provide highly linear frequency sweep output that can be passed through narrow bandpass filter to produce short-duration signal. Q1 generates low-frequency sawtooth that controls higher-frequency sawtooth of Q3. Second stage must usually be at least 10 times frequency of first stage. First stage determines repetition rate and frequency range of swept output, while second stage determines amplitude of its generated higher-frequency sawtooth waveform.—R. Smith, Jr., Cascade UJT Oscillator Generates Linear Frequency Sweeps, *EEE*, April 1968, p 106–107.

10-V LINEAR SWEEP—Combination of fet and μA709 opamp gives highly linear triggered sweep with very low d-c offset, along with blanking output for cro. Schmitt trigger at input drives Q3 and Q4 to provide unblanking output and to initiate sweep by unclamping fet Q5. Q6 is buffer for low-impedance load. Provides sweep speeds from 1 Hz to 100 kHz, depending on values of C, R, and R'.—D. A. Meyer, Triggered Sweep Features Low D-C Offset, *EEE*, Nov. 1969, p 106.


+15V
1.5k
BLANKING OUTPUT
+15V
2.2k
3.3k
Q3
2N2222
C
Q6
2N2219
+15V
TRIGGER INPUT
Q1
2N2222
1.5k
Q2
2N2222
μA709
56
SWEEP OUTPUT
10k
47k
1k
5.1k
R
1k
-15V
-15V
-15V
R'
Q5
2N5434
D
S
G
1k
SWEEP STOP
CR1
1N914
Q4
2N2907
-15V
10k
1.8k
1.5k
CR2
1N914
-15V
-15V

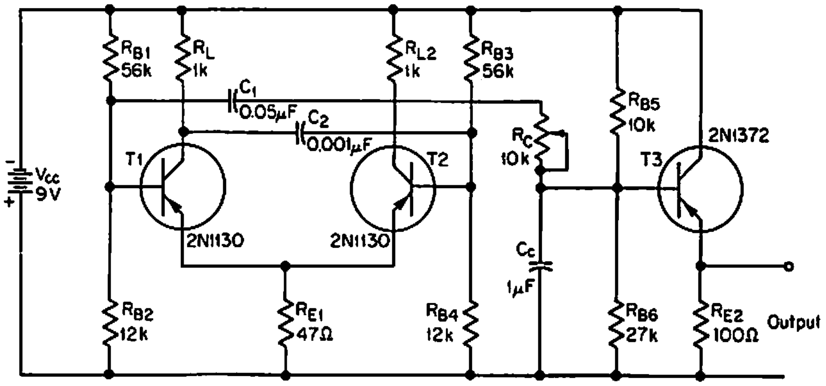

+20v
D2
1N757A
500
Q4
2N2906
180k
R
39k
50
μf
2k
C
0.01μf
D2
1N629
500k
+1.8v
-3v
INPUT
D2
1N629
Q1
2N697
Q2
2N697
Q3
2N697
Q5
2N2906
+12v
0v
OUTPUT
1m
660μf
-20v

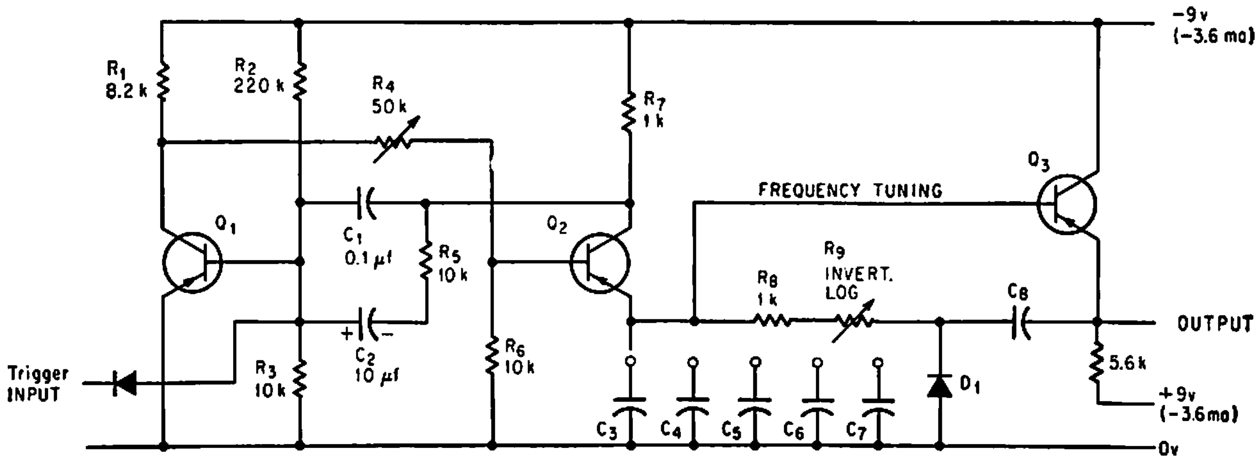
ACTIVE LOAD SPEEDS FLYBACK—Load resistor of Miller sweep is replaced by common-base transistor serving as active load, to reduce flyback time and improve linearity. Transistor acts as current source drawing only a few mA of collector current while providing megohms of dynamic impedance. Positive gating pulse makes Q4 charge C through D2 and switching transistor Q1. When pulse goes negative, Q3 is turned on and C discharges to start Miller rundown at collector of Q3.—D. K. Basu and B. Nag, Improved Miller Sweep Uses an Active Load, *Electronics*, March 31, 1969, p 86.


+9V
R3 1M
4.7k
4.7k
R1 100k
R2 100k
B2
B2
E
E
B1
B1
.022μF C1
.022μF C2
Q1 TIS43
Q2 TIS43
Q3 MPF103
D
G
S
OUT.
4.7k
R4 1M

INDEPENDENTLY VARIABLE—Dual ujt multivibrator generates waveforms with two different repetition rates alternately when R3 is moved away from midpoint. Can be used as tone generator for electronic organ. If used as dual-rate horizontal sweep for oscilloscope, rectangular waveforms at base-2 of ujt's can drive electronic switches that apply the signals under observation alternately to vertical input of scope.—F. H. Tooker, Dual-Rate Sawtooth Generator, *Electronics World*, May 1969, p 74.

ASTABLE-MVBR SAWTOOTH—RC is adjusted until sawtooth waveform across CC has its most linear rise and fall. Common-collector amplifier T3 provides isolation between CC and output.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 280.


RB1 56k
RL 1k
RL2 1k
RB3 56k
C1 0.05μF
C2 0.001μF
RC 10k
RB5 10k
2N1372
T1
T2
T3
Vcc 9V
2N1130
2N1130
CC 1μF
RB2 12k
RE1 47Ω
RB4 12k
RB6 27k
RE2 100Ω
Output

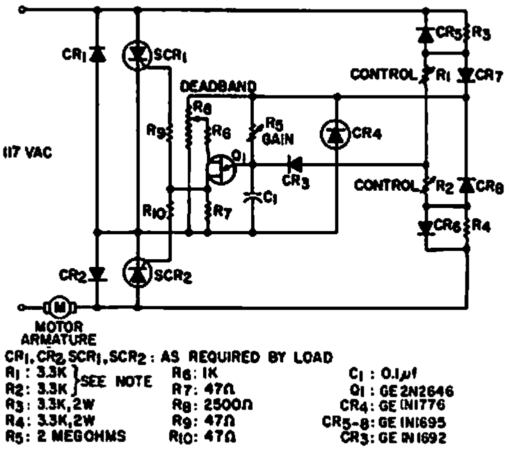

-9v (-3.6 ma)
R1 8.2 k
R2 220 k
R4 50 k
R7 1 k
Q3
FREQUENCY TUNING
Q1
Q2
C1 0.1 μf
R5 10 k
R9 INVERT. LOG
R8 1 k
C8
OUTPUT
C2 10 μf
R6 10 k
R3 10 k
Trigger INPUT
5.6 k
+9v (-3.6ma)
D1
C3
C4
C5
C6
C7
0v

DRIVER FOR PORTABLE SCOPE—Covers 6 Hz to 450 kHz in 5 ranges, with good sawtooth slope linearity and constant amplitude. Trigger input must be 0.5 to 5 V rms. Transistors are AF117 germanium-alloy diffused. Free-running frequencies are determined by capacitor values: C3 = 8 μF for 6–48 Hz; C4 = 0.68 μF for 47–630 Hz; C5 = 0.068 μF for 470–5,900 Hz; C6 = 6,800 pF for 4.7–59 kHz; C7 = 560 pF for 50–450 kHz. C8 is large enough to remain almost fully charged over complete sweep cycle.—C. C. Hoo, Sawtooth Generator Drives Cathode-Ray Tube, *Electronics*, Sept. 19, 1966, p 124–125.

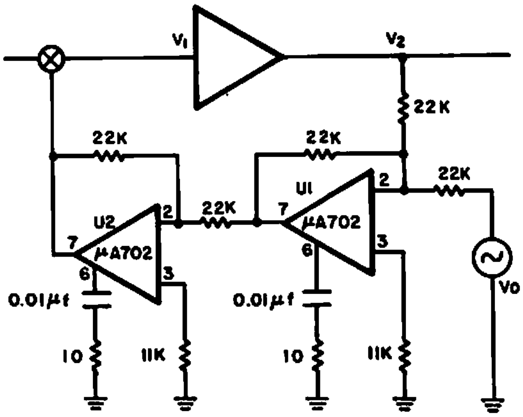
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 76

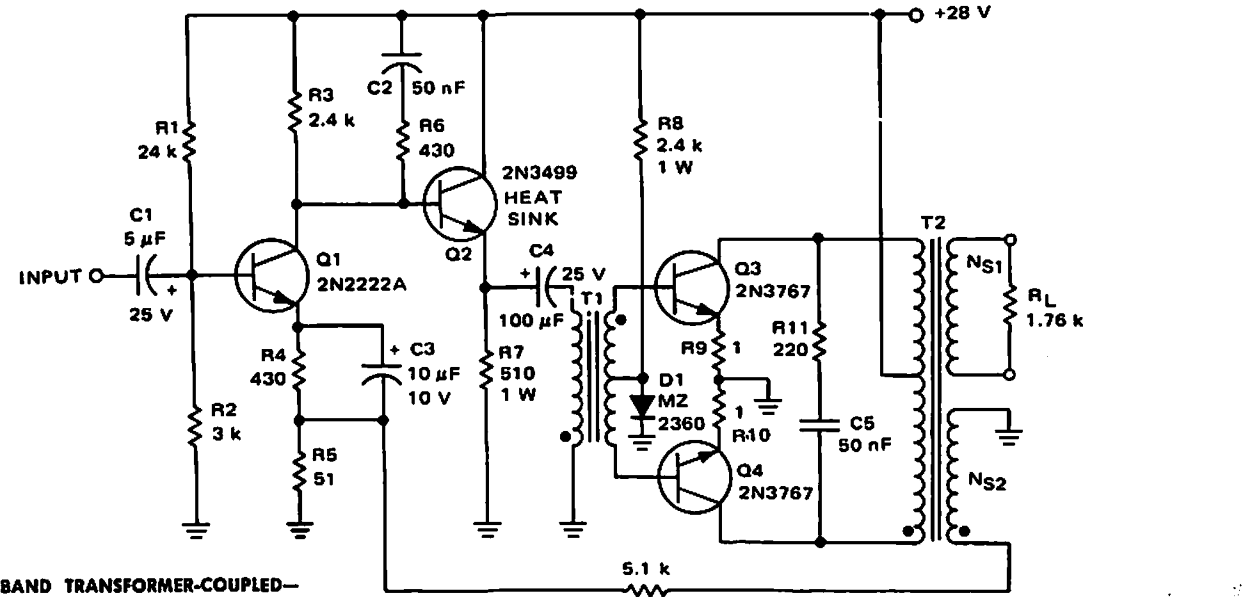
Servo Circuits


117 VAC
CR1
SCR1
DEADBAND
R8
R9
R6
R5 GAIN
Q1
CR3
C1
R10
R7
CR4
CONTROL
R1
CR5
R3
CR7
CONTROL
R2
CR8
CR6
R4
CR2
SCR2
M
MOTOR ARMATURE
CR1, CR2, SCR1, SCR2: AS REQUIRED BY LOAD
R1: 3.3K } SEE NOTE
R2: 3.3K }
R3: 3.3K, 2W
R4: 3.3K, 2W
R5: 2 MEGOHMS
R6: 1K
R7: 47Ω
R8: 2500Ω
R9: 47Ω
R10: 47Ω
C1: 0.1μf
Q1: GE 2N2646
CR4: GE 1N1776
CR5-8: GE 1N1695
CR3: GE 1N1692

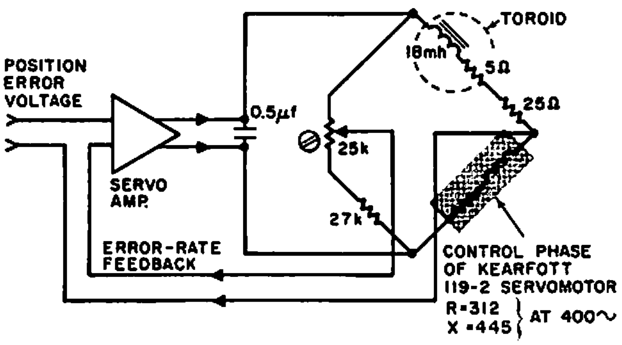
BALANCED-BRIDGE REVERSING SERVO—Phase-sensitive servo drive supplies reversible half-wave power to armature of small p-m or shunt motor. R1 can be GE B425B photoconductor, GE 1D301 thermistor, position-sensing pot, or output from control amplifier.—"SCR Manual," 4th Edition, General Electric, 1967, p 217–218.


V1
V2
22K
22K
22K
22K
22K
U2
μA702
U1
μA702
7
2
6
3
7
2
6
3
0.01μf
0.01μf
10
11K
10
11K
VO

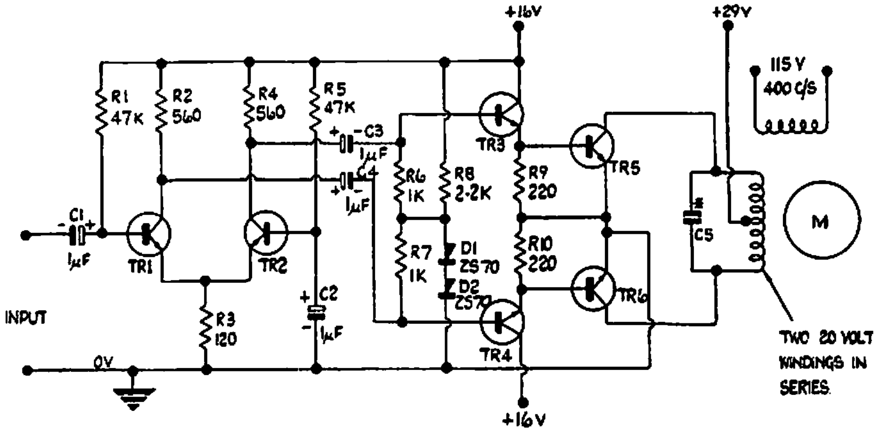
NYQUIST PLOT GENERATOR—Uses Fairchild IC opamps to insert disturbance in feedback path of closed-loop servo system to measure open-loop response in system that cannot be operated under open-loop conditions. Nyquist plot is then readily made.—R. W. Allington, The Integrated Operational Amplifier: A Versatile and Economical Circuit, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 189–194.


+28 V
R1
24 k
R2
3 k
C1
5 μF
25 V
INPUT
Q1
2N2222A
R3
2.4 k
C2
50 nF
R6
430
2N3499
HEAT SINK
Q2
R4
430
C3
10 μF
10 V
R5
51
C4
25 V
100 μF
R7
510
1 W
T1
R8
2.4 k
1 W
D1
MZ
2360
Q3
2N3767
R9
1
R11
220
1
R10
C5
50 nF
Q4
2N3767
T2
NS1
RL
1.76 k
NS2
5.1 k

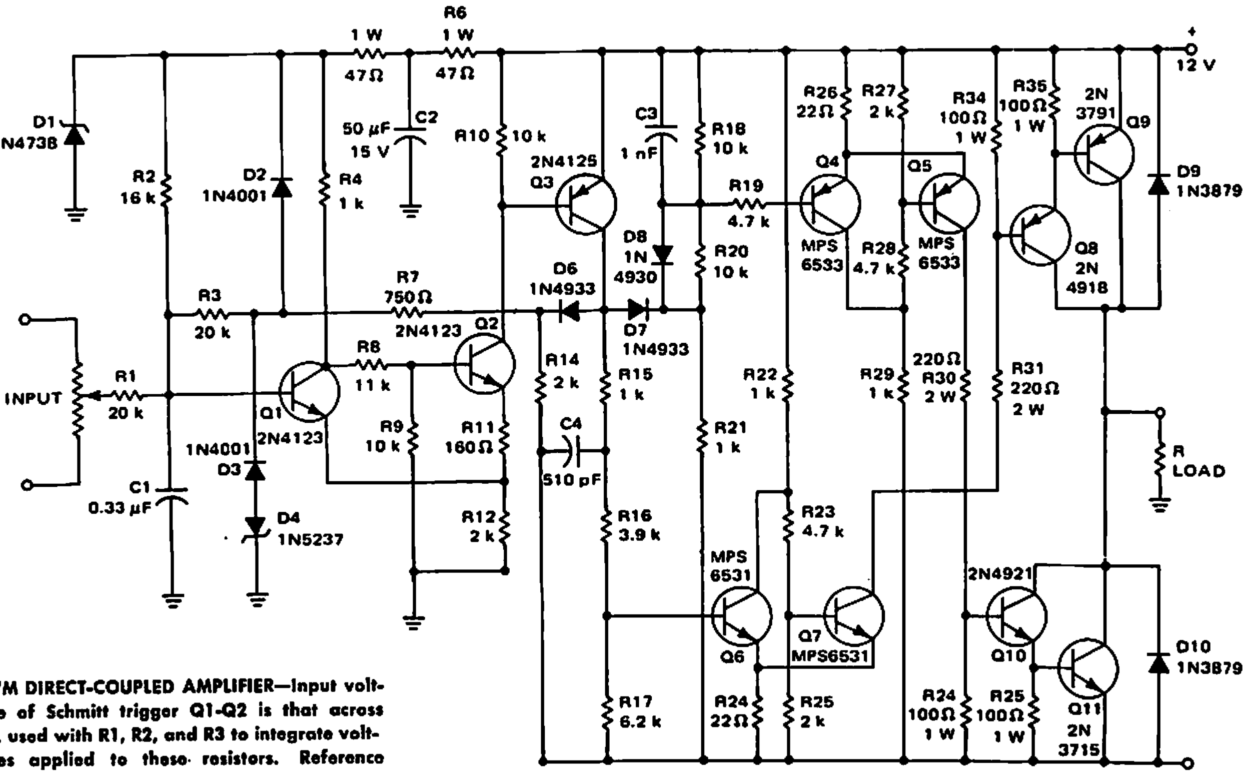
7.5-W WIDEBAND TRANSFORMER-COUPLED—Drives small a-c motor RL from a-c signal whose frequency may range from 50 to 5,000 Hz. Use of common-collector (emitter-follower) stage to provide low-source-impedance drive for transformer keeps phase shift below 10 deg over frequency range handled, to prevent instability. Feedback is derived from separate winding rather than from load or motor winding. Book gives transformer winding data.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–11.


TOROID
18mh
5Ω
25Ω
POSITION ERROR VOLTAGE
0.5μf
25k
SERVO AMP.
27k
ERROR-RATE FEEDBACK
CONTROL PHASE OF KEARFOTT 119-2 SERVOMOTOR
R=312
X=445
AT 400∿

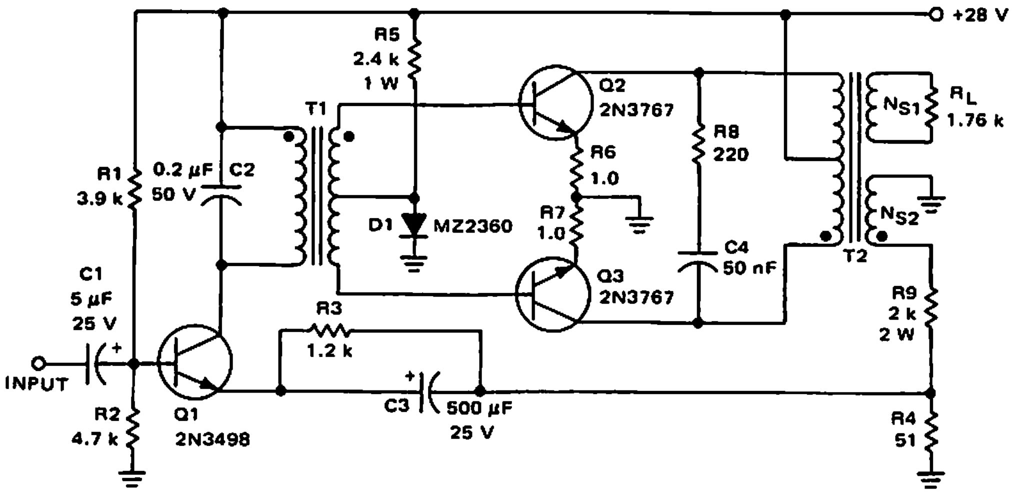
TOROID-BRIDGE TACHOMETER—Serves as inexpensive equivalent of tachometer generator in generating error-rate-feedback signals for servomotor loop. Bridge pot is adjusted for precise null with motor stalled. Circuit can be used only if there is no common connection from input of amplifier to output and if amplifier has sufficient gain and power output to compensate for bridge losses.—F. Close, Error-Rate Feedback Generation in Servomotor Handled by Toroid, *Electronic Design*, April 12, 1965, p 50.


+16V
+29V
115V 400c/s
R1 47K
R2 560
R4 560
R5 47K
C3 1μF
C4 1μF
C1 1μF
TR1
TR2
TR3
TR4
TR5
TR6
R6 1K
R7 1K
R8 2·2K
D1 ZS70
D2 ZS70
R9 220
R10 220
C5
M
C2 1μF
R3 120
INPUT
0V
+16V
TWO 20 VOLT WINDINGS IN SERIES

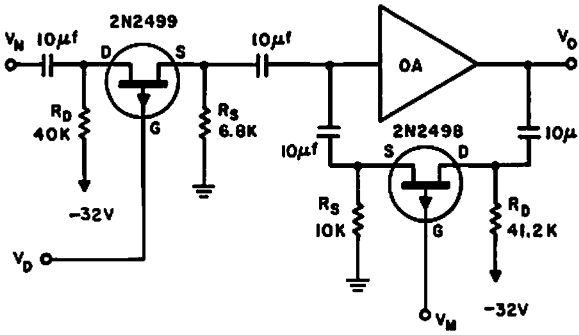
6-W TRANSFORMERLESS SERVO—Suitable for driving control winding of 400-Hz two-phase size 15 servomotor. Class B push-pull output stage uses ZT1479 transistors. Other four transistors can be either ZT20 or ZT40. With bulky output and driver transformers eliminated, amplifier is compact as well as low in cost. Report includes design procedure.—6 Watt-400 c/s Transformerless Servo-Amplifier using Silicon Transistors, Ferranti Ltd., Oldham, Lancs., England, No. 13, 1965.


R6
1 W 47Ω
1 W 47Ω
D1 1N4738
R2 16 k
D2 1N4001
R4 1 k
C2 50 μF 15 V
R10 10 k
2N4125 Q3
C3 1 nF
R18 10 k
R19 4.7 k
D8 1N4930
R20 10 k
D6 1N4933
D7 1N4933
R3 20 k
R7 750Ω
2N4123 Q2
R8 11 k
INPUT
R1 20 k
Q1 2N4123
1N4001 D3
D4 1N5237
C1 0.33 μF
R9 10 k
R11 160Ω
R12 2 k
R14 2 k
R15 1 k
C4 510 pF
R16 3.9 k
R17 6.2 k
R21 1 k
R22 1 k
R23 4.7 k
R24 22Ω
R25 2 k
MPS 6531 Q6
Q7 MPS6531
R26 22Ω
R27 2 k
Q4 MPS 6533
Q5 MPS 6533
R28 4.7 k
R29 1 k
220Ω R30 2 W
R34 100Ω 1 W
R35 100Ω 1 W
R31 220Ω 2 W
2N 3791 Q9
Q8 2N 4918
D9 1N3879
+ 12 V
R LOAD
2N4921 Q10
Q11 2N 3715
R24 100Ω 1 W
R25 100Ω 1 W
D10 1N3879
12 V

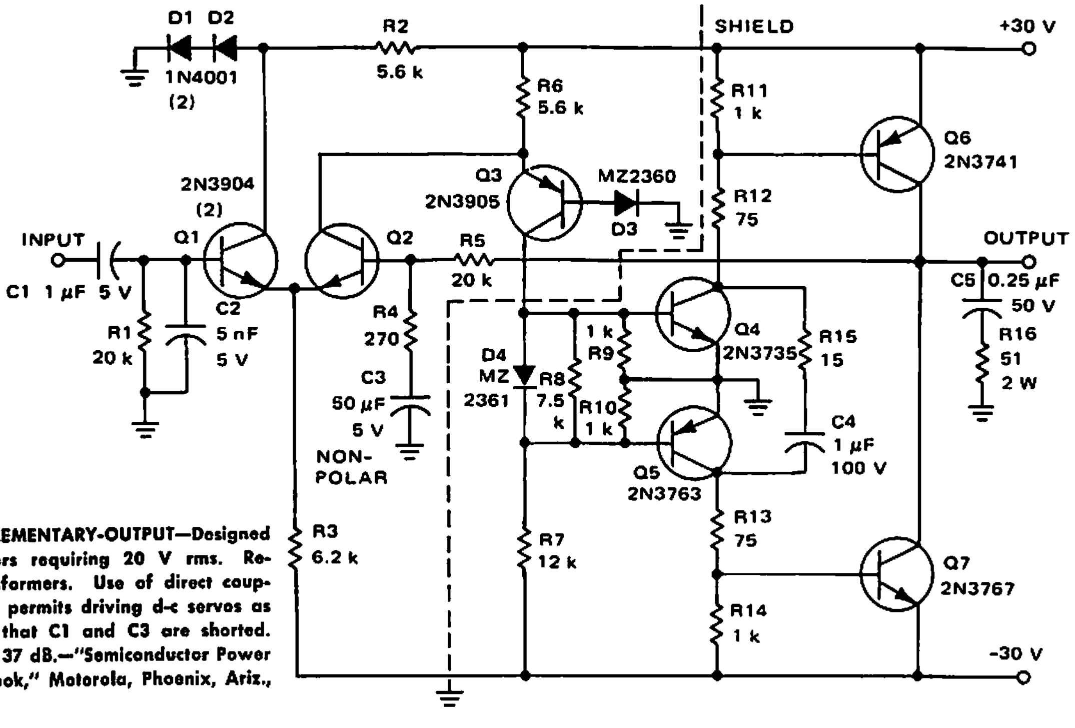
PWM DIRECT-COUPLED AMPLIFIER—Input voltage of Schmitt trigger Q1-Q2 is that across C1, used with R1, R2, and R3 to integrate voltages applied to these resistors. Reference voltage across R2 sets duty cycle of output waveform at 50% when there is no input. Schmitt drives signal-splitter Q3, which furnishes feedback voltage to input through R3, and feeds output drivers Q4-Q5 and Q6-Q7. —"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–26.


+28 V
R5
2.4 k
1 W
T1
Q2
2N3767
R8
220
N_{S1}
R_L
1.76 k
N_{S2}
T2
R6
1.0
R7
1.0
D1
MZ2360
R1
3.9 k
0.2 µF
50 V
C2
C4
50 nF
Q3
2N3767
R9
2 k
2 W
C1
5 µF
25 V
R3
1.2 k
INPUT
R2
4.7 k
Q1
2N3498
C3
500 µF
25 V
R4
51

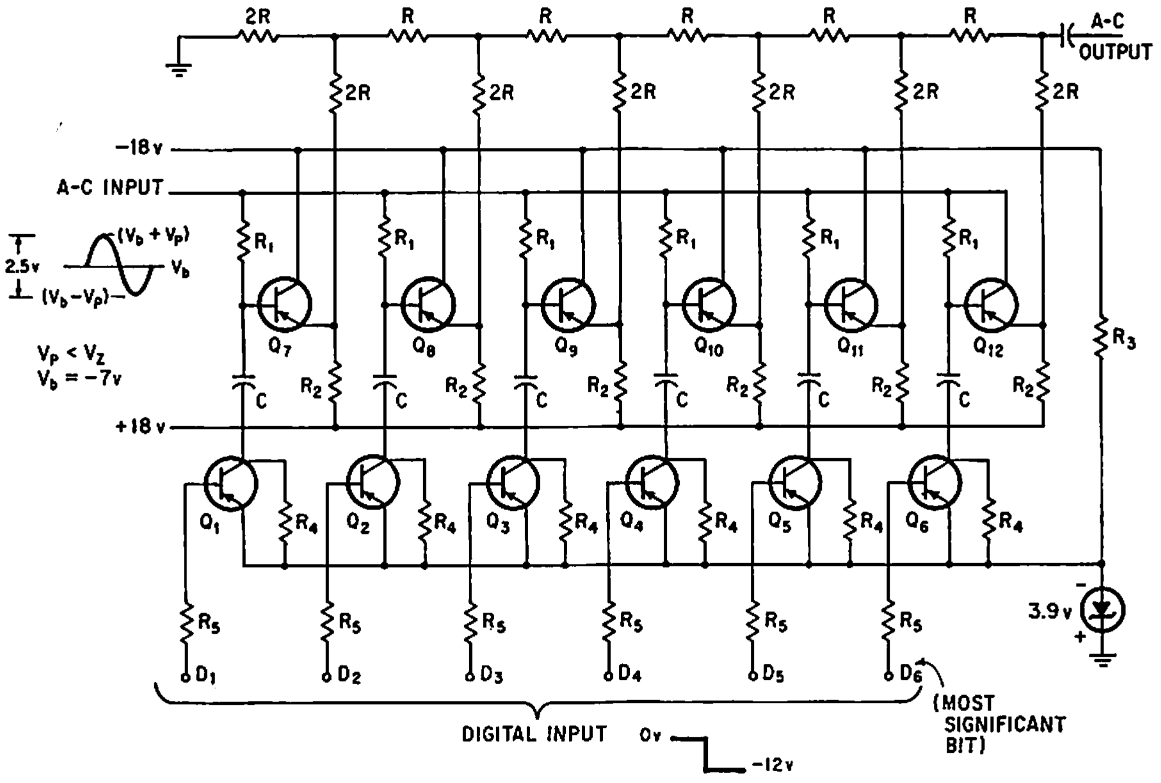
7.5-W TRANSFORMER-COUPLED—Designed to drive small a-c motors. Provides stable voltage gain of 100 with only three transistors. C2 tunes driver transformer primary to minimize phase shift, for applications where operating frequency is nearly constant. Feedback for amplifier is derived from separate winding rather than from load or motor winding. Book gives winding data for both transformers.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–10.


V_N
10µf
2N2499
D
S
10µf
OA
V_O
R_D
40K
G
R_S
6.8K
10µf
2N2498
S
D
10µf
-32V
R_S
10K
G
R_D
41.2K
V_D
V_M
-32V

OPAMP-FET MULTIPLIER-DIVIDER—Fet's serve as input and feedback resistors for IC opamp. Voltage multiplication range is 15:1 with fixed bias on fet at left, representing input resistor. Division range is 1:1/30 when bias of feedback fet at right is fixed. These values correspond to 30 dB of agc range, which is suitable for use as agc of servo error command. Input voltages for multiplying or dividing can be 0.1 to 1.5 V.—E. Hoelken, FET Feedback Configurations Provide Accurate Logic Functions, *Electronic Design,* Dec. 21, 1964, p 52–54.

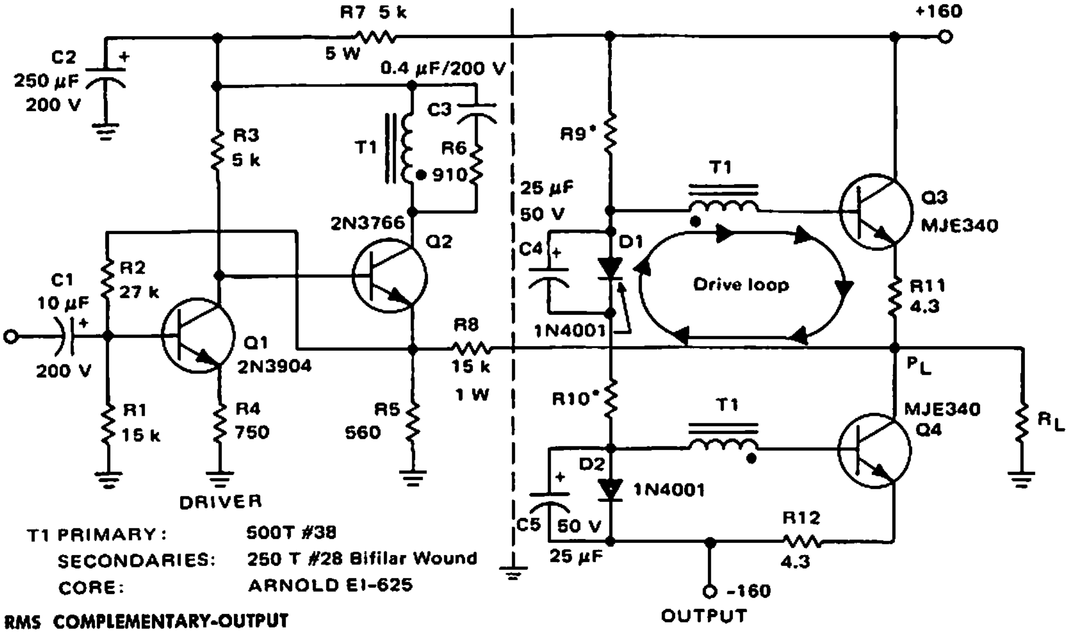

D1 D2
1N4001
(2)
R2
5.6 k
SHIELD
+30 V
R6
5.6 k
R11
1 k
Q6
2N3741
Q3
2N3905
MZ2360
D3
R12
75
2N3904
(2)
Q1
Q2
INPUT
R5
20 k
OUTPUT
C1 1 µF 5 V
C2
5 nF
5 V
R1
20 k
R4
270
C3
50 µF
5 V
NON-
POLAR
D4
MZ
2361
R8
7.5
k
1 k
R9
R10
1 k
Q4
2N3735
R15
15
C5
0.25 µF
50 V
R16
51
2 W
C4
1 µF
100 V
Q5
2N3763
R13
75
R3
6.2 k
R7
12 k
Q7
2N3767
R14
1 k
-30 V

10-W COMPLEMENTARY-OUTPUT—Designed for servo motors requiring 20 V rms. Requires no transformers. Use of direct coupling throughout permits driving d-c servos as well, provided that C1 and C3 are shorted. Voltage gain is 37 dB.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–15.


2R
R
R
R
R
R
A-C OUTPUT
2R
2R
2R
2R
2R
2R
−18 v
A-C INPUT
$(V_b + V_p)$
2.5 v
V_b
$(V_b - V_p)$
$V_p < V_Z$
$V_b = -7$ v
R_1
Q_7
Q_8
Q_9
Q_{10}
Q_{11}
Q_{12}
R_2
C
R_3
+18 v
Q_1
Q_2
Q_3
Q_4
Q_5
Q_6
R_4
R_5
3.9 v
D_1
D_2
D_3
D_4
D_5
D_6
(MOST SIGNIFICANT BIT)
DIGITAL INPUT
0v
−12v

R_1 = 2.2k
R_2 = 2.7k
R_3 = 1.5k
R_4 = 1.0 m
R_5 = 5.6 k
R = 1.0 k
C = 0.1 μf
$Q_1 - Q_{12}$ = 2N3644
FREQUENCY - 1 Mhz

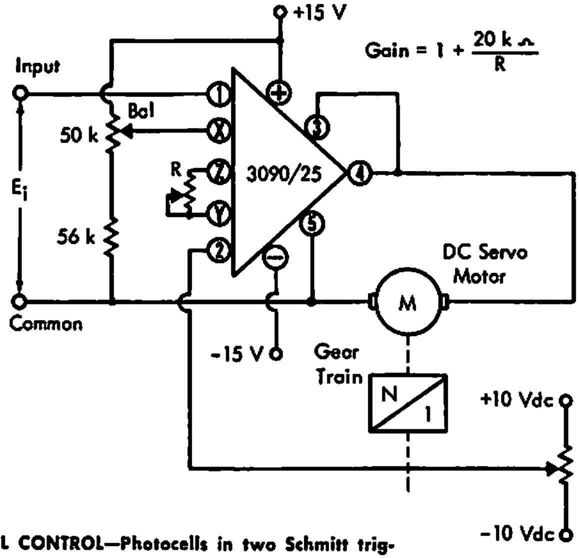
LADDER-TYPE CONVERTER—Delivers a-c output with amplitude proportional to weight of set of binary inputs, for use in a-c servo system. Circuit can be made phase-sensitive by supplying most significant bit Q12 with a-c voltage 180 deg out of phase but with same amplitude and frequency as that used for other bits. This permits use of two's complement binary input code.—D. J. Gawlowicz and R. A. Fisher, Ladder Network Converts Binary Input to A-C Output, *Electronics*, July 7, 1969, p 106–107.

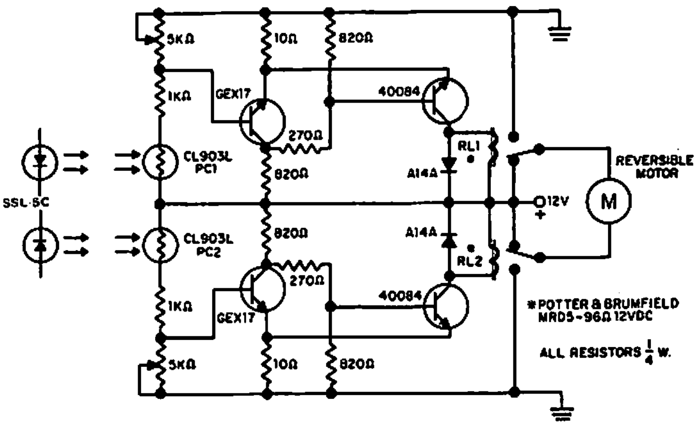

R7 5 k
5 W
+160
C2
250 µF
200 V
0.4 µF/200 V
C3
R3
5 k
T1
R6
910
R9*
T1
Q3
MJE340
25 µF
50 V
C4
D1
Drive loop
2N3766
Q2
C1
10 µF
200 V
R2
27 k
Q1
2N3904
R8
15 k
1 W
1N4001
R11
4.3
P_L
R1
15 k
R4
750
R5
560
R10*
T1
MJE340
Q4
R_L
D2
1N4001
DRIVER
C5
50 V
25 µF
R12
4.3
−160
OUTPUT

T1 PRIMARY: 500T #38
SECONDARIES: 250 T #28 Bifilar Wound
CORE: ARNOLD E1-625

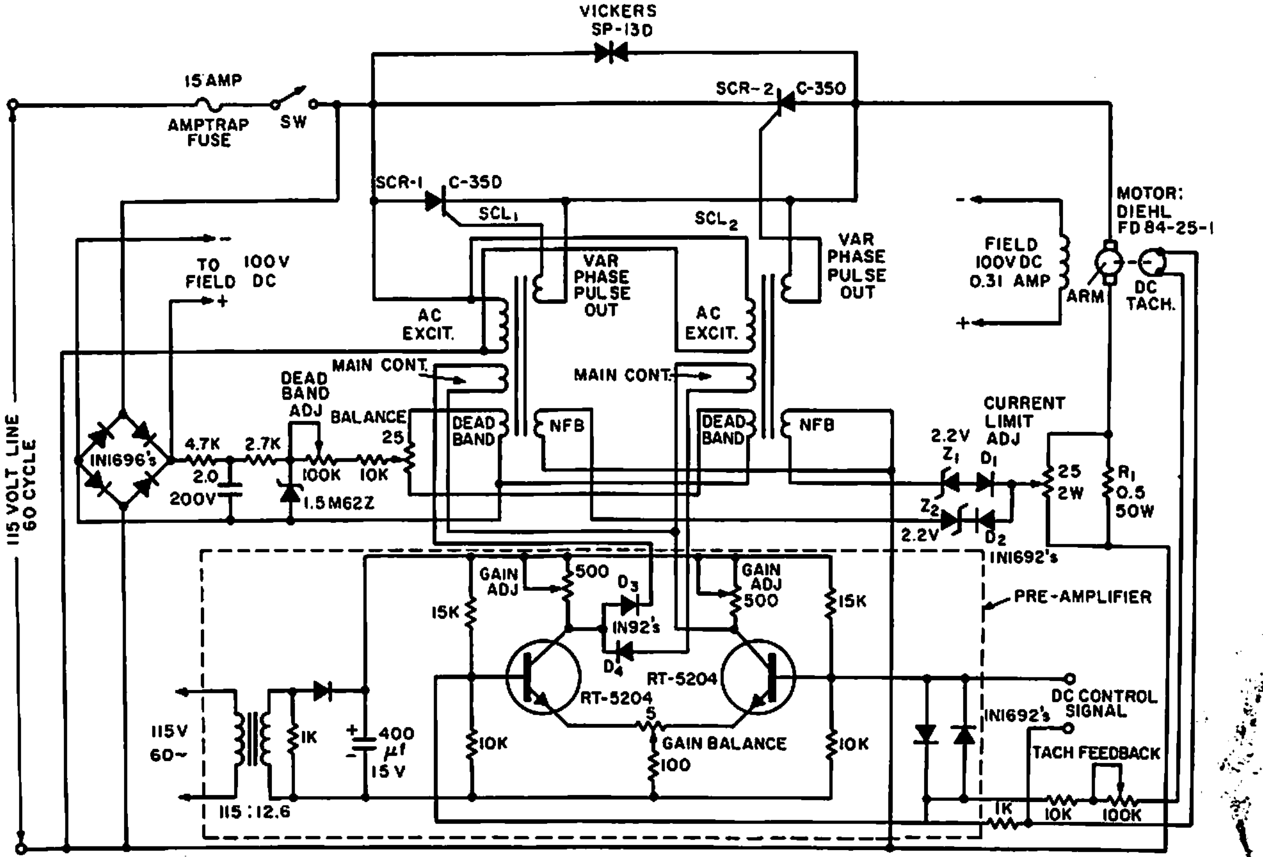
7.5-W 115-V RMS COMPLEMENTARY-OUTPUT—Uses high-voltage transistors to deliver high output voltage to load RL without using output transformer. This reduces phase-shift problems and permits operation from a-c line without power transformer. R9 and R10 should be adjusted so quiescent current of each output transistor does not exceed 15 mA at 100 C. Amplifier has good linearity up to rated output voltage. Frequency response is down only 1 dB from 95 to 2,000 Hz.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–19.

VARIABLE COMMON-MODE LEVEL—With d-c servo amplifier shown, using Burr-Brown differential-input amplifier package, common-mode voltage will vary from −10 V to +10 V as servo follows input voltage. In this arrangement, common-mode rejection may be trimmed up with R for operation at a particular gain, but error from common-mode input cannot be trimmed out by adjusting offset voltage.—Instrument Amplifiers, Burr-Brown Research, Tucson, Ariz., PDS-207C, 1969.

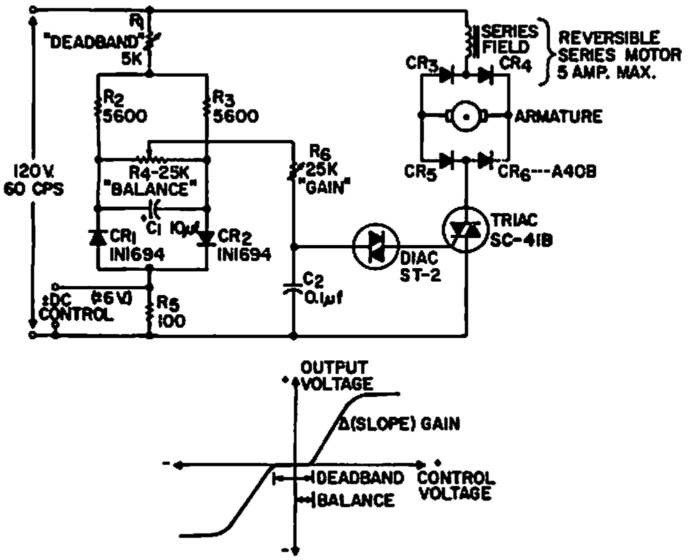

+15 V
Gain = 1 + 20 kΩ / R
Input
Bal
50 k
R
3090/25
E_i
56 k
DC Servo Motor
M
Common
-15 V
Gear Train
N / 1
+10 Vdc
-10 Vdc


5KΩ
10Ω
820Ω
1KΩ
GEX17
40084
270Ω
RL1
CL903L PC1
820Ω
A14A
REVERSIBLE MOTOR
SSL-5C
12V
M
CL903L PC2
820Ω
A14A
RL2
270Ω
40084
1KΩ
GEX17
*POTTER & BRUMFIELD MRD5-96Ω 12VDC
5KΩ
10Ω
820Ω
ALL RESISTORS ¼ W.

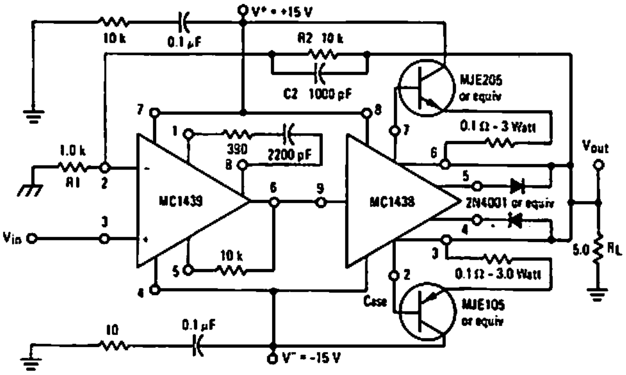
SSL CONTROL—Photocells in two Schmitt triggers coupled back-to-back are energized by solid-state lamps. Under steady-state conditions, both photocells are illuminated by lamps, relays are deenergized, and no voltage is applied to d-c motor. When light on either photocell is interrupted, corresponding relay pulls in and applies voltage to drive motor in one direction.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Cleveland, Ohio, No. 3-0121, 1970, p 24.


VICKERS SP-13D
15 AMP
AMPTRAP FUSE
SW
SCR-2 C-350
SCR-1 C-350
SCL₁
SCL₂
MOTOR: DIEHL FD 84-25-1
TO FIELD 100V DC
VAR PHASE PULSE OUT
VAR PHASE PULSE OUT
FIELD 100V DC 0.31 AMP
ARM
DC TACH.
AC EXCIT.
AC EXCIT.
MAIN CONT.
MAIN CONT.
DEAD BAND ADJ
BALANCE 25
DEAD BAND
NFB
DEAD BAND
NFB
CURRENT LIMIT ADJ
115 VOLT LINE 60 CYCLE
IN1696's
4.7K
2.7K
2.0 200V
100K
10K
1.5M62Z
2.2V
Z₁
D₁
25 2W
R₁ 0.5 50W
Z₂
D₂
2.2V
IN1692's
PRE-AMPLIFIER
GAIN ADJ
500
D₃
GAIN ADJ
500
15K
IN92's
15K
D₄
RT-5204
RT-5204
5
DC CONTROL SIGNAL
IN1692's
115V 60~
1K
400 μf 15 V
10K
GAIN BALANCE
100
10K
TACH FEEDBACK
115 : 12.6
1K
10K
100K

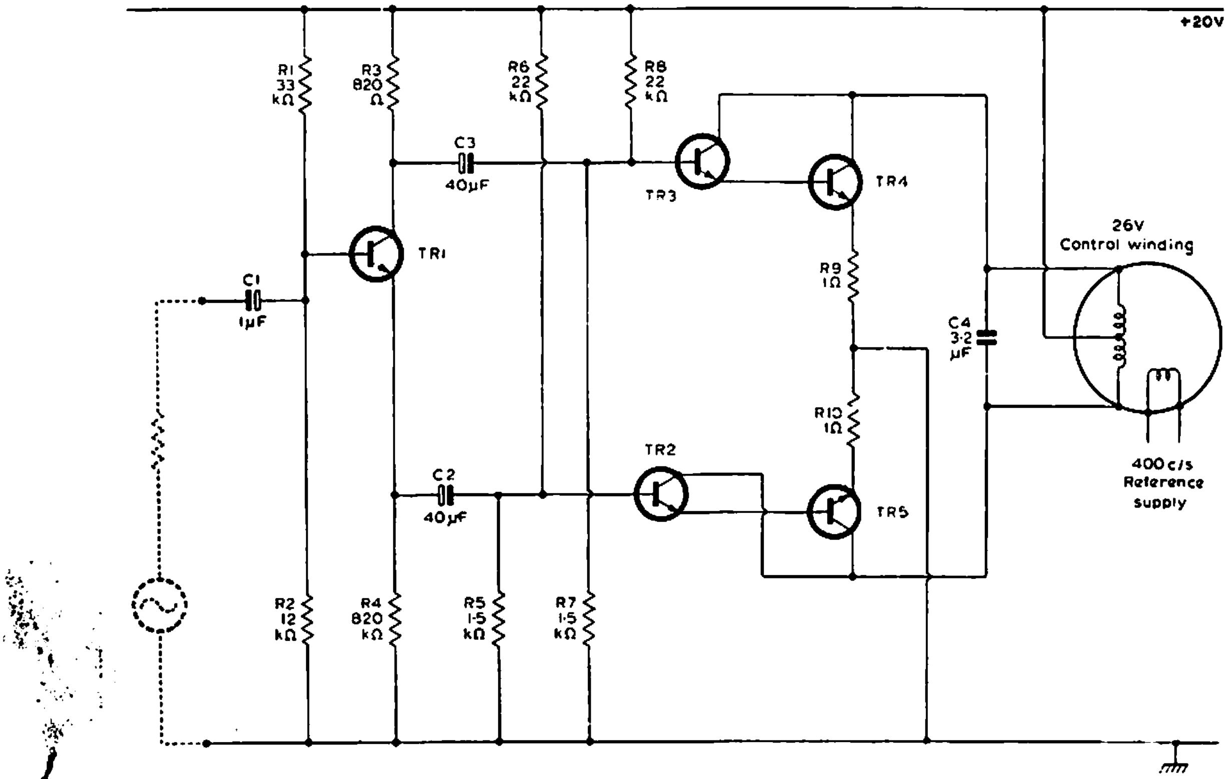
30 REVERSALS PER S—Pair of scr's can provide acceleration of d-c shunt-wound servomotor up to 5,300 radians per s and up to 30 complete reversals of armature current at 60 Hz (120 at 400 Hz). Article describes circuit operation in detail.—W. J. Brown and N. G. Muskovac, Compact Servoamp Has Fast Response, *Electronic Design*, Feb. 17, 1964, p 96—99.


R1
"DEADBAND"
5K
R2
5600
R3
5600
R4-25K
"BALANCE"
R6
25K
"GAIN"
C1 10μf
CR1
IN1694
CR2
IN1694
120V
60 CPS
±DC (±6V)
CONTROL
R5
100
C2
0.1μf
SERIES
FIELD
REVERSIBLE
SERIES MOTOR
5 AMP. MAX.
CR3
CR4
ARMATURE
CR5
CR6---A40B
TRIAC
SC-41B
DIAC
ST-2
OUTPUT
VOLTAGE
Δ(SLOPE) GAIN
DEADBAND
BALANCE
CONTROL
VOLTAGE

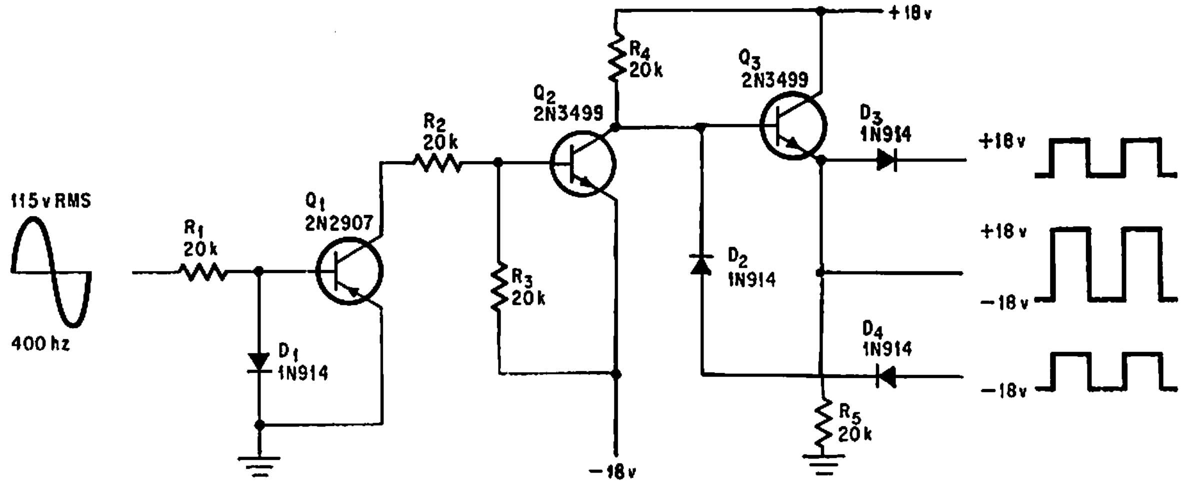
REVERSING DRIVE WITH D-C CONTROL—Positioning servo drive provides adjustment of balance, gain, and deadband. Polarity of 6-V d-c control signal determines direction of rotation. Mechanical control may be applied to balance control. Alternatively, pair of resistance transducers may be substituted for balance control, to give control either by light or temperature.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 24.


V⁺ = +15 V
10 k
0.1 μF
R2 10 k
C2 1000 pF
MJE205
or equiv
0.1 Ω - 3 Watt
1.0 k
R1
Vin
MC1439
390
2200 pF
10 k
MC1438
2N4001 or equiv
5.0
RL
Vout
0.1 Ω - 3.0 Watt
Case
MJE105
or equiv
10
0.1 μF
V⁻ = -15 V
1
2
3
4
5
6
7
8
9

30-W SERVO AMPLIFIER—Uses Motorola amplifier providing 70 dB current gain and unity voltage gain, preceded by MC1439 opamp providing high voltage gain.—Power Booster MC1438R, Motorola, Phoenix, Ariz., ADI-14R1, 1969.

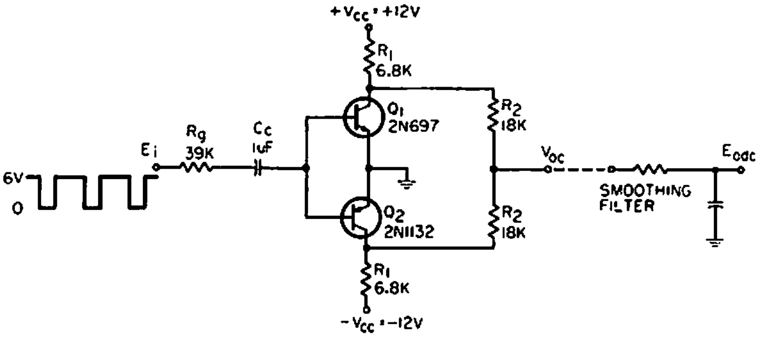

+20V
R1
33
kΩ
R3
820
Ω
R6
22
kΩ
R8
22
kΩ
C3
40μF
TR3
TR4
TR1
C1
1μF
R9
1Ω
C4
3·2
μF
26V
Control winding
R10
1Ω
TR2
C2
40μF
TR5
400 c/s
Reference
supply
R2
12
kΩ
R4
820
kΩ
R5
1·5
kΩ
R7
1·5
kΩ

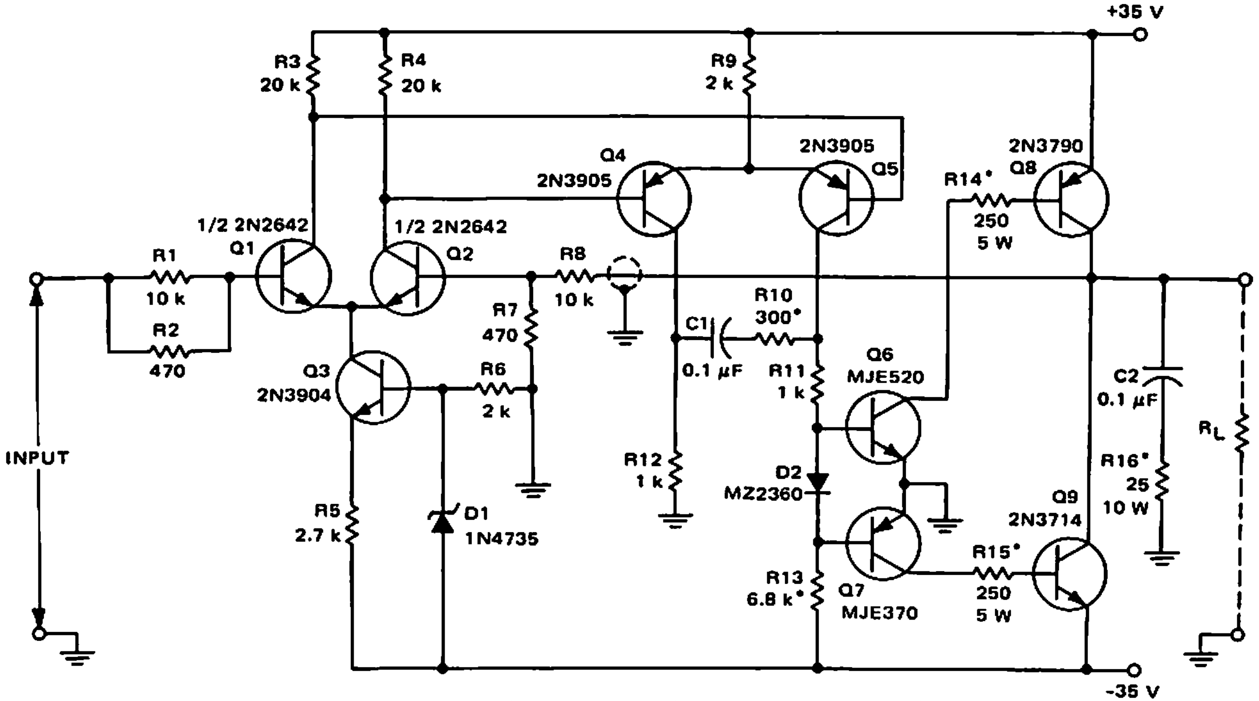
26-V 400-HZ DRIVE FOR 08, 10, AND 11 SERVOS—Provides 35 dB voltage gain when using BFY51 for TR1 and BFY52 for other transistors. Suitable for systems using velocity feedback, but not those depending on inherent viscous damping characteristics of motor.—Applications of the BFY50, BFY51, and BFY52, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 428, 1965.


115 v RMS
400 hz
R1
20 k
D1
1N914
Q1
2N2907
R2
20 k
R3
20 k
Q2
2N3499
R4
20 k
−18 v
+18 v
Q3
2N3499
D2
1N914
D3
1N914
D4
1N914
R5
20 k
+18 v
+18 v
−18 v
−18 v

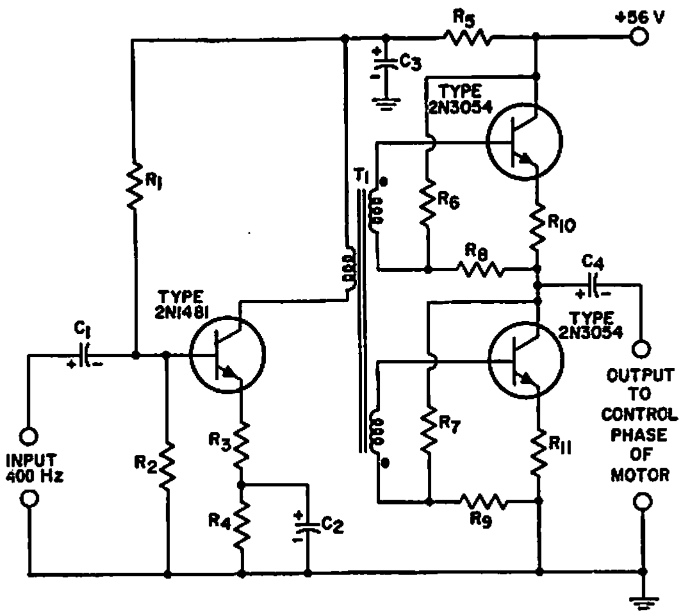
SQUARE WAVES FROM 400-HZ LINE—Provides highly accurate and stable frequency, with high peak voltage, for demodulating output of servo control amplifiers in ships and aircraft having 400-Hz power.—H. W. Candel, Sine Waves Become Square, With A Symmetrical Switch, *Electronics*, May 13, 1968, p 74.

DISCRIMINATOR—Gives linear changes in output voltage for changes in input duty cycle. Output is independent of amplitude of input pulses because Q1 and Q2 are operated in switching mode. Used in self-balancing servo loop in which R2 was pot geared to servomotor. Output voltage swings between fixed positive and negative voltages, with average value therefore depending on duty cycle.—P. Cutler, Pulse-Width Discriminator, *EEE*, Nov. 1966, p 152–153.

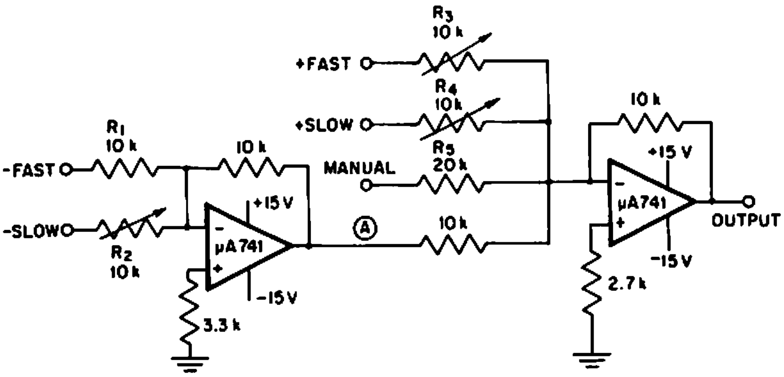

+Vcc = +12V
R1
6.8K
Q1
2N697
R2
18K
6V
0
Ei
Rg
39K
Cc
1uF
Voc
Eodc
SMOOTHING FILTER
Q2
2N1132
R2
18K
R1
6.8K
−Vcc = −12V


+35 V
R3
20 k
R4
20 k
R9
2 k
Q4
2N3905
2N3905
Q5
2N3790
Q8
R14*
250
5 W
1/2 2N2642
Q1
1/2 2N2642
Q2
R1
10 k
R2
470
R8
10 k
R7
470
R10
300*
C1
0.1 µF
R11
1 k
Q6
MJE520
Q3
2N3904
R6
2 k
INPUT
C2
0.1 µF
RL
R16*
25
10 W
R12
1 k
D2
MZ2360
R5
2.7 k
D1
1N4735
Q9
2N3714
R15*
250
5 W
R13
6.8 k*
Q7
MJE370
−35 V

28-W 28-V D-C—Can drive 1-A load. Differential amplifier Q1-Q3 receives other input from amplifier output through R8, for negative feedback. Gain is about 22. Second stage, Q4-Q5, is differential-to-single-ended converter. Both driver and output stages use complementary-transistor connection.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 5–23.


R5
+56 V
C3
TYPE 2N3054
T1
R6
R10
R8
C4
R1
TYPE 2N1481
C1
TYPE 2N3054
OUTPUT TO CONTROL PHASE OF MOTOR
INPUT 400 Hz
R2
R3
R4
C2
R7
R11
R9

6-W 400-HZ AMPLIFIER—Upper transistor handles positive half-cycles of output signal and lower transistor handles negative half-cycles, so voltage swings are equal at motor. Values: R1 68K; R2 5.6K; R3 56; R4 560; R5 3.3K; R6-R7 18K; R8-R9 400; R10-R11 4; C1 10 μF; C2 47 μF; C3 20 μF; C4 500 μF; T1 1,500 turns primary and 225 turns each secondary bifilar wound.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 529.

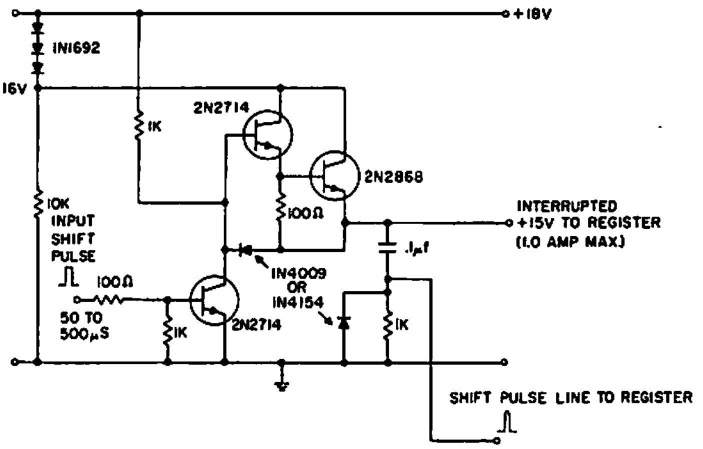

R3 10 k
+FAST
R4 10k
+SLOW
R5 20k
MANUAL
10 k
+15 V
μA741
-15 V
OUTPUT
2.7k
R1 10 k
-FAST
10 k
-SLOW
R2 10k
+15V
μA741
-15V
3.3 k
Ⓐ
10 k

VELOCITY SERVO INTERFACE—Required when system must provide bidirectional rotation for both analog and digital inputs, with positive voltage providing drive in one direction and negative voltage in other direction. Combination of two opamps accepts either input logic levels from digital circuits or bipolar manual input such as from speed control, for either fast or slow motion in either direction. Manual input can be continuously variable from −15 V to +15 V, while other four inputs take 5-V logic. Output ranges from −10 V to +10 V.—J. E. McAlister, Bipolar Analog/Digital Interface for Servos, *EEE*, July 1970, p 85–86.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

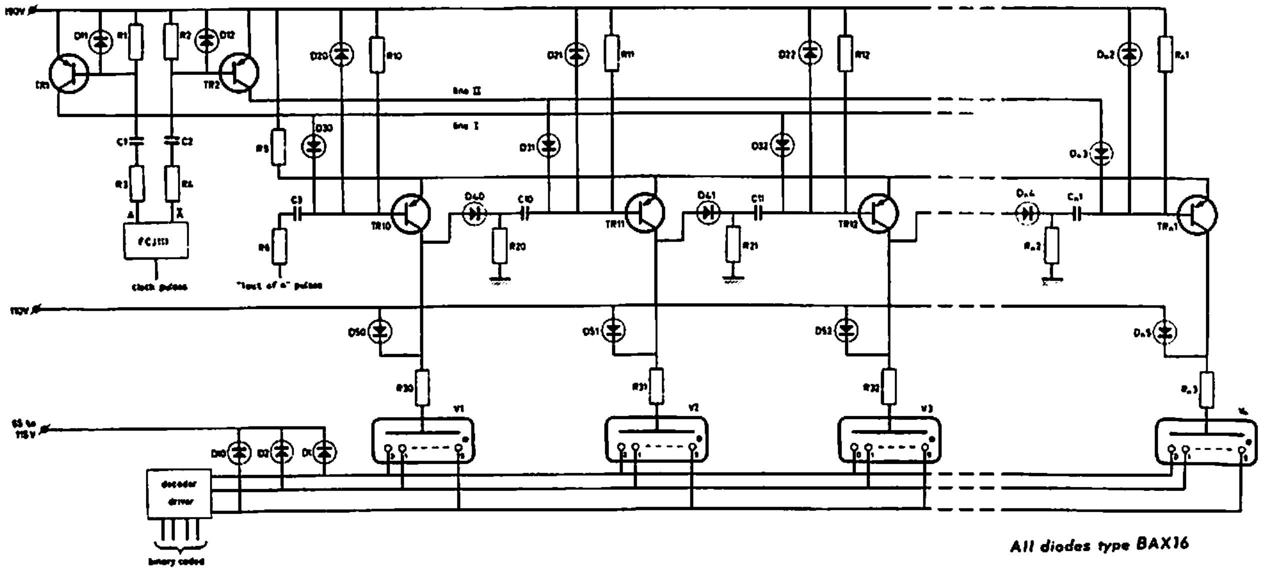
CHAPTER 77

Shift Register Circuits



+18V
IN1692
16V
IK
2N2714
2N2868
10K
INPUT SHIFT PULSE
100Ω
50 TO 500μS
IK
2N2714
100Ω
IN4009 OR IN4154
.1μf
IK
INTERRUPTED +15V TO REGISTER (1.0 AMP MAX)
SHIFT PULSE LINE TO REGISTER

DARLINGTON DRIVER—Shift pulse input saturates lower 2N2714, depriving Darlington combination (above it) of base drive. Resulting negative pulse on 15-V line is differentiated to give desired positive output trigger pulse at its trailing edge, for driving shift register. Required 16-V power supply is synthesized from 18 V by using 1N1692 rectifiers.—Planar Silicon Controlled Switch 3N84/3N85, General Electric, Syracuse, N.Y., No. 65.18, 1964.



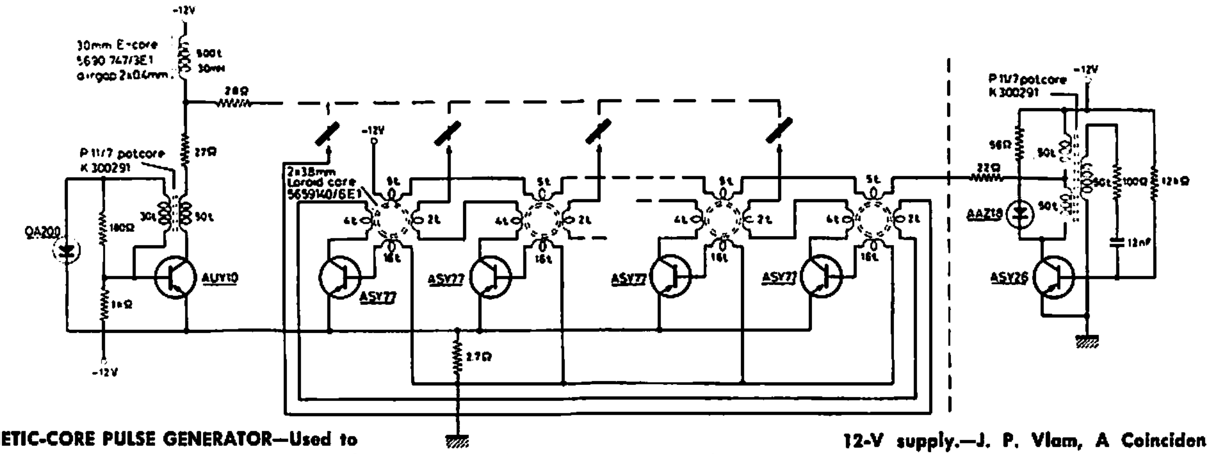
190V
D11
R1
R2
D12
TR1
TR2
D20
R10
D21
R11
D22
R12
line II
line I
C1
C2
R3
R4
R5
D30
D31
D32
FCJ111
clock pulses
C3
R6
"1out of n" pulses
TR10
D40
C10
R20
TR11
D41
C11
R21
TR12
110V
D50
D51
D52
R30
R31
R32
V1
V2
V3
65 to 115V
D10
D2
D1
decoder driver
binary coded information from shift register

SYNCHRONIZED DYNAMIC DRIVE FOR INDICATORS—Will display information contained in shift register. Clock pulses (10 kHz) supplied to FCJ111 flip-flop provide synchronization so each digit is displayed by correct indicator tube.—D. J. G. Janssen, A. G. Korteling, and P. H. G. van Vlodrop, Cold Cathode Numerical Indicator Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 327, 1968.

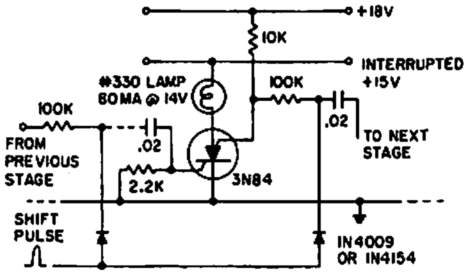
C1 = 10 nF
C2 = 10 nF
C3 = 100 nF
C10, C11...Cn1 = 1 nF
TR1, TR2 = BCY72
TR10, TR11...TRn1 = 516BSY

All diodes type BAX16

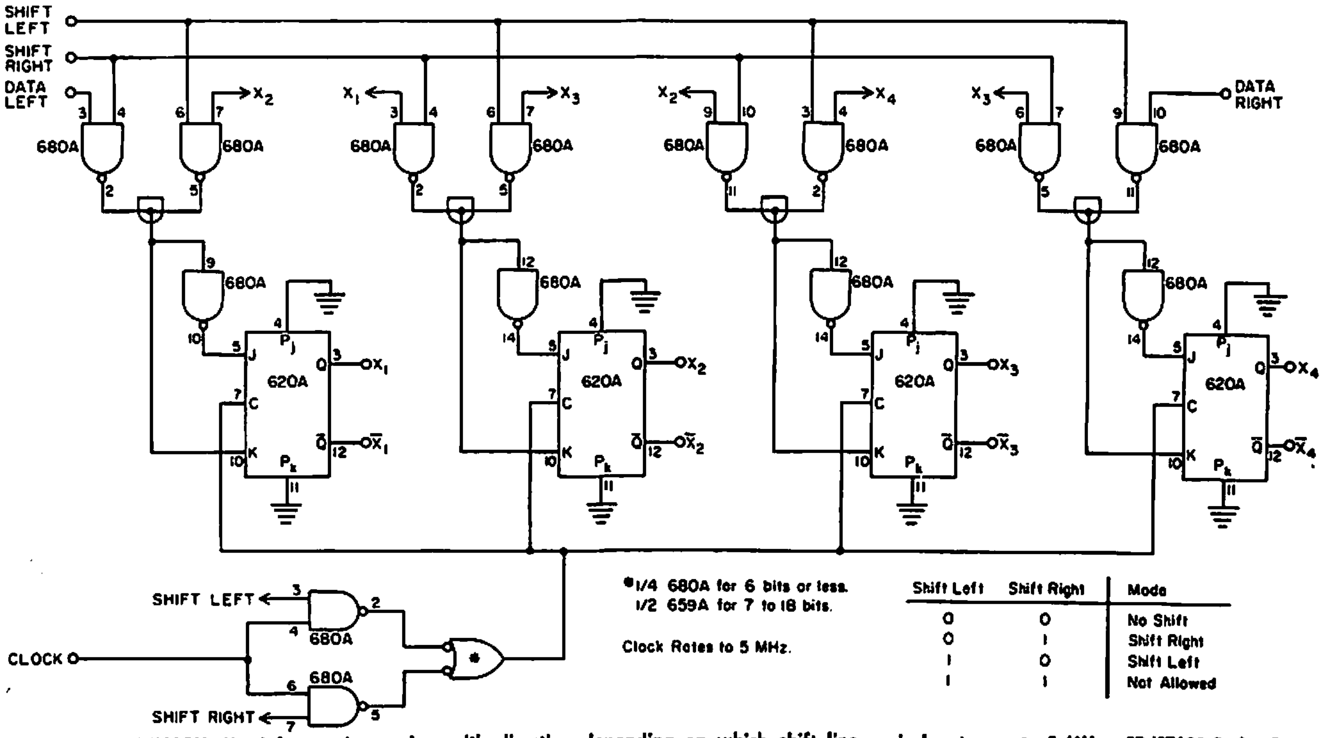
R1 = 10 kΩ
R2 = 10 kΩ
R3 = 10 kΩ
R4 = 10 kΩ
R5 = 270 Ω
R6 = 10 kΩ
R10, R11...Rn1 = 10 kΩ
R20, R21...Rn2 = 150 kΩ
R30, R31...Rn3 = 3.3 kΩ


-12V
30mm E-core
5630 747/3E1
airgap 2x0.4mm
500t
30mt
28Ω
27Ω
P11/7 potcore
K 300291
OA200
180Ω
30t
50t
AUY10
1kΩ
-12V
2x38mm
toroid core
5659140/6E1
-12V
5t
4t
2t
16t
ASY77
27Ω
P11/7 potcore
K 300291
-12V
56Ω
50t
22Ω
AAZ15
50t
100Ω
12kΩ
12nF
ASY26

MAGNETIC-CORE PULSE GENERATOR—Used to supply 12-μs 3-mA current pulses to vertical wires in shift register. Rise time of 0.15 μs is independent of number of cores to be driven. Each transistor is part of triggered blocking oscillator using square-loop ferrite cores as transformers. Circuit requires only 12-V supply.—J. P. Vlam, A Coincident-Current Magnetic-Core Shift Register, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 825, 1965.


+18V
10K
INTERRUPTED +15V
#330 LAMP
80MA @ 14V
100K
100K
.02
.02
TO NEXT STAGE
FROM PREVIOUS STAGE
2.2K
3N84
SHIFT PULSE
IN4009
OR IN4154

BASIC SCS STAGE—Planar scs gives immunity to voltage transients without affecting triggering sensitivity or transient response time. Shift pulse from driver should be less than 15 V. Anode supply is interrupted prior to each shift pulse to turn off all stages. Stored capacitor charge determines which stages will be retriggered.—Planar Silicon Controlled Switch 3N84/3N85, General Electric, Syracuse, N.Y., No. 65.18, 1964.

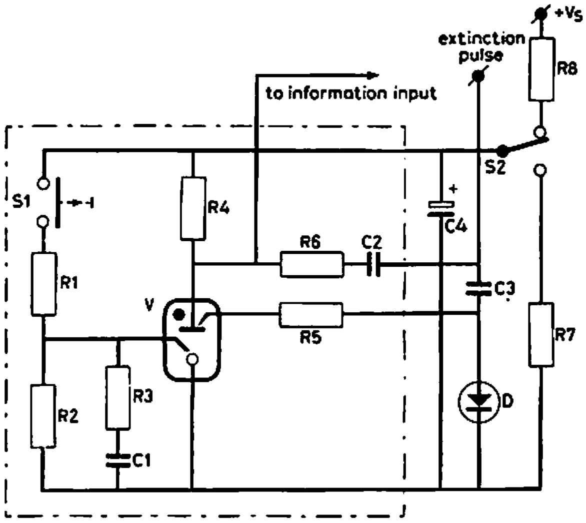

SHIFT LEFT
SHIFT RIGHT
DATA LEFT
DATA RIGHT
680A
620A
X1
X2
X3
X4
J
C
K
Pj
Pk
Q
Q̄
SHIFT LEFT
SHIFT RIGHT
CLOCK
*

*1/4 680A for 6 bits or less.
1/2 659A for 7 to 18 bits.

Clock Rates to 5 MHz.

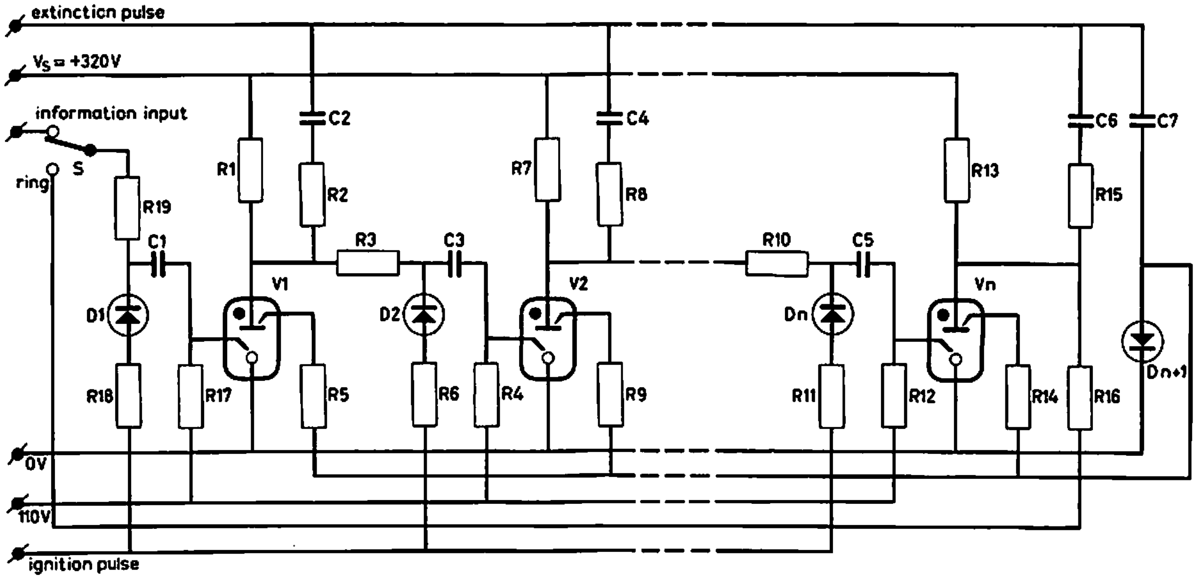
Shift Left	Shift Right	Mode
0	0	No Shift
0	1	Shift Right
1	0	Shift Left
1	1	Not Allowed

SERIAL-ENTRY BINARY—Used for storing and transferring binary numbers in or out in either direction (left-right) one at a time, with direction depending on which shift line is high at clock time. Uses Signetics IC gates and J-K binary IC elements. Will operate at clock rates up to 5 MHz.—SP/ST600-Series Design Data and Applications, Signetics, Sunnyvale, Cal., 1966, AN108.


+Vs
extinction pulse
R8
to information input
S2
S1
R4
R6
C2
C4
C3
R1
V
R5
R7
D
R2
R3
C1

TRIGGER FOR RUNNING TEXT DISPLAY—Used for writing information into shift register having neon trigger tubes serving also as lamps for running-text display. Function of S1 is normally performed by punched paper tape reader containing text for display.—J. G. M. Thaens and P. H. G. van Vlodrop, Running Text Display with Cold-Cathode Trigger Tubes, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 3, 1966–1967, p 92–102.

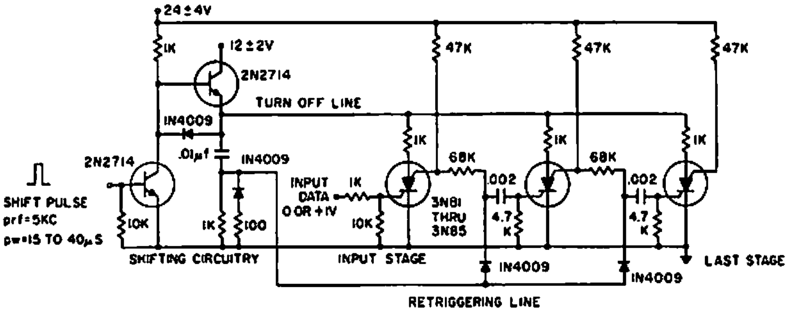
R_1	100 kΩ, ¼ W ± 5%	R_8	4.7 kΩ, 1 W ± 5%
R_2	2.2 MΩ, ¼ W ± 10%	C_1	2.2 nF ± 10%
R_3	10 kΩ, ⅛ W ± 5%	C_2	2.2 nF ± 10%
R_4	82 kΩ, ¼ W ± 5%	C_3	220 nF ± 10%
R_5	10 MΩ, ⅛ W ± 10%	C_4	64 μF ± 20%
R_6	22 kΩ, ⅛ W ± 5%	D	BYX10
R_7	3.3 kΩ, 1 W ± 5%	V	ZC1050


extinction pulse
Vs = +320V
information input
S
ring
R19
C1
D1
R18
R17
R1
C2
R2
R3
C3
V1
R5
D2
R6
R4
R7
C4
R8
V2
R9
R10
C5
Dn
R11
R12
Vn
R13
R14
R15
R16
C6
C7
Dn+1
0V
110V
ignition pulse

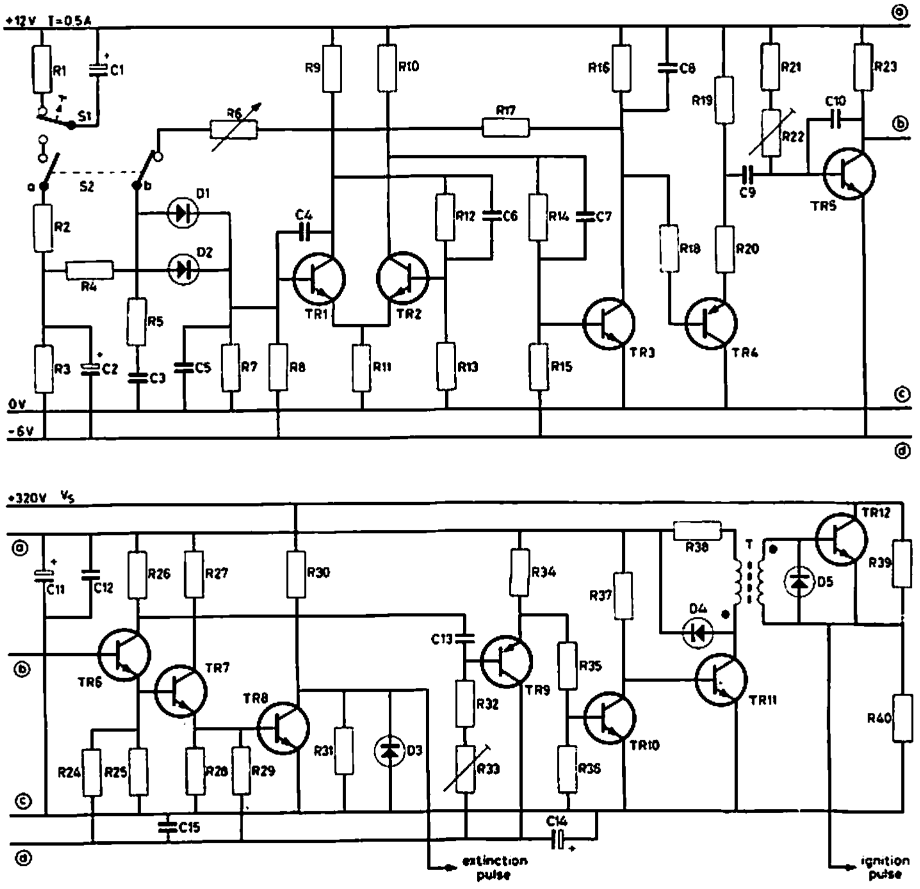
R_1, R_7, R_{13}	82 kΩ, ¼ W,	C_1 - C_6	2.2 nF ± 15%
R_2, R_8, R_{15}	22 kΩ, ⅛ W,	C_7	470 nF ± 15%
R_3, R_{10}, R_{19}, R_4, R_{12}, R_{17}	1 MΩ, ¼ W,	D_1 - D_{n+1}	BYX10
R_5, R_9, R_{14}	10 MΩ, ⅛ W ± 10%	V_1 - V_n	ZC1050
R_6, R_{11}, R_{18}	10 kΩ, ⅛ W,		
R_{16}	100 kΩ, ¼ W,		

SHIFT REGISTER FOR RUNNING TEXT—Used to activate one of seven rows of neon-filled trigger tubes on which moving letters are formed in 5-by-7 matrix. Neons serve also as switching elements V1-Vn of shift register, because ZC1050 neon trigger has pure molybdenum cathode and very high light output. Other advantages are high switching speed, complete lack of afterglow, and guaranteed minimum life of 10,000 hours. Size of matrix is limited only by budget; seven rows are minimum for readable letters. Article gives all circuits and construction details.—J. G. M. Thaens and P. H. G. van Vlodrop, Running Text Display with Cold-Cathode Trigger Tubes, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 3, 1966–1967, p 92–102.

5-KHZ WITH UP TO 10 SCS STAGES—Shift pulse at input turns off all scs's. Trailing edge of turnoff pulse is differentiated for turning on appropriate stages. Will easily handle up to ten stages.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.



+24±4V
1K
12±2V
2N2714
TURN OFF LINE
IN4009
.01μf
IN4009
2N2714
SHIFT PULSE
prf=5KC
pw=15 TO 40μS
10K
1K
100
SHIFTING CIRCUITRY
47K
1K
INPUT DATA 0 OR +1V
1K
10K
68K
.002
4.7K
3N81 THRU 3N85
INPUT STAGE
IN4009
47K
1K
68K
.002
4.7K
IN4009
47K
1K
LAST STAGE
RETRIGGERING LINE

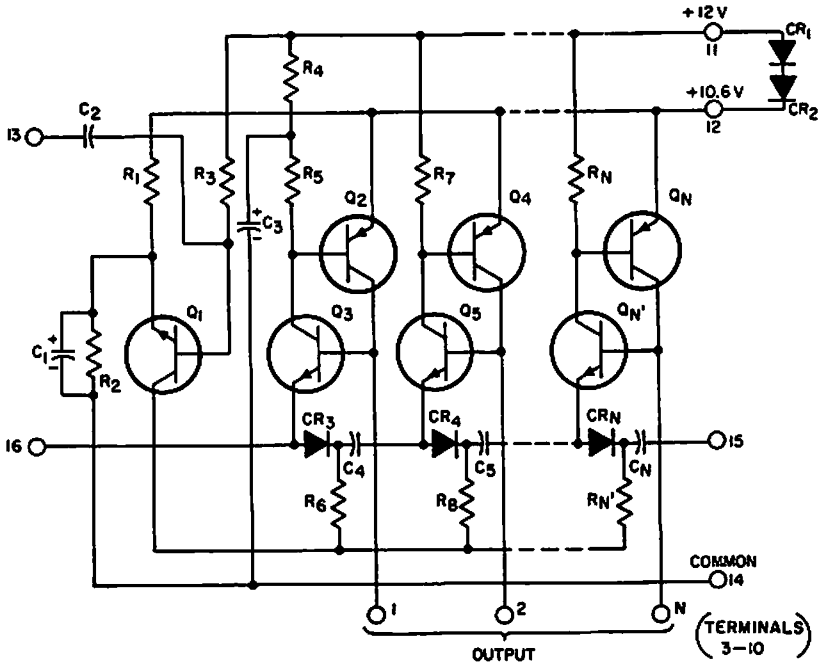


+12V I=0.5A
R1
C1
S1
S2
a
b
R2
R4
D1
D2
R3
C2
R5
C3
C5
R6
R7
C4
R8
R9
R10
TR1
TR2
R11
R12
C6
R13
R14
C7
R15
R17
TR3
R16
C8
R18
R19
R21
R22
C10
C9
R20
TR4
R23
TR5
0V
-6V
+320V Vs
C11
C12
R26
R27
R30
TR6
TR7
TR8
R24
R25
C15
R28
R29
R31
D3
C13
R32
R33
TR9
R34
R35
R36
TR10
C14
R37
R38
D4
T
TR11
TR12
D5
R39
R40
extinction pulse
ignition pulse
a
b
c
d

Transformer *T*: H20 core; secondary: 25 turns 0.35 mm diameter enamelled copper wire; primary: 100 turns 0.28 mm diameter enamelled copper wire wound on top of and insulated from the secondary.

R_1	5.6 kΩ,	¼ W
R_2	27 Ω,	¼ W
R_3	10 kΩ,	¼ W
R_4	10 kΩ,	¼ W
R_5	470 Ω,	¼ W
R_6	100 kΩ,	¼ W pot.
R_7	470 kΩ,	¼ W
R_8	270 kΩ,	¼ W
R_9	1.5 kΩ,	¼ W
R_{10}	1.5 kΩ,	¼ W
R_{11}	220 Ω,	¼ W
R_{12}	15 kΩ,	¼ W
R_{13}	22 kΩ,	¼ W
R_{14}	15 kΩ,	¼ W
R_{15}	22 kΩ,	¼ W
R_{16}	2.2 kΩ,	¼ W
R_{17}	12 kΩ,	¼ W
R_{18}	10 kΩ,	¼ W
R_{19}	470 Ω,	¼ W
R_{20}	560 Ω,	¼ W
R_{21}	10 kΩ,	¼ W
R_{22}	10 kΩ,	¼ W pot.
R_{23}	1 kΩ,	¼ W
R_{24}	6.8 kΩ,	¼ W
R_{25}	4.7 kΩ,	¼ W
R_{26}	560 Ω,	½ W
R_{27}	27 Ω,	2 W
R_{28}	1 kΩ,	¼ W
R_{29}	1 kΩ,	¼ W
R_{30}	3.9 kΩ.	16 W
R_{31}	10 kΩ,	16 W
R_{32}	10 kΩ,	¼ W
R_{33}	5 kΩ,	¼ W pot.
R_{34}	1.5 kΩ,	¼ W
R_{35}	3.3 kΩ,	¼ W
R_{36}	1.5 kΩ,	¼ W
R_{37}	330 Ω,	½ W
R_{38}	33 Ω,	8 W
R_{39}	39 kΩ, 5.5 W in parallel with 68 kΩ, 1 W	
R_{40}	15 kΩ,	5.5 W
C_1	2.5 μF	electrolytic
C_2	1 μF	electrolytic
C_3	4.4 μF	polyester
C_4	2.2 nF	
C_5	12 nF	
C_6	220 pF	
C_7	330 pF	
C_8	8.2 nF	
C_9	220 nF	
C_{10}	3.3 NF	
C_{11}	1000 μF	electrolytic
C_{12}	3.3 nF	
C_{13}	8.2 nF	polyester
C_{14}	40 μF	electrolytic
C_{15}	3.3 nF	

SHIFT REGISTER DRIVER FOR RUNNING TEXT—Generates extinction and ignition pulses for driving shift register using neon trigger tubes that serve also as lamps for running-text display. With switch S2a closed, each operation of S1 makes Schmitt trigger TR1-TR2 produce one positive-going pulse at collector of TR2. When S2b is closed, this output pulse is amplified and inverted by TR3 and fed back to base of TR1, making circuit astable at repetition frequency adjustable by R6 from 8 to 90 Hz. Article describes circuit operation in detail. Values shown are for display having seven rows with 100 tubes each.—J. G. M. Thaens and P. H. G. van Vladrop, Running Text Display with Cold-Cathode Trigger Tubes, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 3, 1966–1967, p 92–102.


+12V
11
CR1
+10.6V
12
CR2
13
C2
R4
R1
R3
R5
C3
Q2
R7
Q4
RN
QN
Q1
Q3
Q5
QN'
C1
R2
16
CR3
CR4
CRN
15
C4
C5
CN
R6
R8
RN'
COMMON
14
1
2
N
OUTPUT
TERMINALS 3–10

C_1 = 100 microfarads, 10 volts, electrolytic

C_2 C_4 C_5 C_N = 0.05 microfarad, 50 volts or greater

C_3 = 10 microfarads, 15 volts, electrolytic

CR_1 CR_2 CR_N = silicon diode, type 1N270

Q_1 Q_3 Q_5 $Q_{N'}$ = transistor, RCA SK3005

$Q_2 Q_4 Q_N$ = transistor, RCA SK3010

R_1 R_7 R_N = 1000 ohms, 1/2 watt, 10%

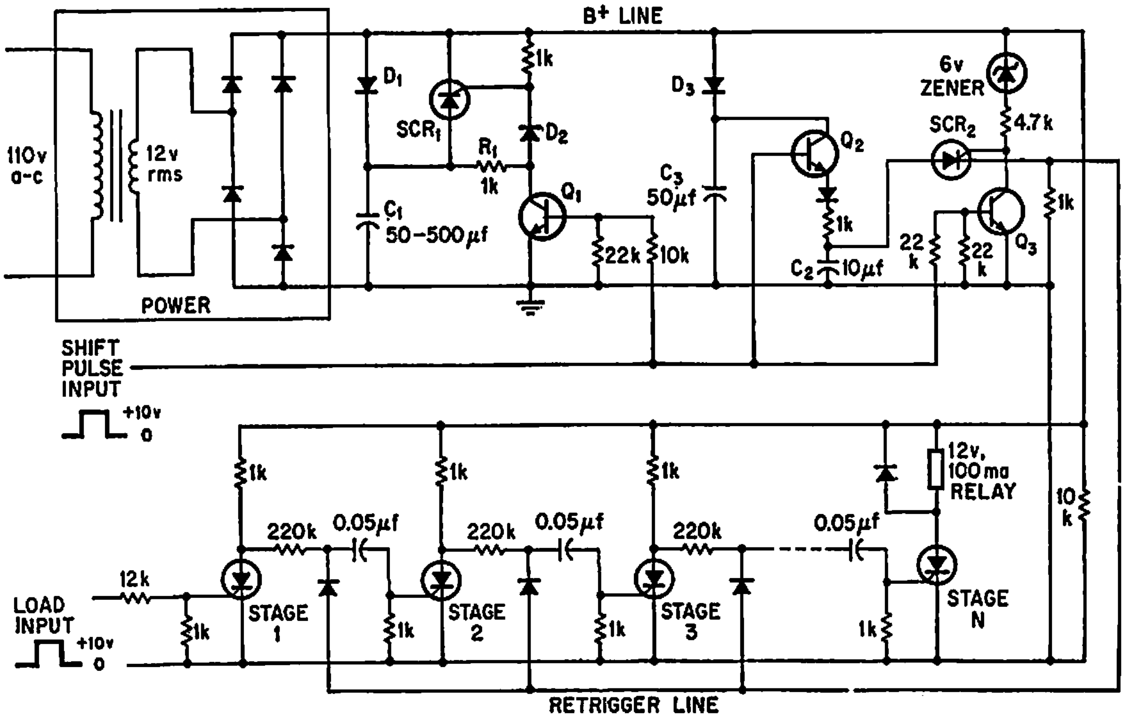
R_2 = 47 ohms, 1/2 watt, 10%

R_3 = 5600 ohms, 1/2 watt, 10%

$R_4 R_5$ = 470 ohms, 1/2 watt, 10%

$R_6 R_8 R_{N'}$ = 270 ohms, 1/2 watt, 10%

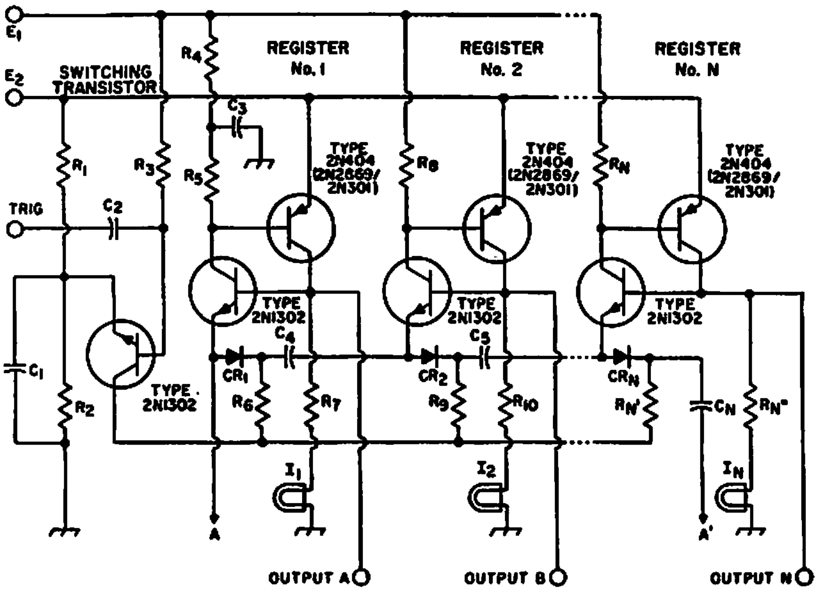
TEN-STAGE CIRCUIT—Requires 2-V negative pulse at terminal 13 to change register to next stage. Required 10.6-V d-c supply is obtained from two diodes connected in series to 12-V supply. Each register stage is basically two-transistor regenerative switch using npn and pnp transistors; if either starts to conduct, both are quickly driven into saturation by regenerative action. Load connected to each output terminal should be under 1,000 ohms and draw less than 200 mA.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 56.


B+ LINE
110v a-c
12v rms
POWER
D1
SCR1
1k
D2
R1 1k
Q1
C1 50–500μf
22k
10k
D3
C3 50μf
Q2
1k
C2 10μf
6v ZENER
SCR2
4.7k
22 k
22 k
Q3
1k
SHIFT PULSE INPUT
+10v
0
1k
220k
0.05μf
12v, 100ma RELAY
10 k
12k
LOAD INPUT
+10v
0
STAGE 1
STAGE 2
STAGE 3
STAGE N
RETRIGGER LINE

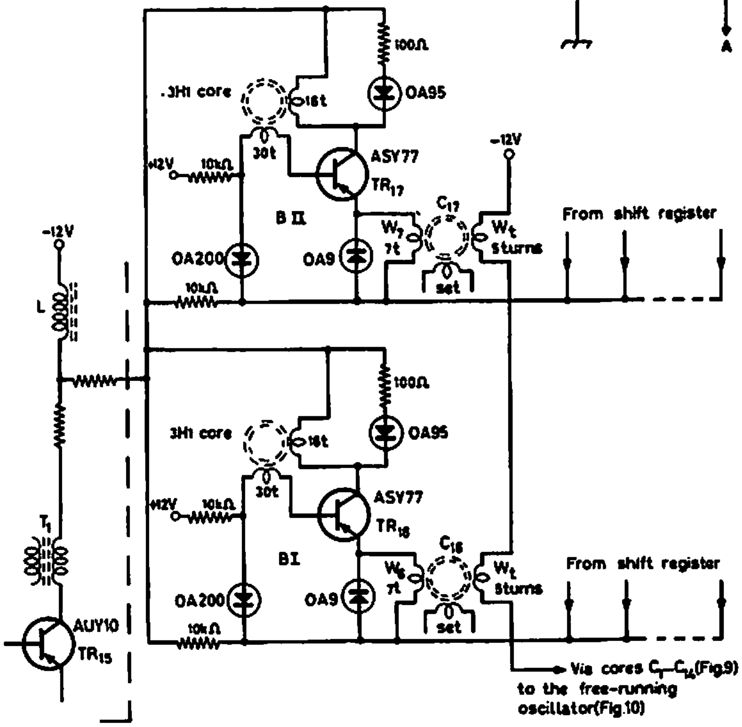
DIODES - 1N4004 TRANSISTORS - 2N3053 SCR's - 2N5060

NOISE REJECTION—Can be used near factory production lines where electrical noise would cause false triggering of conventional shift registers if used to record data on components passed or rejected by automatic testing machine. For 60-Hz line, maximum shift rate is 120-Hz power-supply ripple frequency. Higher shift rate can be obtained with higher line frequency if 0.05-μF scr coupling capacitors are reduced in value.—J. G. Silverman, SCR Shift Register Can Take a Lot of Noise, *Electronics*, June 23, 1969, p 104–105.

REGENERATIVE-SWITCH REGISTER—Each shift register stage may be made regenerative by connecting points A and A'. Circuit can readily be adapted for other output current levels than 40-mA value obtained with 12 V for E1 and 9 V for E2. Values in parentheses will give output level of 3 A with 27 V for E1 and 24 V for E2. With regenerative connection, may be used as ring counter. Can have any number of stages.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 530.

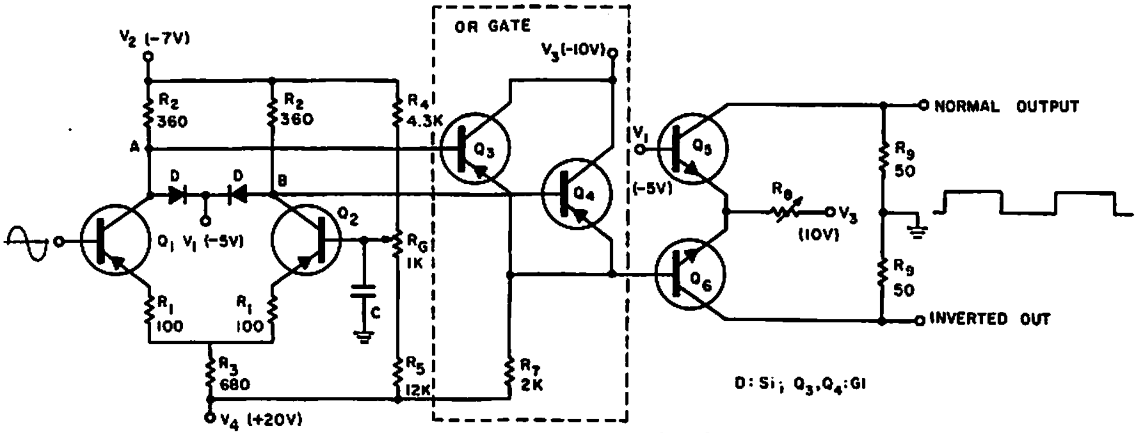


E_1
E_2
SWITCHING TRANSISTOR
TRIG
R_1
R_2
R_3
R_4
R_5
C_1
C2
C_3
TYPE 2N1302
REGISTER No. 1
REGISTER No. 2
REGISTER No. N
TYPE 2N404 (2N2869/ 2N301)
TYPE 2N1302
CR_1
C_4
R_6
R_7
R_8
CR_2
C_5
R_9
R_{10}
R_N
CR_N
R_N'
C_N
R_N''
I_1
I_2
I_N
A
A'
OUTPUT A
OUTPUT B
OUTPUT N



-12V
L
T_1
AUY10
TR_{15}
3H1 core
18t
30t
100Ω
OA95
+12V
10kΩ
ASY77
TR_{17}
B II
OA200
OA9
10kΩ
C_{17}
W_7
7t
W_t
5turns
set
-12V
From shift register
3H1 core
18t
30t
100Ω
OA95
+12V
10kΩ
ASY77
TR_{16}
B I
OA200
OA9
10kΩ
C_{16}
W_6
7t
W_t
5turns
set
From shift register
Via cores C_1–C_{14}(Fig.9) to the free-running oscillator(Fig.10)

MAGNETIC-CORE SHIFT REGISTER—Used for storing information in desk calculators. Contents of magnetic cores are shifted sequentially by means of coincidence of two currents. Requires only one core per bit. Operates in low-speed region, involving add or subtract time of about 10 ms and multiply or divide time of 100 ms. Blocking oscillators TR16 and TR17 serve as switches triggered by pulses from shift register.—J. P. Vlam, A Coincident-Current Magnetic-Core Shift Register, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 825, 1965.

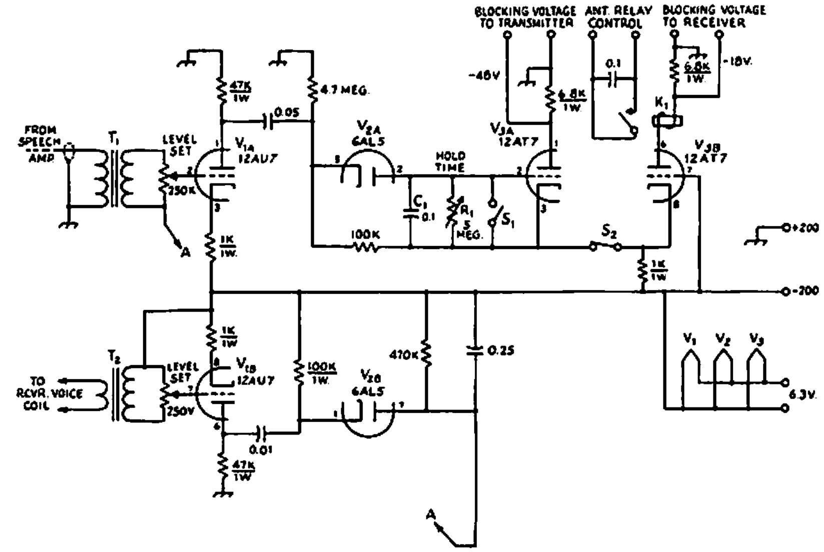


V_2 (-7V)
R_2 360
R_2 360
R_4 4.3K
A
B
D
D
Q_1
V_1 (-5V)
Q_2
R_{G1} 1K
C
R_1 100
R_1 100
R_3 680
V_4 (+20V)
R_5 12K
OR GATE
V_3(-10V)
Q_3
Q_4
R_7 2K
V_1
(-5V)
Q_5
Q_6
R_8
V_3 (10V)
R_9 50
R_9 50
NORMAL OUTPUT
INVERTED OUT
D: Si; Q_3,Q_4:Ge

SHIFT REGISTER TESTER—Square-wave generator provides two separate waveforms, one representing information to be stored, and the other representing writing pulses, for testing register at its maximum clock rate. Transistors can be 2N797 for npn and 2N976 for pnp.—P. Maestrini, Generator Tests Register At Maximum Clock Rates, *Electronic Design*, Oct. 12, 1964, p 74–75.

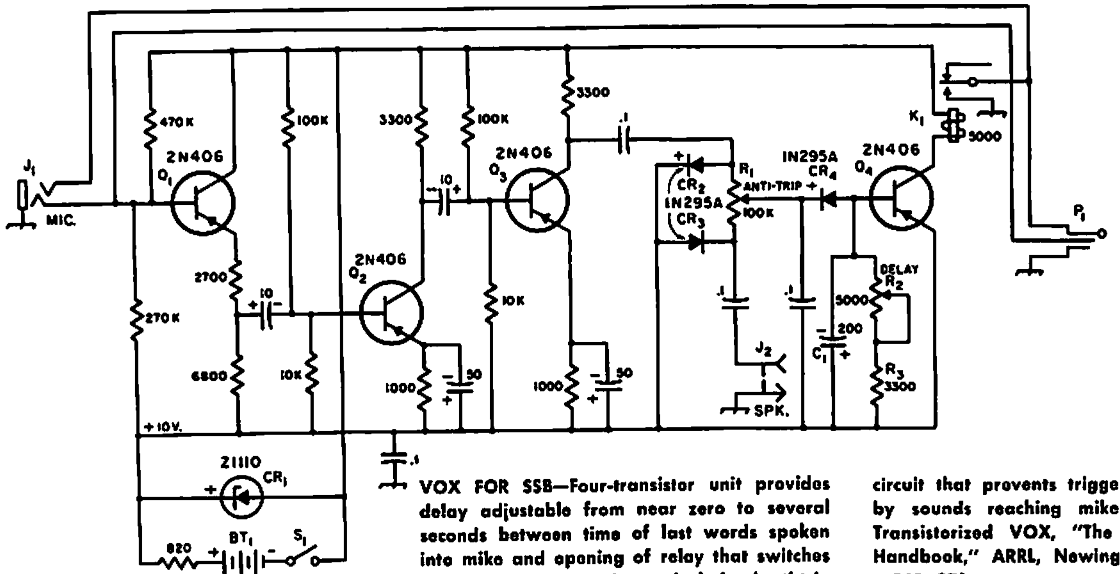
CHAPTER 78

Single-Sideband Circuits



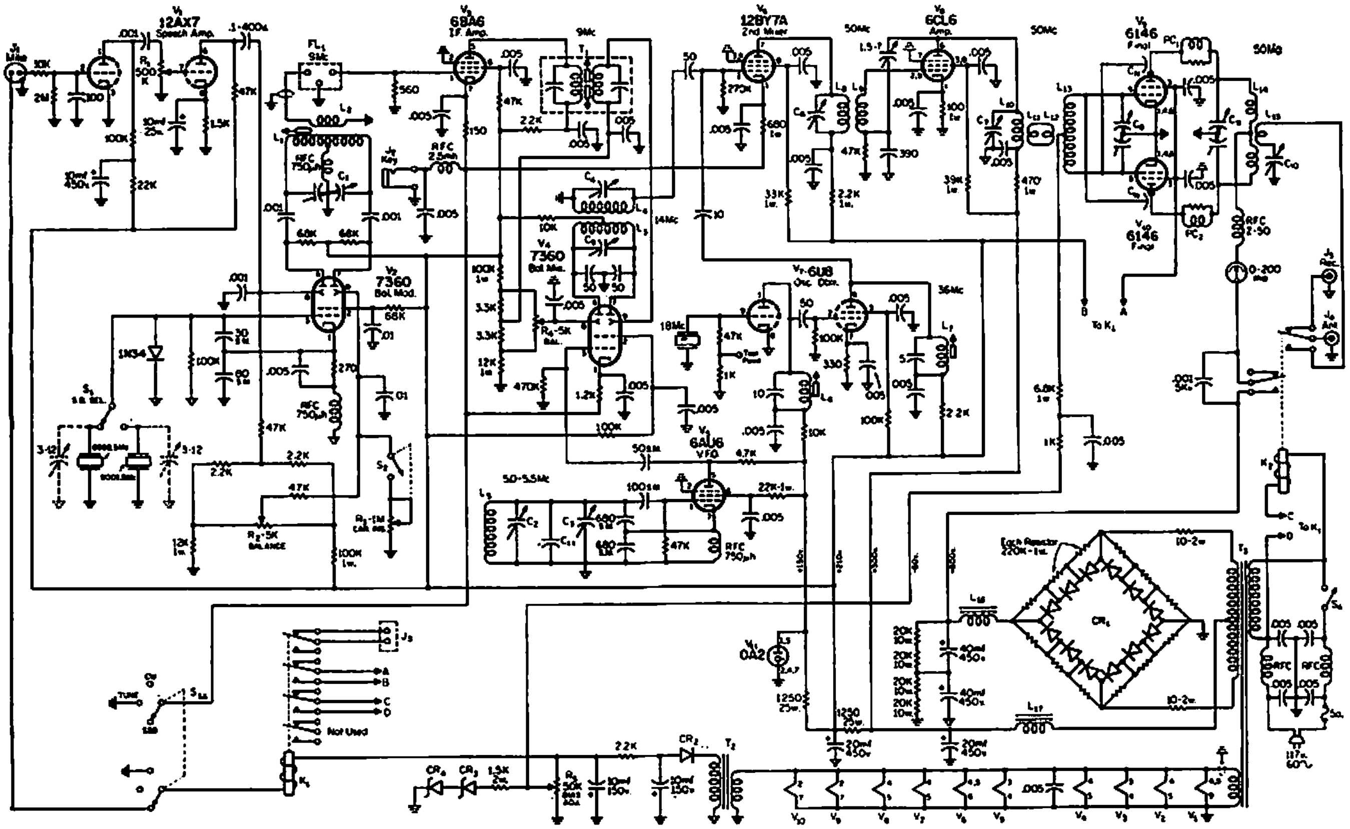
BLOCKING VOLTAGE TO TRANSMITTER
ANT. RELAY CONTROL
BLOCKING VOLTAGE TO RECEIVER
47K 1W
4.7 MEG.
0.05
-48V
6.8K 1W
0.1
6.8K 1W
-18V.
K_1
FROM SPEECH AMP
T_1
LEVEL SET
250K
V_{1A} 12AU7
V_{2A} 6AL5
HOLD TIME
V_{3A} 12AT7
V_{3B} 12AT7
C_1 0.1
R_1 5 MEG.
S_1
S_2
100K
1K 1W
A
+200
-200
1K 1W
T_2
TO RCVR. VOICE COIL
LEVEL SET
250V
V_{1B} 12AU7
100K 1W
V_{2B} 6AL5
470K
0.25
V_1 V_2 V_3
6.3V.
0.01
47K 1W
A

VOICE-CONTROLLED BREAK-IN—Provides VOX operation along with positive anti-trip for ssb receiver. Receiver audio voltage, taken from voice coil, is applied to circuit through T2 which may be almost any low-power tube to voice-coil transformer. Interstage transformer T1 is not critical. Book gives construction and adjustment details.—L. O. Leigh, Universal Voice-Control Circuit, "Single Sideband for the Radio Amateur," ARRL, Newington, Conn., 1965, p 231–232.

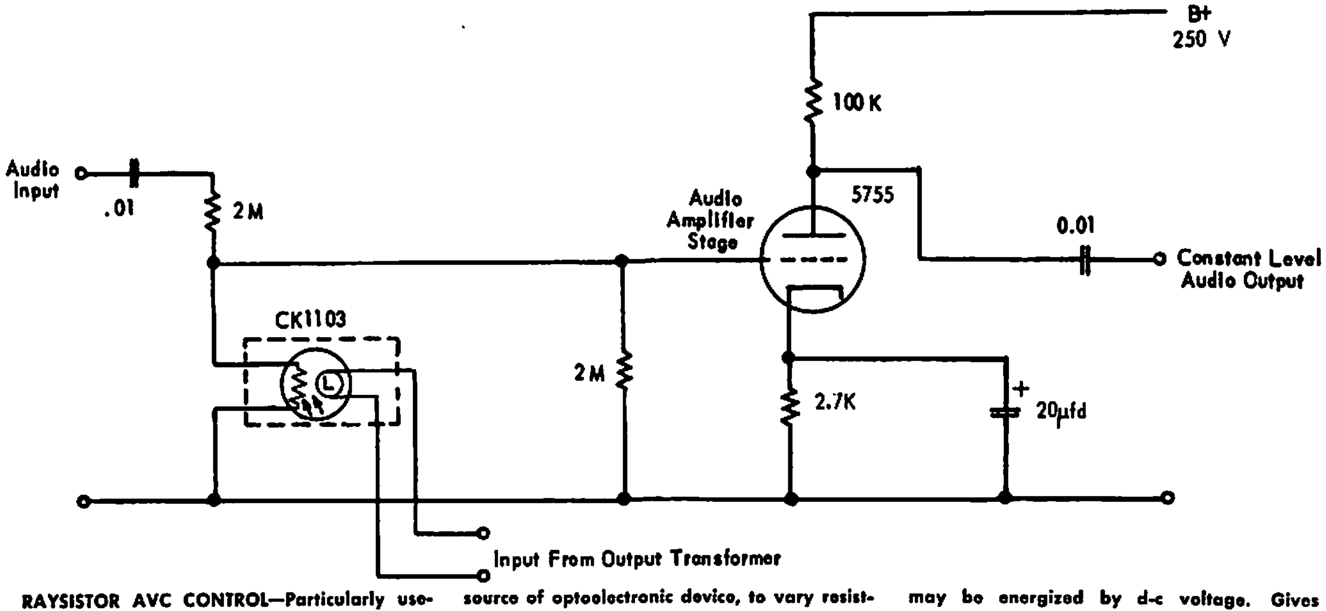


J_1
MIC.
470K
2N406
Q_1
100K
3300
100K
2N406
Q_3
3300
.1
K_1
5000
IN295A
CR_4
2N406
Q_4
CR_2
R_1
ANTI-TRIP
IN295A
CR_3
100K
10
2700
10
2N406
Q_2
10K
270K
6800
10K
1000
50
1000
50
.1
.1
J_2
SPK.
DELAY
R_2
5000
200
C_1
R_3
3300
P_1
+10V.
.1
Z1110
CR_1
820
BT_1
S_1
15V.

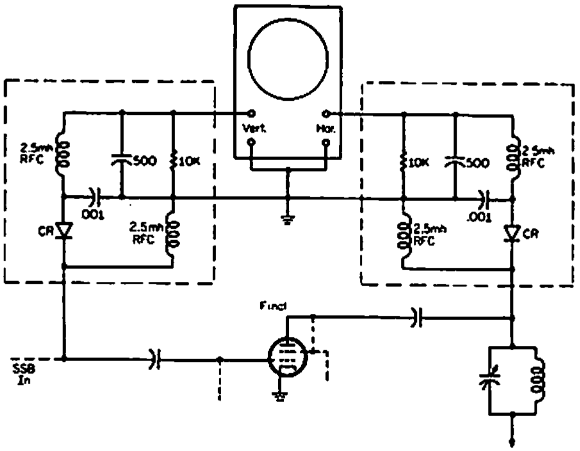
VOX FOR SSB—Four-transistor unit provides delay adjustable from near zero to several seconds between time of last words spoken into mike and opening of relay that switches over to ssb transmitter. Includes 'anti-trip circuit that prevents triggering of VOX unit by sounds reaching mike from speaker.—Transistorized VOX, "The Radio Amateur's Handbook," ARRL, Newington, Conn., 1969, p 269–271.


V1 12AX7 Speech Amp.
V3 6BA6 I.F. Amp.
V5 12BY7A 2nd Mixer
V6 6CL6 Amp.
V9 6146 Final
V10 6146 Final
V2 7360 Bal. Mod.
V4 7360 Bal. Mix.
V7 6U8 Osc. Obr.
V8 6AU6 VFO
V11 0A2
FL1 9Mc
9Mc
50Mc
50Mc
14Mc
18Mc
36Mc
50-5.5Mc
1N34
S1 S.B. Sel.
R2-5K BALANCE
R3-1M Car. Ins.
R4-5K Bal.
RFC 2.5mh
RFC 750μh
0-200 ma
To K1
Each Resistor 220K-1w.
CR1
T1
T2
T3
K1
K2
S2
S3a
S3b
Tune
SSB
CW
Not Used
J1 Mike
J2 Key
J3
J4 Ant.
J5 Rec.
117v. 60~

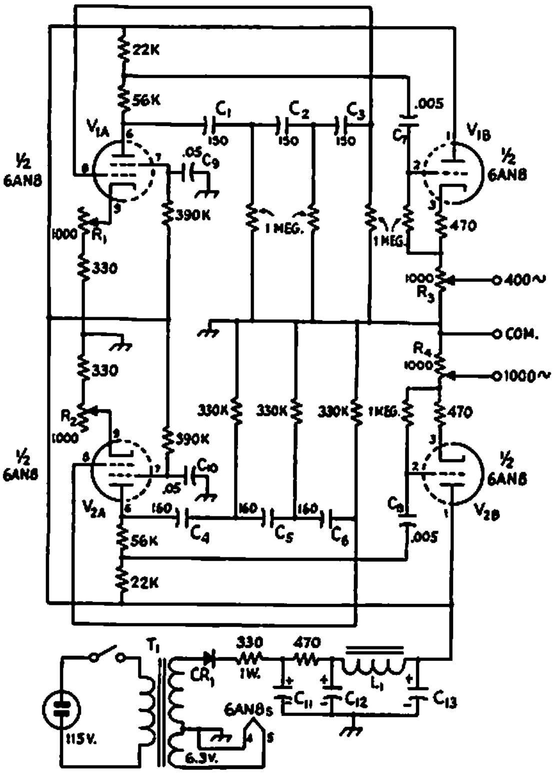
6-METER SSB TRANSMITTER—Complete self-contained transmitter is designed to produce only 50-MHz (6-meter) ssb signal, eliminating need for band-changing switches. Uses push-to-talk switch on mike. Article gives complete circuit description and construction details.—C. Johnson, A Six Meter S. S. B. Transmitter, CQ, May 1965, p 26–31 and 104.


B+
250 V
100 K
Audio Input
.01
2 M
CK1103
2 M
Audio Amplifier Stage
5755
2.7K
20μfd
0.01
Constant Level Audio Output
Input From Output Transformer

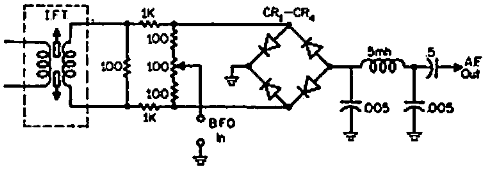
RAYSISTOR AVC CONTROL—Particularly useful in ssb suppressed-carrier receivers where normal avc will not operate because there is no carrier when there is no modulation. Audio output of receiver is fed into light source of optoelectronic device, to vary resistance of photocell used in place of normal volume control. Has fast ON action (10 ms) and slow OFF action (800 ms), which is ideal for ssb receiver. For remote control, lamp may be energized by d-c voltage. Gives greater than 60 dB control range, for photocell resistance change from 200 ohms to 2 meg.—Raysistor Optoelectronic Devices, Raytheon, Quincy, Mass., 1967, p 10–11.


Vert.
Hor.
2.5mh RFC
500
10K
.001
CR
2.5mh RFC
Final
SSB In

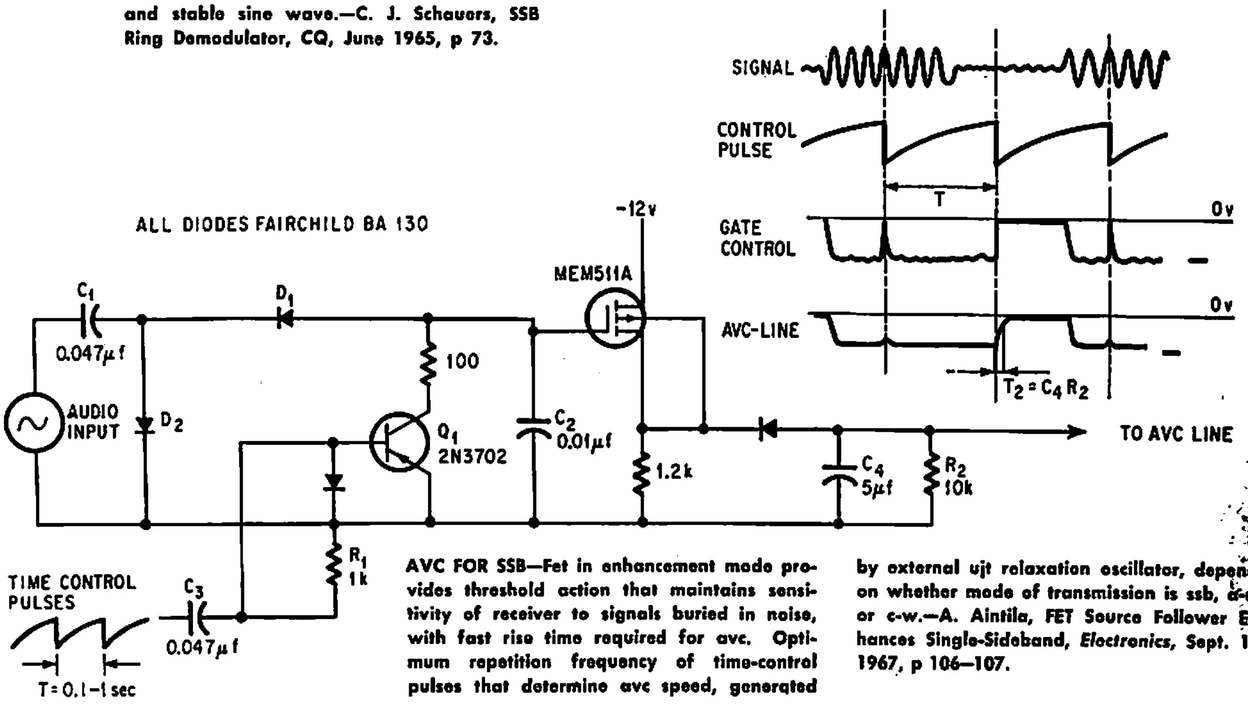
MONITOR—Two envelope detectors shielded from each other permit monitoring of ssb voice signal or two-tone test signal on cro. Diodes are matched RCA 1N445B. Diagonal straight line on screen for voice modulation means no distortion. Input to horizontal terminal of cro may be taken from any linear stage preceding final amplifier.—"Electronic Circuits Handbook," Vol. II, Cowan Pub. Corp., Port Washington, N.Y., 1966, p 52.


22K
56K
V_{1A}
½ 6AN8
C_1 150
C_2 150
C_3 150
.005
C_7
V_{1B}
½ 6AN8
.05 C_9
390K
1000 R_1
330
1 MEG.
1 MEG.
470
1000 R_3
400~
COM.
R_4 1000
1000~
330
R_2 1000
½ 6AN8
V_{2A}
390K
C_{10} .05
330K
330K
330K
1 MEG.
470
160 C_4
160 C_5
160 C_6
C_8 .005
½ 6AN8
V_{2B}
56K
22K
T_1
CR_1
330 1W.
470
L_1
C_{11}
C_{12}
C_{13}
115V.
6AN8s 4 5
6.3V.

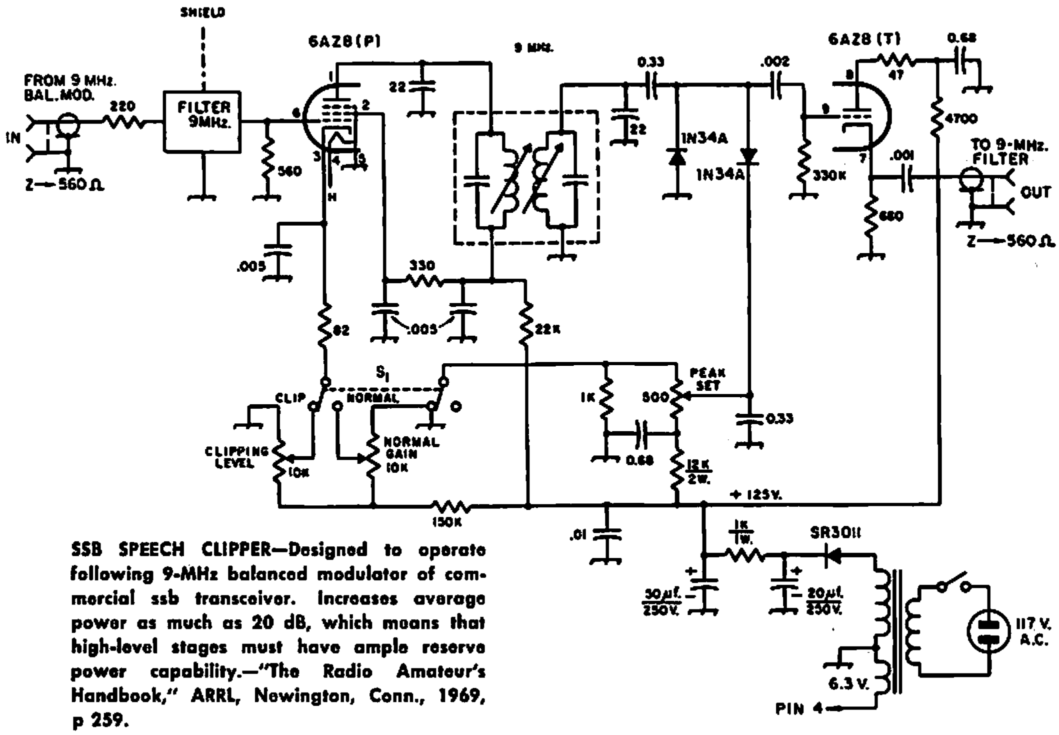
TWO-TONE AUDIO—Provides choice of two different audio frequencies in range of 250 to 2,000 Hz with good waveform, as required for ssb transmitter testing. CR1 is 75-mA selenium rectifier and L1 is 5 H at 50 mA. C11 and C12 are 120 μF; C13 is 40 μF.—R. F. Tschannen, Two-Tone Test Generator, "Single Sideband for the Radio Amateur," ARRL, Newington, Conn., 1965, p 204–206.


I.F.T.
100
1K
100
100
100
1K
CR_1–CR_4
5mh
5
AF Out
.005
.005
BFO In

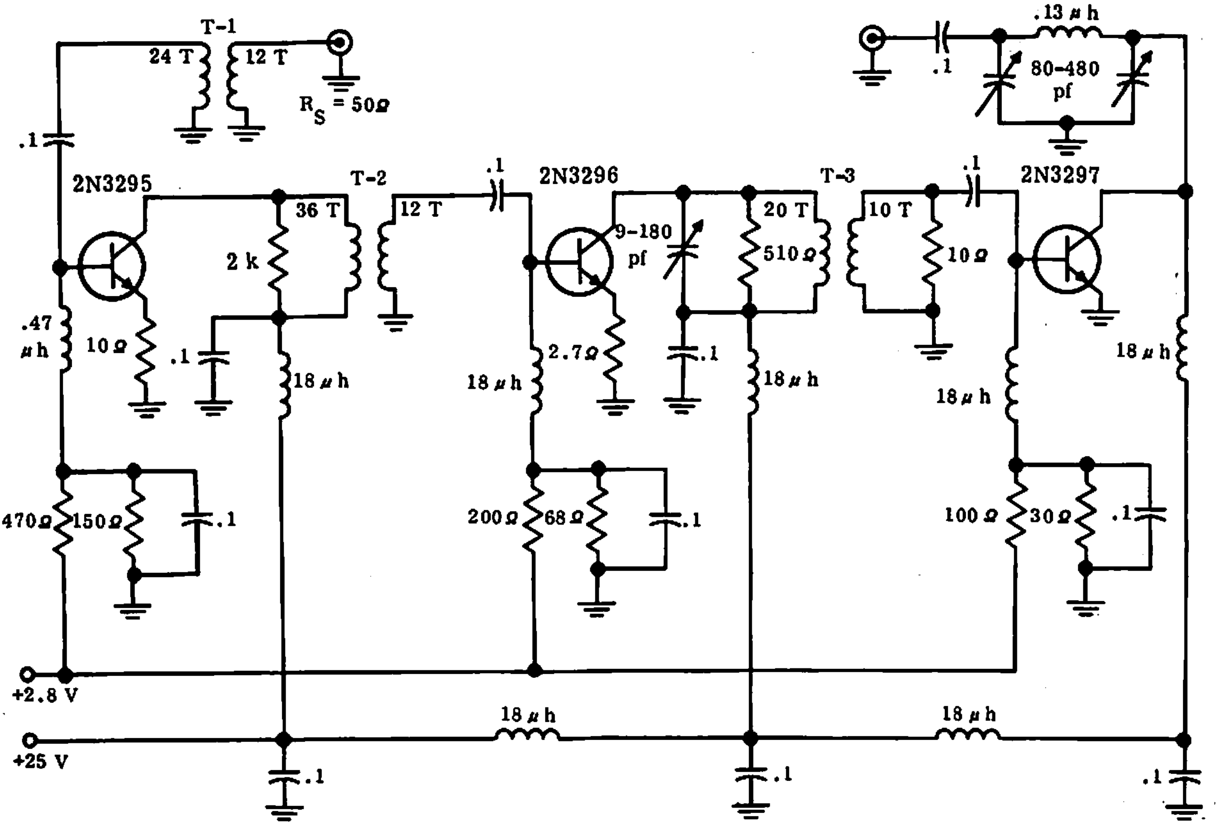
SSB RING DEMODULATOR—Diodes can be 1N78B or any other having low front-back resistance. Performance is excellent if bfo signal injected through i-f transformer is clean and stable sine wave.—C. J. Schauers, SSB Ring Demodulator, CQ, June 1965, p 73.


SIGNAL
CONTROL PULSE
T
GATE CONTROL
0v
AVC-LINE
0v
$T_2 = C_4 R_2$
ALL DIODES FAIRCHILD BA 130
-12v
MEM511A
C_1
0.047μf
D_1
100
AUDIO INPUT
D_2
Q_1 2N3702
C_2 0.01μf
1.2k
C_4 5μf
R_2 10k
TO AVC LINE
R_1 1k
TIME CONTROL PULSES
C_3 0.047μf
T = 0.1–1 sec

AVC FOR SSB—Fet in enhancement mode provides threshold action that maintains sensitivity of receiver to signals buried in noise, with fast rise time required for avc. Optimum repetition frequency of time-control pulses that determine avc speed, generated by external ujt relaxation oscillator, depends on whether mode of transmission is ssb, a-m, or c-w.—A. Aintila, FET Source Follower Enhances Single-Sideband, *Electronics*, Sept. 18, 1967, p 106–107.


SHIELD
FROM 9 MHz. BAL. MOD.
IN
Z—560Ω
220
FILTER 9MHz.
560
6AZ8(P)
22
9 MHz.
.005
82
330
.005
22K
0.33
22
1N34A
1N34A
.002
330K
6AZ8(T)
47
0.68
4700
.001
680
TO 9-MHz. FILTER
OUT
Z—560Ω
S1
CLIP
NORMAL
CLIPPING LEVEL
10K
NORMAL GAIN 10K
150K
1K
500
PEAK SET
0.68
12K 2W.
0.33
+125V.
.01
1K 1W.
SR3011
30µf. 250V.
20µf. 250V.
117V. A.C.
6.3V.
PIN 4

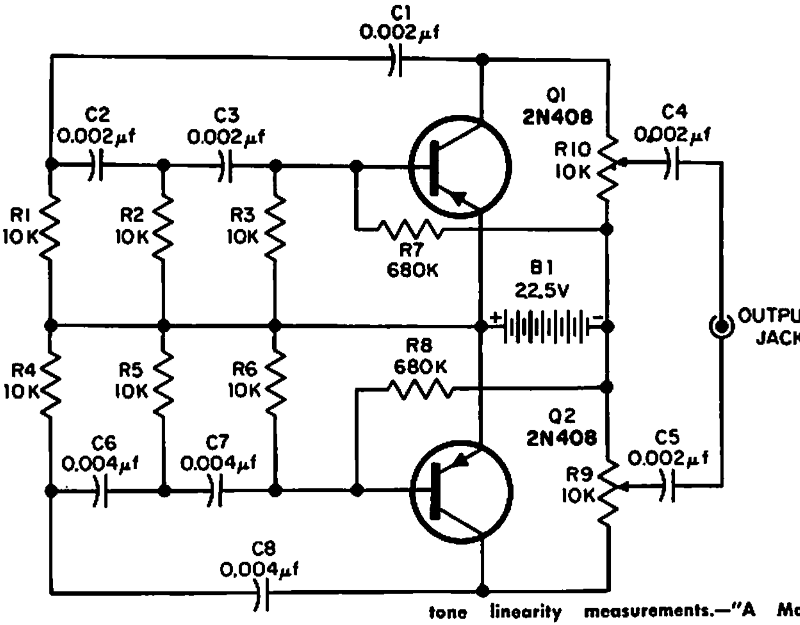
SSB SPEECH CLIPPER—Designed to operate following 9-MHz balanced modulator of commercial ssb transceiver. Increases average power as much as 20 dB, which means that high-level stages must have ample reserve power capability.—"The Radio Amateur's Handbook," ARRL, Newington, Conn., 1969, p 259.


T-1
24 T
12 T
RS = 50Ω
.1
2N3295
.47 µh
10Ω
.1
2 k
36 T
18µh
T-2
12 T
.1
2N3296
9-180 pf
20 T
510Ω
2.7Ω
18µh
.1
18µh
T-3
10 T
10Ω
.1
2N3297
18µh
18µh
.13µh
80-480 pf
.1
470Ω
150Ω
.1
200Ω
68Ω
.1
100Ω
30Ω
.1
+2.8 V
+25 V
18µh
18µh
.1
.1
.1

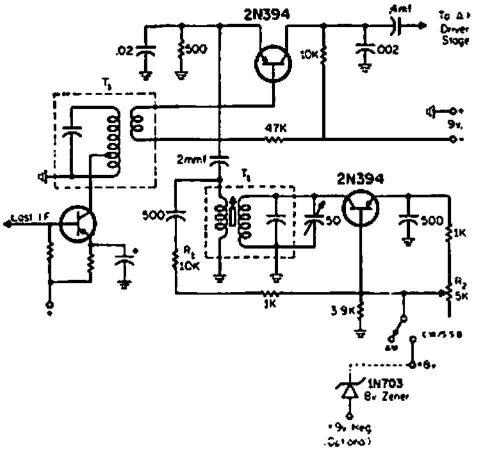
T_1, T_2 #32 Bifilar Wound Toroid on Micrometals T-20-6 Core

T_3 #22 Bifilar Wound Toroid on Micrometals T-44-10

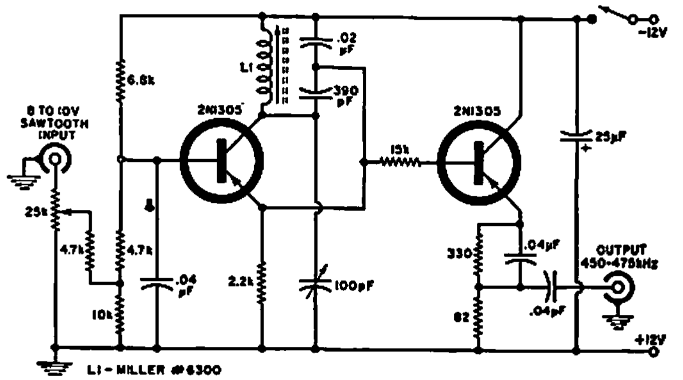
10-W 30-MHZ SSB—Requires only three transistors to give overall power gain of 35 dB for ssb operation. On two-tone test, all odd-order distortion products are more than 30 dB down from reference level. Unbypassed resistors in emitters of first two stages provide current feedback for stability.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-3-2.


C1
0.002μf
C2
0.002μf
C3
0.002μf
Q1
2N408
R10
10K
C4
0.002μf
R1
10K
R2
10K
R3
10K
R7
680K
B1
22.5V
OUTPUT
JACK
R4
10K
R5
10K
R6
10K
R8
680K
Q2
2N408
C5
0.002μf
C6
0.004μf
C7
0.004μf
R9
10K
C8
0.004μf

TWO-TONE SSB TEST OSCILLATOR—Output can be fed into ssb generator to make two-tone linearity measurements.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 11.

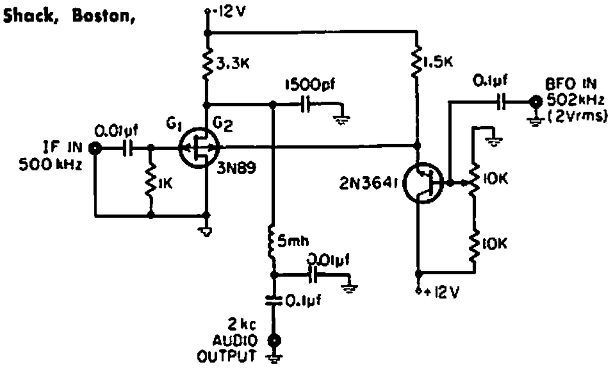

2N394
.02
500
10K
.002
To A-F
Driver
Stage
T1
47K
9v.
2mmf
T1
2N394
Last IF
500
R1
10K
50
500
1K
R2
5K
1K
3.9K
CW/SSB
AM
+B
1N703
8v Zener
+9v Reg

PRODUCT DETECTOR—Circuit works equally well on c-w and ssb. By switching out bfo, works on a-m as well.—C. J. Schauers, Transistorized Product Detector, CQ, Nov. 1964, p 113.

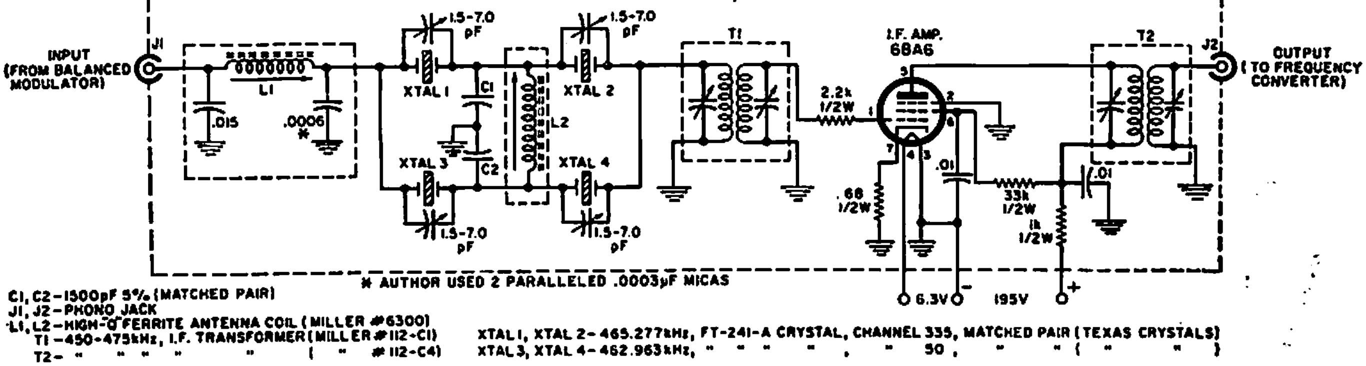

-12V
.02
μF
6.8k
L1
390
pF
8 TO 10V
SAWTOOTH
INPUT
2N1305
2N1305
15k
25μF
25k
4.7k
4.7k
.04
μF
2.2k
100pF
330
.04μF
OUTPUT
450-475kHz
10k
82
.04μF
+12V

L1-MILLER #6300

TEST SWEEP FOR SSB FILTER—Gives sweep range of about 25 kHz for sawtooth input of about 8 V peak from any scope. Designed for checking passband characteristics of crystal sideband filter between 460 and 466 kHz.—R. A. Genaille, Ferrite Coil and Crystal Sideband Filter, *Electronics World*, June 1967, p 46–47 and 80–81.


-12V
3.3K
1.5K
1500pf
0.1μf
BFO IN
502kHz
(2Vrms)
IF IN
500 kHz
0.01μf
G1
G2
3N89
1K
2N3641
10K
10K
5mh
0.01μf
0.1μf
+12V
2 kc
AUDIO
OUTPUT

FET TETRODE PRODUCT DETECTOR—When 500-kHz i-f signal is fed into one gate of fet and beat-frequency oscillator voltage into other oscillator, output current is proportional to product of the two voltages over wide dynamic range. 2N3641 transistor isolates bfo from fet and provides proper bias for fet. Can be used in ssb receivers.—H. Olson, Product Detector Uses FET Tetrode, *EEE*, Sept. 1966, p 146.


SIDEBAND FILTER 464.5kHz
INPUT
(FROM BALANCED
MODULATOR)
J1
L1
.015
.0006
*
1.5-7.0
pF
XTAL 1
C1
L2
1.5-7.0
pF
XTAL 2
XTAL 3
C2
XTAL 4
1.5-7.0
pF
1.5-7.0
pF
T1
2.2k
1/2W
I.F. AMP.
6BA6
.68
1/2W
.01
33k
1/2W
1k
1/2W
.01
T2
J2
OUTPUT
(TO FREQUENCY
CONVERTER)
6.3V
195V

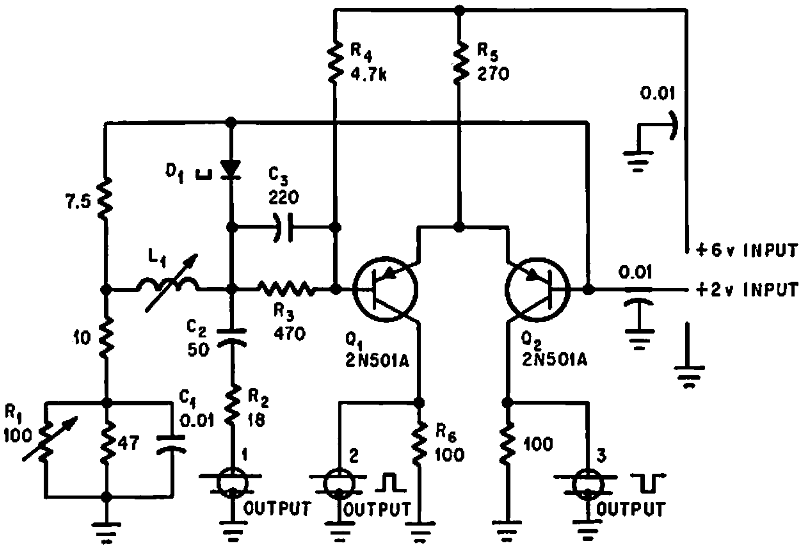
* AUTHOR USED 2 PARALLELED .0003μF MICAS

C1, C2–1500pF 5% (MATCHED PAIR)
J1, J2–PHONO JACK
L1, L2–HIGH-Q FERRITE ANTENNA COIL (MILLER #6300)
T1–450-475kHz, I.F. TRANSFORMER (MILLER #112-C1)
T2– " " " " " (" #112-C4)

XTAL 1, XTAL 2–465.277kHz, FT-241-A CRYSTAL, CHANNEL 335, MATCHED PAIR (TEXAS CRYSTALS)
XTAL 3, XTAL 4–462.963kHz, " " " " , " 50 , " " (" ")

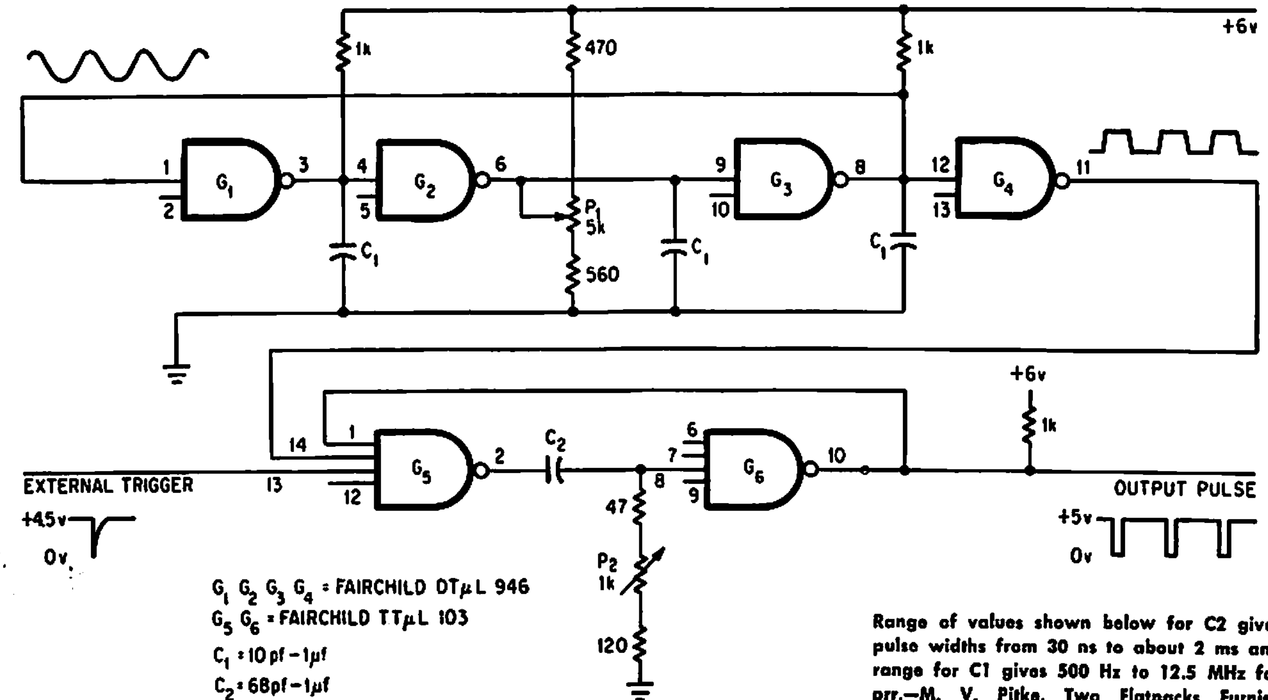
SSB CRYSTAL FILTER—Uses four easily obtainable quartz crystals uniquely combined with ordinary ferrite antenna coils to select one sideband. Filter can serve as starting point for building ssb transmitter. Frequency separation of about 2.3 kHz between pairs of crystals gives bandwidth of about 2.9 kHz for reasonable voice quality. Consists of two cascaded half-lattice crystal-filter sections arranged for low-impedance input and high-impedance output to i-f stage. Article gives construction and alignment details.—R. A. Genaille, Ferrite Coil and Crystal Sideband Filter, *Electronics World*, June 1967, p 46–47 and 80–81.

CHAPTER 79
Square-Wave Generator Circuits



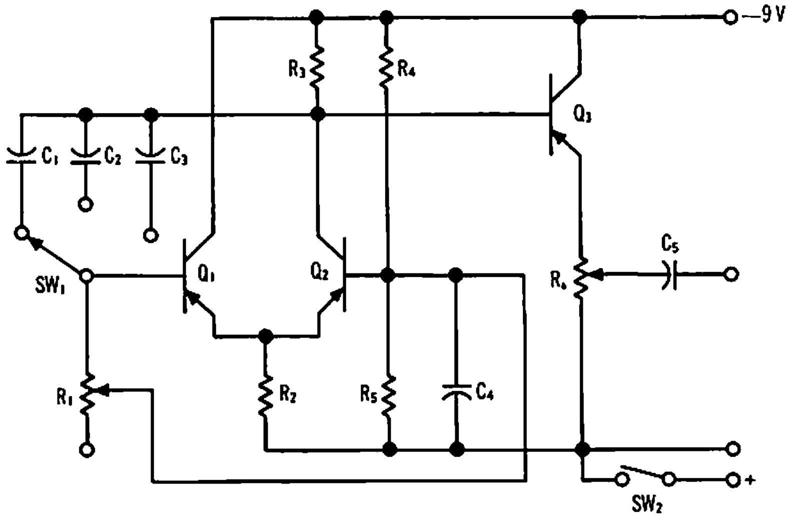
R_4 4.7k
R_5 270
0.01
D_1
C_3 220
7.5
L_1
R_3 470
Q_1 2N501A
Q_2 2N501A
0.01
+6v INPUT
+2v INPUT
10
C_2 50
R_1 100
47
C_4 0.01
R_2 18
1
2
R_6 100
100
3
OUTPUT
OUTPUT
OUTPUT

FLIP-FLOP TESTER—Provides positive or negative square-wave pulses at repetition rates up to 50 MHz for testing fast flip-flops, using gallium arsenide tunnel diode D1 (similar to RCA 40062) as relaxation oscillator. L1 controls frequency; at 0.5 μH, prf is 25 MHz. R1 changes ratio of pulse width to repetition period. Output terminal 1 gives positive and negative pulses in sequence, while terminals 2 and 3 give polarities shown. For 2-V supply, output pulse is 1.8 V and output impedance 100 ohms, for feeding into 100-ohm coax.—O. A. Horna, Bipolar Pulse Generator Tests Fast Flip-Flops, *Electronics*, Dec. 12, 1966, p 109.



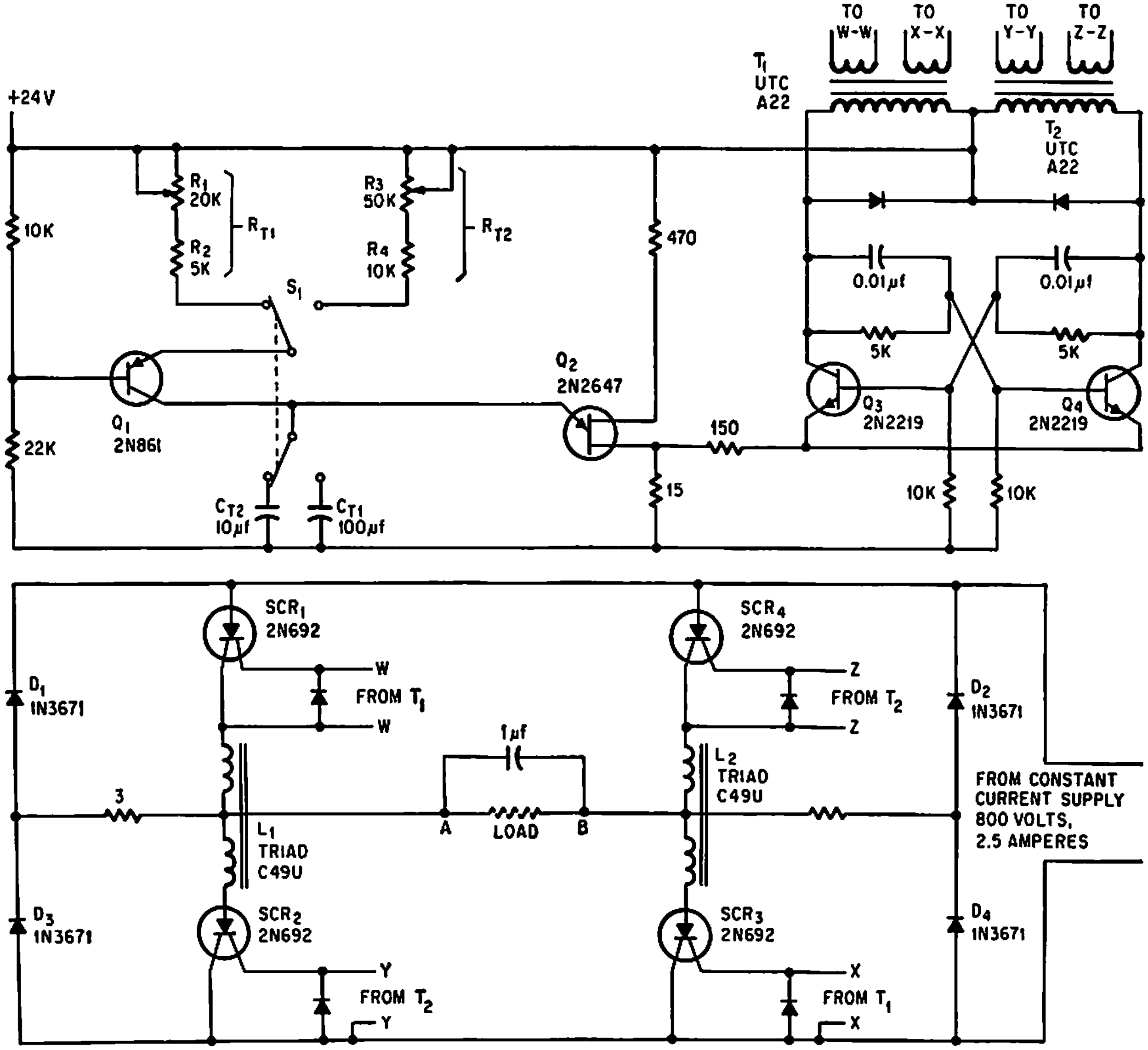
1k
470
1k
+6v
1
2
G_1
3
4
5
G_2
6
P_1 5k
560
C_1
C_1
C_1
9
10
G_3
8
12
13
G_4
11
14
1
G_5
2
13
12
EXTERNAL TRIGGER
+4.5v
0v
C_2
7
6
8
9
G_6
10
47
P_2 1k
120
+6v
1k
OUTPUT PULSE
+5v
0v
G_1 G_2 G_3 G_4 = FAIRCHILD DTμL 946
G_5 G_6 = FAIRCHILD TTμL 103
C_1 = 10 pf – 1 μf
C_2 = 68 pf – 1 μf

VARIABLE WIDTH AND PRR WITH IC'S—Push-pull oscillator G1-G2-G3 establishes pulse repetition rate of monostable mvbr G5-G6. G4 shapes output to desired pulse waveform. Range of values shown below for C2 gives pulse widths from 30 ns to about 2 ms and range for C1 gives 500 Hz to 12.5 MHz for prr.—M. V. Pitke, Two Flatpacks Furnish Pulses for IC Testing, *Electronics*, June 26, 1967, p 107–108.



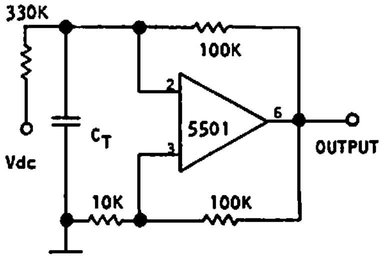
−9V
R3
R4
Q3
C1
C2
C3
SW1
Q1
Q2
C5
R6
R1
R2
R5
C4
+
SW2

7.5—20,000 HZ SQUARE-WAVE—Economical and self-contained unit for general audio testing. Covers a-f spectrum in three ranges. Article gives construction details. Parts values are: R1 25K; R2 1.2K; R3 2.4K; R4–R5 3K; R6 2.5K; C1 1 μF; C2 0.1 μF; C3 0.01 μF; C4 5 μF; C5 0.25 μF; Q1-Q2 HEP253; Q3 HEP254.—"Solid State Projects Manual," 2nd Edition, Motorola, Phoenix, Ariz., 1968, p 27–32.



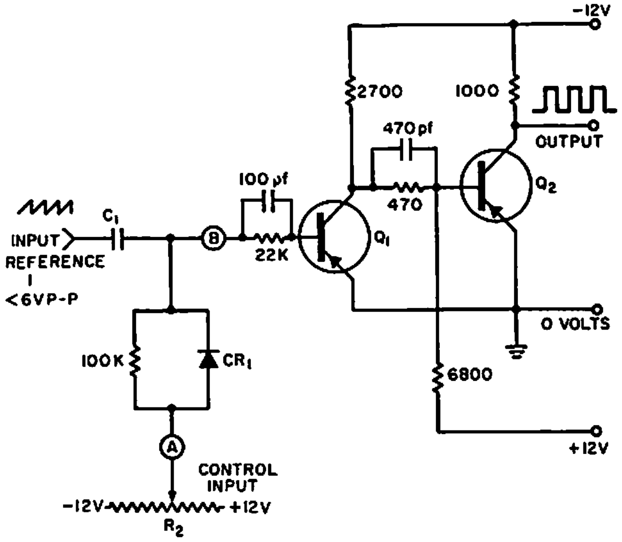
TO W-W
TO X-X
TO Y-Y
TO Z-Z
T1 UTC A22
T2 UTC A22
+24V
10K
22K
R1 20K
R2 5K
RT1
R3 50K
R4 10K
RT2
S1
470
Q1 2N861
Q2 2N2647
CT2 10μf
CT1 100μf
150
15
0.01μf
0.01μf
5K
5K
Q3 2N2219
Q4 2N2219
10K
10K
SCR1 2N692
SCR4 2N692
W
FROM T1
W
Z
FROM T2
Z
D1 1N3671
D2 1N3671
1μf
3
L1 TRIAD C49U
L2 TRIAD C49U
A
LOAD
B
FROM CONSTANT CURRENT SUPPLY 800 VOLTS, 2.5 AMPERES
D3 1N3671
D4 1N3671
SCR2 2N692
SCR3 2N692
Y
FROM T2
Y
X
FROM T1
X

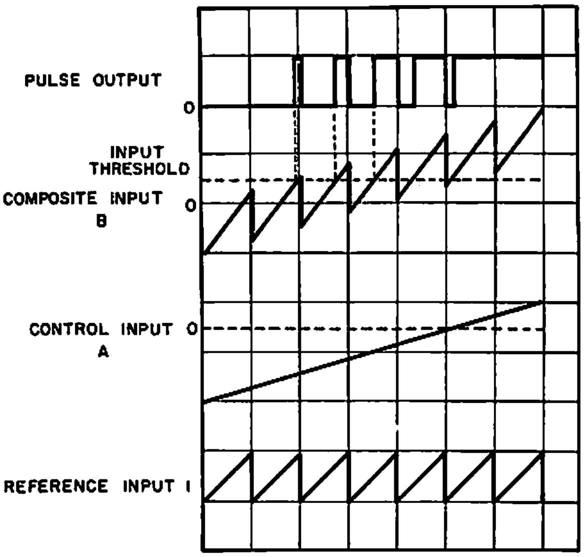
HIGH-POWER SQUARE WAVES—Used for measuring earth conductivity in geophysical applications, for which square waves of 0.1 to 4 Hz are usually required. Frequency can be boosted to 100 Hz by changing timing capacitors, but circuit losses become severe above this value. Uses bridge inverter to provide bipolar square wave, eliminating need for center-tapped constant-current supply. Transformer connections in upper circuit go to scr's in lower circuit.—S. I. Gaytan, Low-Frequency Oscillator Supplies High Pulse Power, *Electronics*, Oct. 17, 1966, p 90–91.


330K
100K
2
6
5501
3
OUTPUT
Vdc
C_T
10K
100K

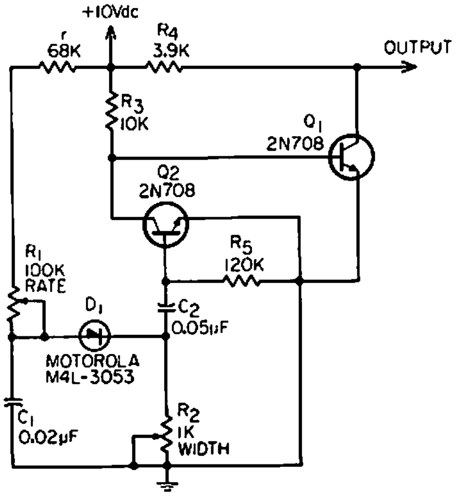
$f_0 = 0.025/C_T$ kHz, C_T in uF

PWM—Analog comparator chip connected as shown functions as flexible square-wave oscillator having good frequency stability, with stable duty cycle and pulse-width modulator capability. Positive feedback causes output to be at either +10 or −10 V when power is applied, charging CT until pin 2 voltage equals pin 3, when 5501 changes state to begin cycle again.—Applying the Model 5501 Monolithic Analog Comparator, Optical Electronics, Tucson, Ariz., No. 10147.


-12V
2700
1000
470pf
OUTPUT
100pf
470
Q_2
INPUT
REFERENCE
I
<6VP-P
C_1
B
22K
Q_1
0 VOLTS
100K
CR_1
6800
+12V
A
CONTROL
INPUT
-12V
+12V
R_2

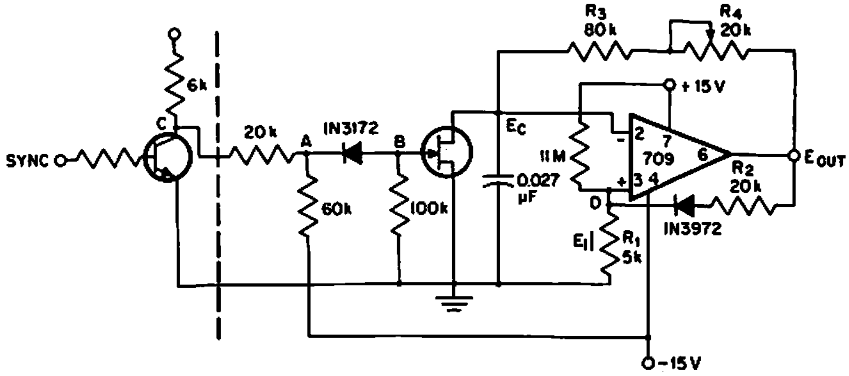


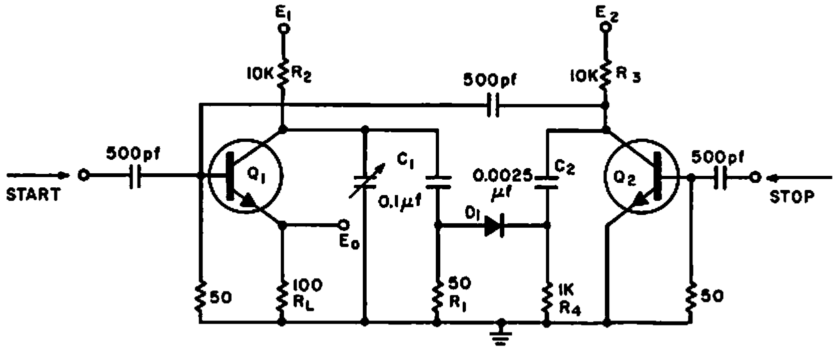
0–100% DUTY CYCLE—Standard clamp circuit using CR1, followed by conventional two-stage d-c amplifier Q1-Q2, gives infinitely adjustable pulse-width generator. Reference and control inputs, added at point B, make Q1 fire and produce output pulse whenever sum of voltages exceeds input threshold of Q1. Input may have any waveform. Transistor types are not critical.—T. Hart, Generator Permits Infinite Pulse Width Variation, *Electronic Design*, June 22, 1964, p 69–71.


+10Vdc
r
68K
R4
3.9K
OUTPUT
R3
10K
Q1
2N708
Q2
2N708
R5
120K
R1
100K
RATE
D1
C2
0.05μF
MOTOROLA
M4L-3053
C1
0.02μF
R2
1K
WIDTH

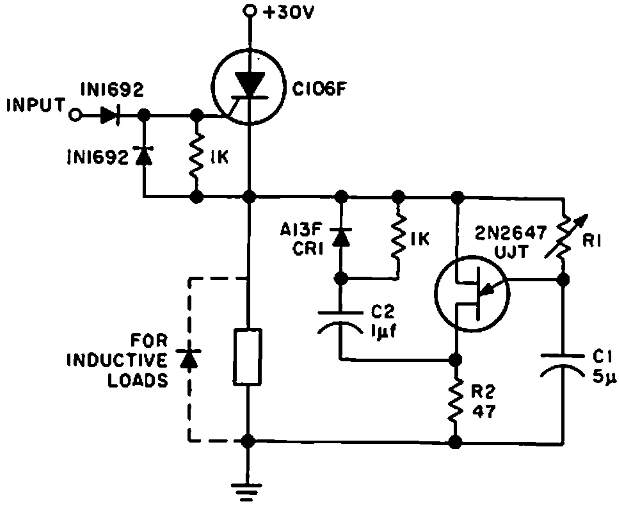
1–5 KHZ ADJUSTABLE-WIDTH—Four-layer diode D1 breaks down at threshold voltage of about 10 V, to give simple relaxation oscillator for generating pulses adjustable in width from 300 ns to 3 μs. Can be packaged in less than 0.5 cu in. Cost of components is about $10. Rise time is about 100 ns, but 2N4137 transistors will bring it below 20 ns.—G. B. Jordan, Pulse Generator with Variable Rate and Width, *EEE*, Feb. 1967, p 145–146.

1-KHZ SYNCHRONIZED TO 60 HZ—Output shifts regularly between positive and negative saturation to give 50% duty cycle at frequency determined by voltage divider and R-C time constant. If output is in positive saturation when sync pulse arrives, it stays positive. If output is in negative saturation, sync pulse makes it switch to positive saturation. To sync at higher frequencies, change opamp to μA702 or μA710. Fet is 2N3792.—M. R. Utenick, FET and IC Make Syncable Oscillator, *EEE*, July 1969, p 105–106.

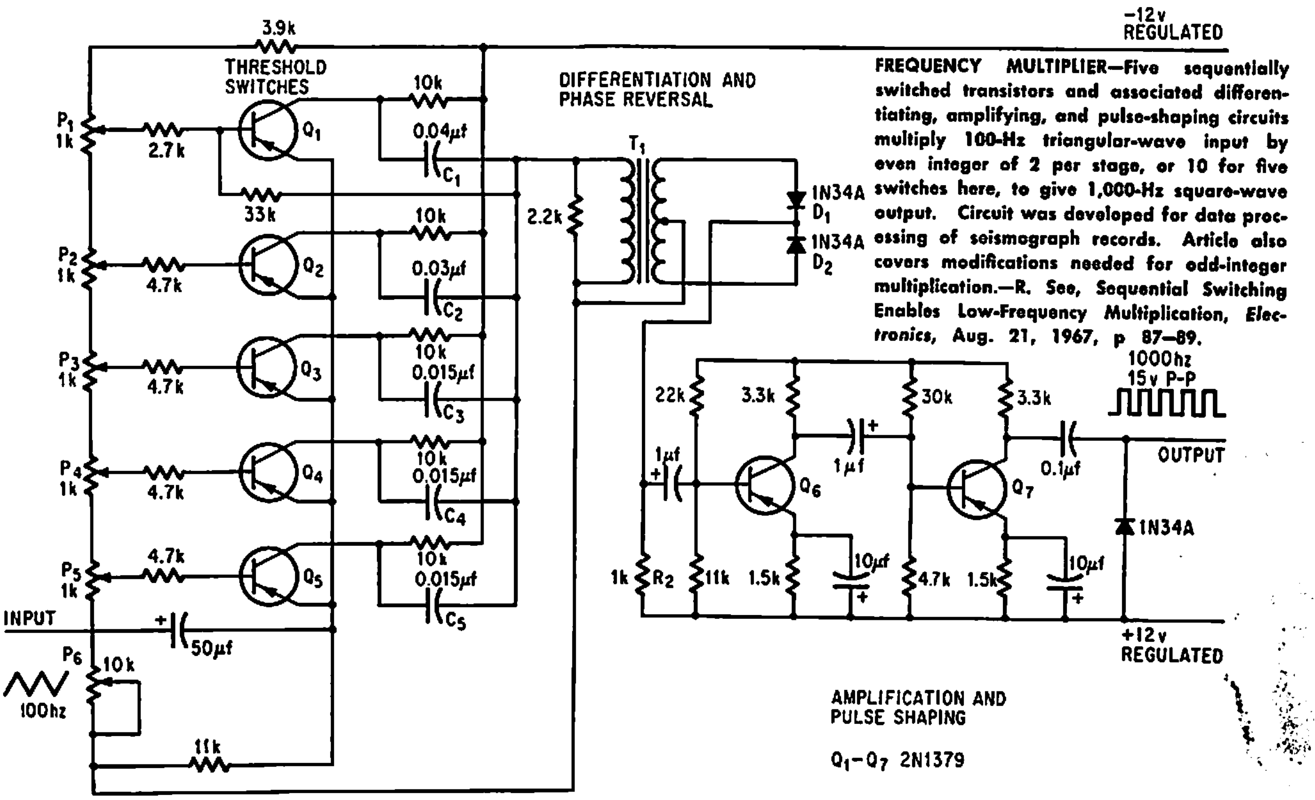

SYNC
6k
C
20k
A
IN3172
B
60k
100k
E_C
0.027
μF
11M
R3
80k
R4
20k
+15V
2
7
709
6
3
4
D
E_{OUT}
R2
20k
IN3972
E_I
R1
5k
-15V


E1
10K
R2
E2
10K
R3
500pf
500pf
START
Q1
C1
0.1μf
0.0025
μf
C2
D1
Q2
500pf
STOP
E0
50
100
RL
50
R1
1K
R4
50

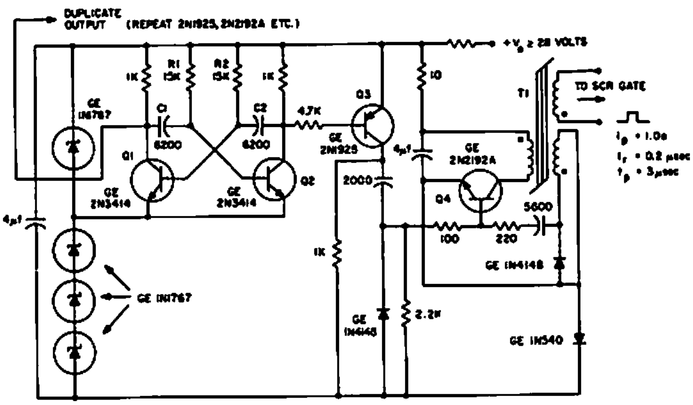
VARIABLE-WIDTH AVALANCHE PULSES—Uses two NS1110 avalanche transistors and two trigger inputs, one for start of rectangular output pulse and other for end of pulse. Pulse width is thus continuously adjustable by changing time interval between triggers, from a few ns to over 1 μs. Rise and fall times are about 2 ns.—B. H. Bell, Avalanche Circuits Are More Versatile Than You Think, *Electronic Design*, June 8, 1964, p 56–63.


+30V
INPUT
IN1692
IN1692
1K
C106F
A13F
CR1
1K
2N2647
UJT
R1
C2
1μf
FOR
INDUCTIVE
LOADS
R2
47
C1
5μf

UJT-SCR ONE-SHOT—Input pulse triggers scr and energizes load. Voltage drop across load energizes ujt timer. When ujt fires after time interval, voltage pulse across R2 turns off scr to give single square-wave output pulse.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 26.

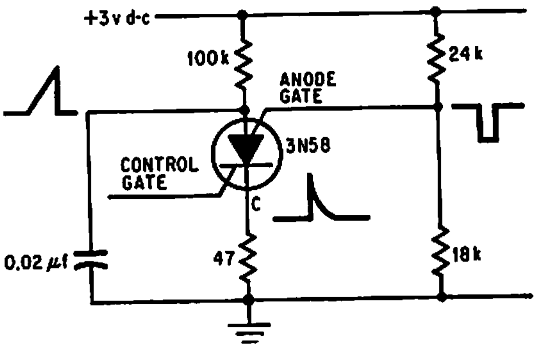

3.9k
THRESHOLD
SWITCHES
-12v
REGULATED
P1
1k
2.7k
Q1
10k
0.04μf
C1
33k
P2
1k
4.7k
Q2
10k
0.03μf
C2
P3
1k
4.7k
Q3
10k
0.015μf
C3
P4
1k
4.7k
Q4
10k
0.015μf
C4
P5
1k
4.7k
Q5
10k
0.015μf
C5
INPUT
50μf
P6
10k
100hz
11k
DIFFERENTIATION AND
PHASE REVERSAL
T1
2.2k
1N34A
D1
1N34A
D2
22k
3.3k
30k
3.3k
1000hz
15v P-P
1μf
1μf
Q6
Q7
0.1μf
OUTPUT
1N34A
1k
R2
11k
1.5k
10μf
4.7k
1.5k
10μf
+12v
REGULATED
AMPLIFICATION AND
PULSE SHAPING
Q1–Q7 2N1379

FREQUENCY MULTIPLIER—Five sequentially switched transistors and associated differentiating, amplifying, and pulse-shaping circuits multiply 100-Hz triangular-wave input by even integer of 2 per stage, or 10 for five switches here, to give 1,000-Hz square-wave output. Circuit was developed for data processing of seismograph records. Article also covers modifications needed for odd-integer multiplication.—R. See, Sequential Switching Enables Low-Frequency Multiplication, *Electronics*, Aug. 21, 1967, p 87–89.

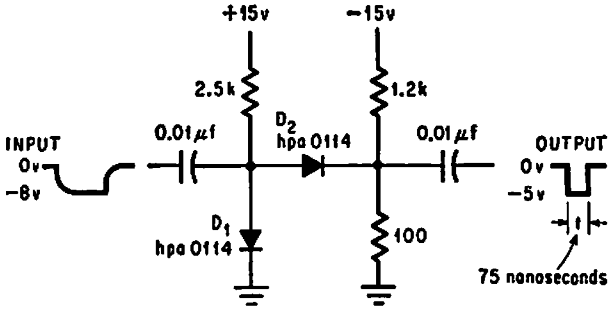

DUPLICATE OUTPUT (REPEAT 2N1925, 2N2192A ETC.)
+V ≥ 28 VOLTS
1K
R1 15K
R2 15K
1K
GE 1N767
C1
6200
C2
6200
4.7K
Q3
GE 2N1925
10
T1
TO SCR GATE
I_p = 1.0a
t_r = 0.2 μsec
t_p = 3μsec
Q1
GE 2N3414
Q2
GE 2N3414
4μf
2000
GE 2N2192A
Q4
5600
100
220
GE 1N4148
4μf
1K
GE 1N767
GE 1N4148
2.2K
GE 1N540

NOTES:
(1) ALL CAPACITANCE VALUES IN pf UNLESS OTHERWISE SHOWN
(2) CHANGE R1, R2, C1 AND C2 TO CHANGE FREQUENCY
(3) T1 IS 76 TURNS (EACH WINDING) OF #32 HF, TRIFILAR WOUND ON INDIANA GENERAL FERRAMIC 05-CF110 CORE

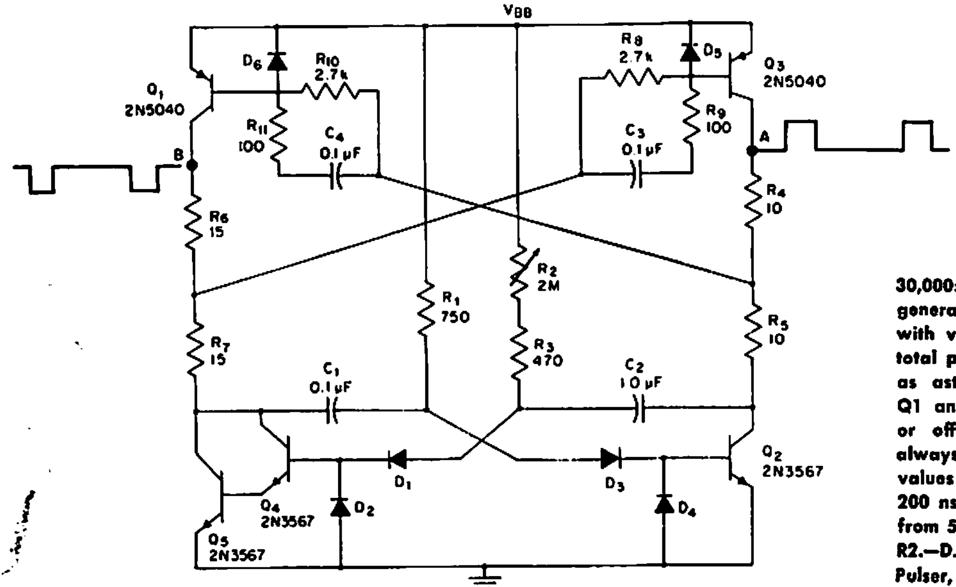
MVBR-DRIVEN BLOCKING OSCILLATOR—Produces rectangular gate pulses up to 1 A, for triggering thyristors in inverters, pulse modulators, and other circuits requiring fast turn-on.—"SCR Manual," 4th Edition, General Electric, 1967, p 85.


+3v d-c
100k
24k
ANODE GATE
3N58
CONTROL GATE
C
0.02μf
47
18k

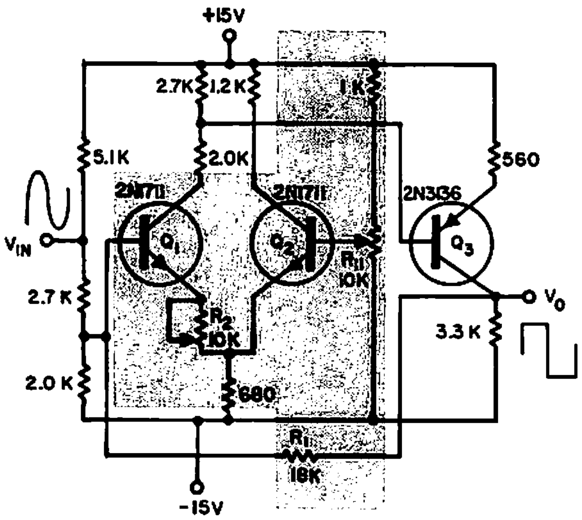
SCS RELAXATION OSCILLATOR—Consumes less power than ujt, operates at levels as low as 2 V, and produces more powerful output pulse with sharpened leading and falling edges. Frequency is 1 kHz and rise time about 60 ns.—J. S. Hayhurst, SCS Outperforms UJT in Relaxation Oscillator, *Electronics*, Sept. 16, 1968, p 100.


+15v
−15v
2.5k
1.2k
D_2
hpa 0114
INPUT
0v
−8v
0.01μf
0.01μf
OUTPUT
0v
−5v
D_1
hpa 0114
100
75 nanoseconds

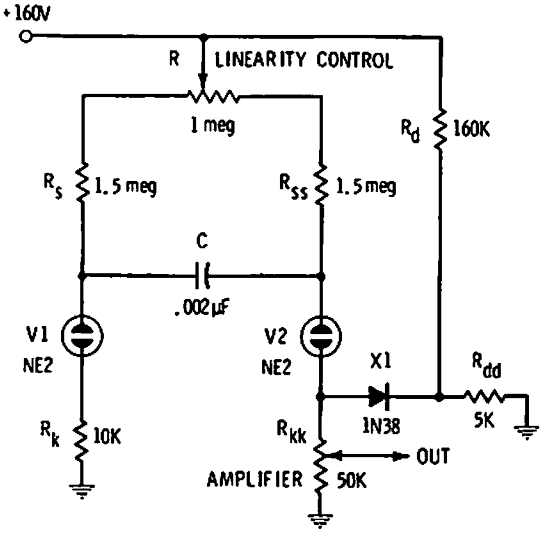
NANOSECOND PULSES WITH STEP RECOVERY DIODES—Pulse width is determined by difference in storage times of two diodes, which varies little with temperature, so width remains constant from −55 to 80 deg C. Pulse width may be varied from 1 to 1,000 ns by changing forward bias current.—L. St. Mario, Fast Pulse Generator is Temperature Stable, *Electronics*, Feb. 6, 1967, p 70–71.


V_{BB}
D_6
R_{10} 2.7k
Q_1 2N5040
R_{11} 100
C_4 0.1μF
B
R_8 2.7k
D_5
Q_3 2N5040
R_9 100
C_3 0.1μF
A
R_4 10
R_6 15
R_2 2M
R_1 750
R_5 10
R_7 15
R_3 470
C_1 0.1μF
C_2 1.0μF
D_1
D_3
Q_2 2N3567
Q_4 2N3567
D_2
D_4
Q_5 2N3567

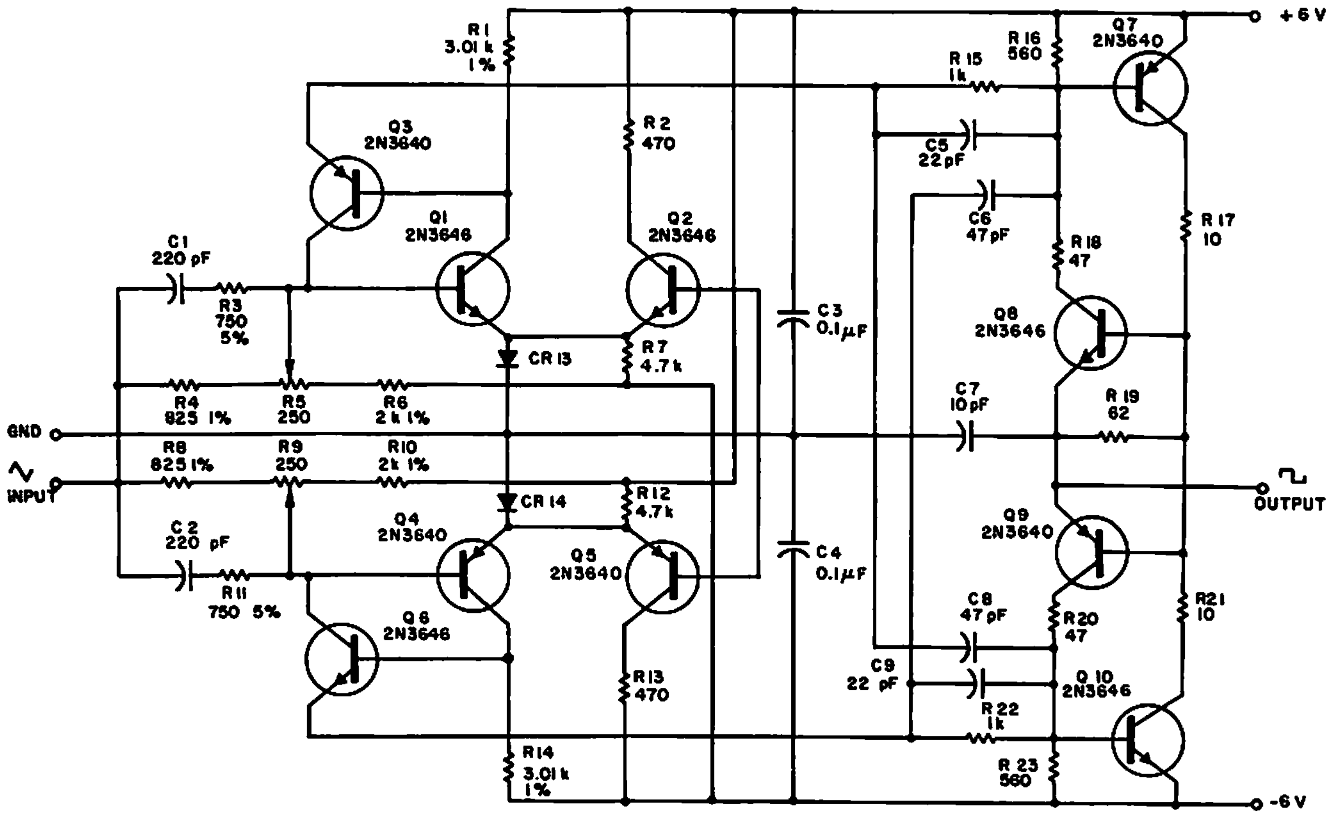
30,000:1 PERIOD-TO-PULSE RATIO—Used for generating fast-rise pulse or train of pulses with very narrow width in comparison with total period. If R1 is variable, can be used as astable, monostable, or bistable mvbr. Q1 and Q2 are simultaneously in either on or off state, with other three transistors always in opposite state to Q1-Q2. For values shown, pulse width is 50 μs, rise time 200 ns, fall time 20 ns, and periods ranging from 500 μs to 1.5 s depending on setting of R2.—D. R. Matthews, Ultralow-Duty-Cycle Pulser, *EEE*, March 1970, p 129.


+15V
2.7K
1.2K
1K
5.1K
2.0K
560
2N711
2N711
2N336
Q_1
Q_2
Q_3
V_{IN}
2.7K
R_{11}
10K
V_0
3.3K
R_2
10K
2.0K
680
R_1
18K
-15V

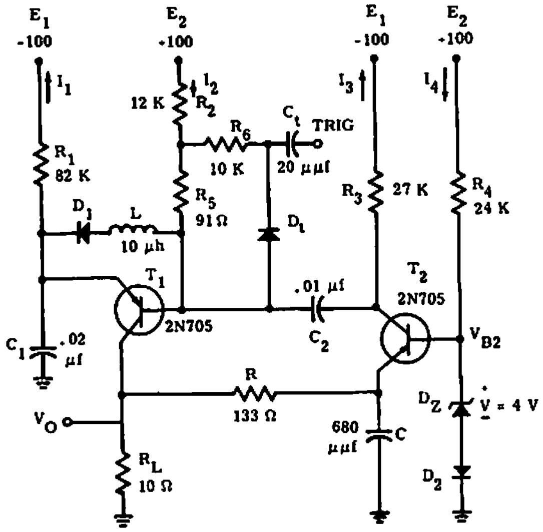
TEMPERATURE-STABLE SQUARE WAVES—Converts sine waves to square waves, with good isolation of output from input and excellent trigger stability for temperature changes. Shaded area covers differential amplifier and feedback loop. Output is 25 V p-p.—B. Pearl, Improved Squaring Circuit is Less Temperature Sensitive, *Electronic Design*, July 19, 1965, p 40–41.


+160V
R
LINEARITY CONTROL
1 meg
R_d
160K
R_s
1.5 meg
R_{ss}
1.5meg
C
.002µF
V1
NE2
V2
NE2
X1
R_{dd}
1N38
5K
R_k
10K
R_{kk}
OUT
AMPLIFIER
50K

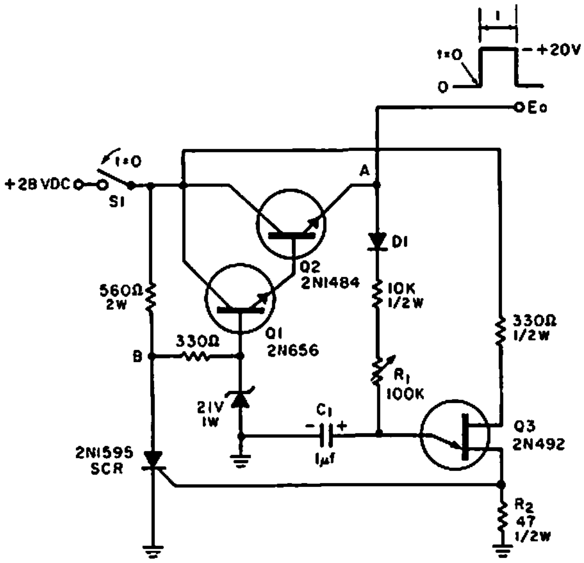
500-HZ SQUARE-WAVE—Uses neon mvbr to generate 0–4 C p-p sloped square wave, and diode clipper to straighten its top. Linearity control is used to adjust pulse width.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 45.


+6 V
R1
3.01 k
1%
Q3
2N3640
R2
470
Q1
2N3646
Q2
2N3646
C1
220 pF
R3
750
5%
CR13
R7
4.7 k
R4
825 1%
R5
250
R6
2 k 1%
GND
R8
825 1%
R9
250
R10
2k 1%
INPUT
CR 14
R12
4.7 k
C 2
220 pF
Q4
2N3640
Q5
2N3640
R11
750 5%
Q 6
2N3646
R13
470
R14
3.01 k
1%
C3
0.1µF
C4
0.1µF
R 16
560
R 15
1k
Q7
2N3640
C5
22 pF
C6
47 pF
R 17
10
R 18
47
Q8
2N3646
C7
10 pF
R 19
62
OUTPUT
Q9
2N3640
C8
47 pF
R20
47
R21
10
C9
22 pF
Q 10
2N3646
R 22
1k
R 23
560
-6 V

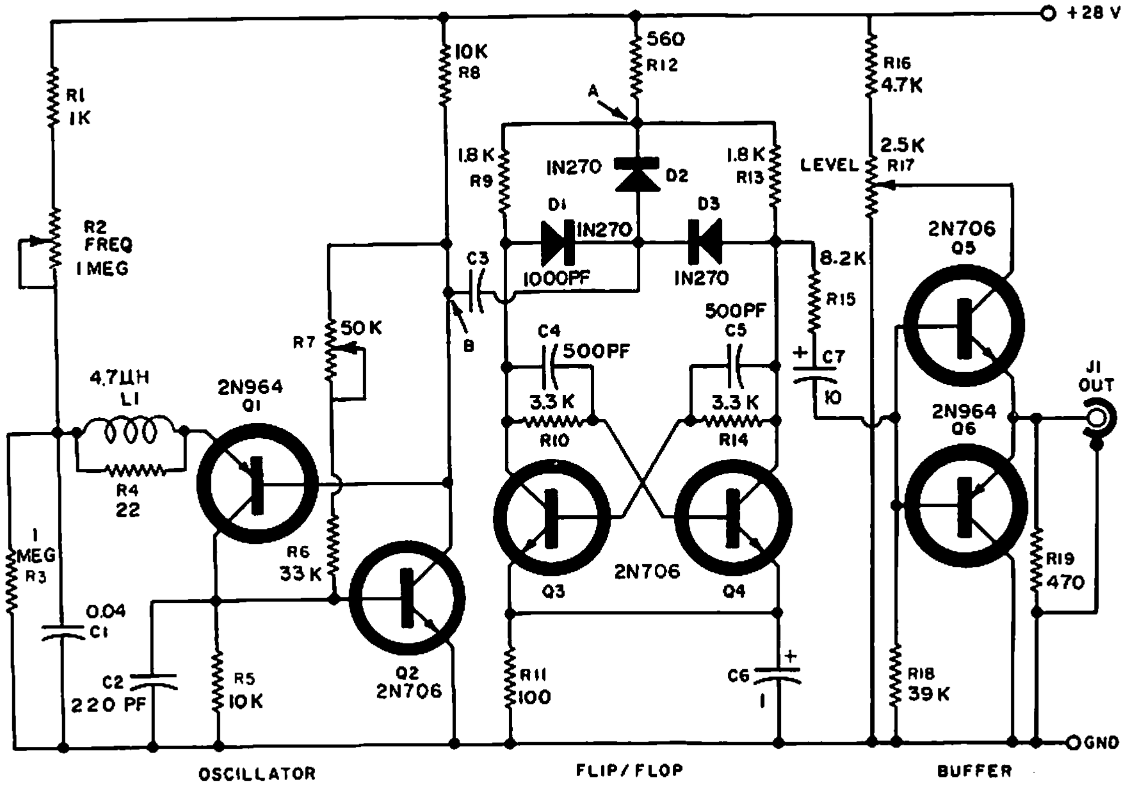
10-V P-P SQUARE WAVES—Provides excellent isolation between input and output over passband of d-c to 1 MHz, with less than 0.1 dB variation in output magnitude over frequency range. Rise time is 5 ns. Output is +5 V for input of +2.5 V and −5 V for input of −2.5 V. Q7-Q10 form bistable regenerative output switch driven by hysteresis switch Q1-Q6. Q1-Q2 form comparator for negative hysteresis level. Dividers in bases of Q1 and Q4 set precise firing levels for Q3 and Q6.—J. F. Foster, Bistable DC-Coupled Switch Has 5-Nanosecond Rise Time, *Electronic Design*, Nov. 8, 1967, p 120.


E1
-100
E2
+100
E1
-100
E2
+100
I1
I2
I3
I4
12 K
R2
R6
10 K
Ct
TRIG
20 μμf
R1
82 K
R5
91Ω
D1
L
10 μh
Dt
R3
27 K
R4
24 K
T1
2N705
.01 μf
C2
T2
2N705
VB2
C1
.02 μf
R
133 Ω
680 μμf
C
DZ
V = 4 V
D2
VO
RL
10 Ω

HIGH-CURRENT PULSES—Gives square-wave output waveform with amplitude of 5 V and width of about 200 ns at 0.5 A. Recovery time limits maximum repetition rate to range of 40 to 140 kHz, depending on permissible reduction in pulse amplitude.—"High Speed Switching Transistor Handbook," Motorola, Phoenix, Ariz., 1969, p 300.

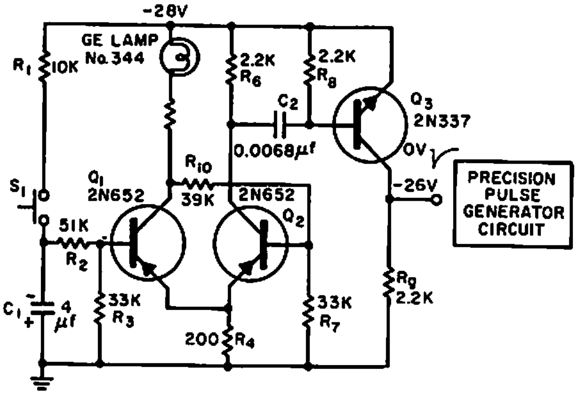

t
t=0
0
+20V
Eo
t=0
+28VDC
S1
A
Q2
2N1484
D1
10K
1/2W
560Ω
2W
Q1
2N656
330Ω
1/2W
B
330Ω
R1
100K
21V
1W
C1
1μf
Q3
2N492
2N1595
SCR
R2
47
1/2W

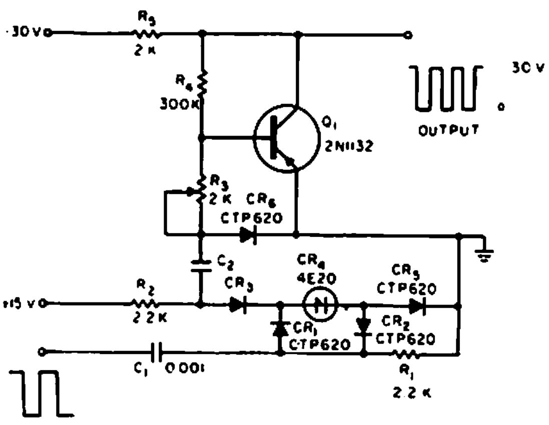
ADJUSTABLE PULSE WIDTH—R1 and C1 determine width of square-wave output independently of load. Values shown give 20-V pulse at 1 A, adjustable from 100 μs to 10 ms. Uses series regulator in combination with ujt time delay Q3.—G. E. Bloom, Time-Adjustable Pulse Generator Combines Unijunction, Zener, SCR, *Electronic Design*, May 25, 1964, p 68.


+28 V
R1
1K
10K
R8
560
R12
A
R16
4.7K
R2
FREQ
1 MEG
1.8 K
R9
IN270
D2
1.8 K
R13
LEVEL
2.5K
R17
D1
IN270
D3
C3
1000PF
IN270
8.2K
R15
2N706
Q5
B
R7
50K
C4
500PF
500PF
C5
+
C7
10
4.7μH
L1
2N964
Q1
3.3 K
R10
3.3 K
R14
2N964
Q6
J1
OUT
R4
22
1
MEG
R3
R6
33 K
2N706
Q3
Q4
R19
470
0.04
C1
C2
220 PF
R5
10K
Q2
2N706
R11
100
C6
1
+
R18
39 K
GND
OSCILLATOR
FLIP/FLOP
BUFFER

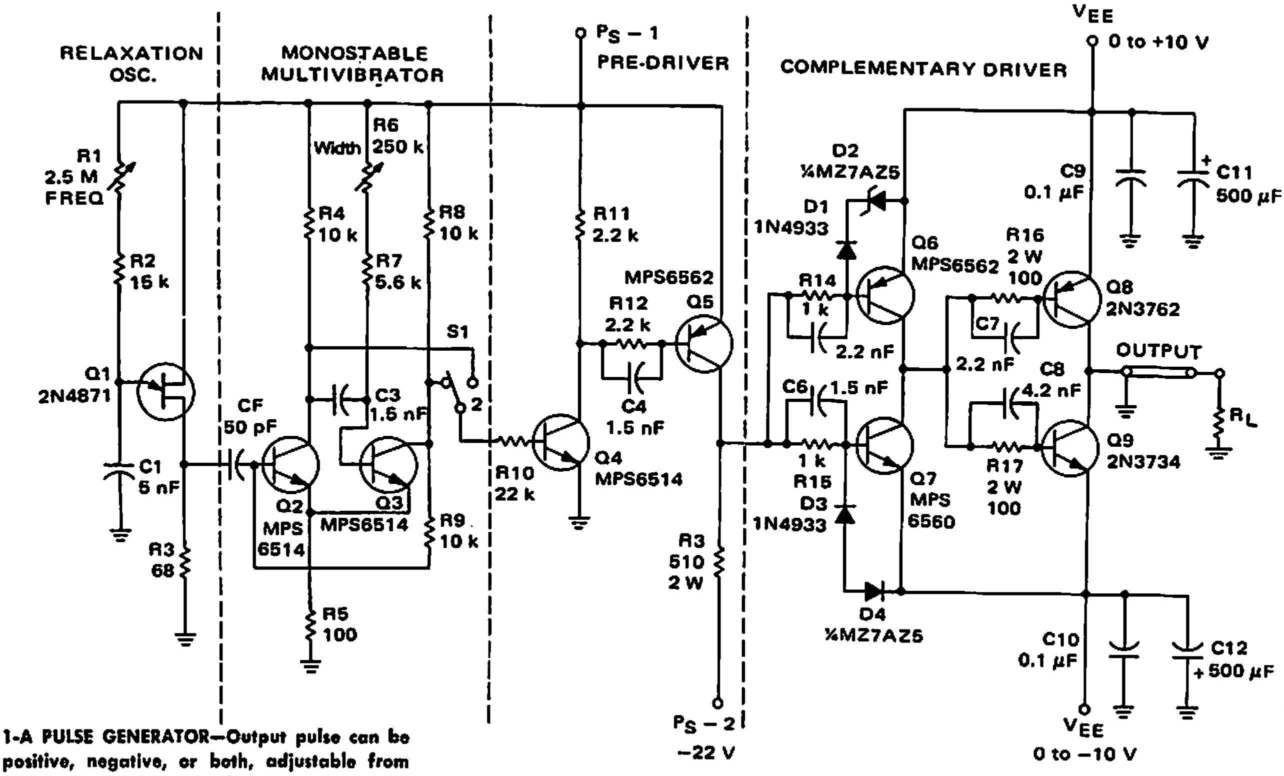
20–20,000-HZ SQUARE WAVES—Covers range with single-turn frequency control. Relaxation oscillator Q1-Q2 is adjustable over 1,000:1 with R7, to cover audio band without range switch. Triggered flip-flop Q3-Q4 serves as frequency divider for 40–40,000-Hz output of oscillator, while creating ideal square waves. Power supply should be zener-stabilized.—C. J. Ulrick, High-Quality Square-Wave Generator, *Electronics World*, Nov. 1966, p 43 and 82.

GUARANTEED SINGLE PULSE—Schmitt trigger and amplifier produce one and only one pulse when pushbutton is pressed, regardless of contact bounce. S1 is held down until C1 has charged to about 5 V, Schmitt has flipped, and lamp indicator has come on. When S1 is released, C1 starts discharging; when below 5 V, Schmitt flips again, lamp goes out, C2 starts charging through R8, and Q3 generates 26-V negative output pulse.—G. Domjanenko, Push-Button Single-Pulse Generator Is More Dependable, *Electronic Design*, Aug. 3, 1964, p 43.

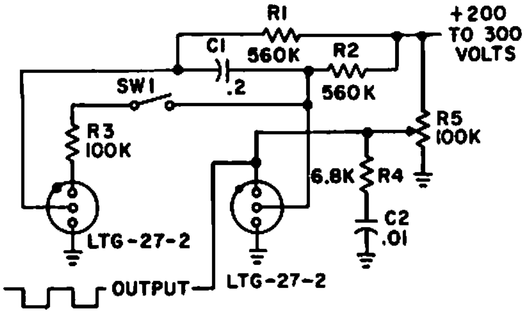

-28V
GE LAMP No.344
R1 10K
2.2K R6
2.2K R8
C2
0.0068μf
Q3 2N337
0V
-26V
PRECISION PULSE GENERATOR CIRCUIT
R10 39K
S1
Q1 2N652
2N652 Q2
51K R2
C1 4 μf
33K R3
200 R4
33K R7
R9 2.2K


-30 V
R5 2K
R4 300K
Q1 2N1132
30 V
0
OUTPUT
R3 2K
CR6 CTP620
C2
CR3
CR4 4E20
CR5 CTP620
+15 V
R2 22K
CR1 CTP620
CR2 CTP620
C1 0.001
R1 22K

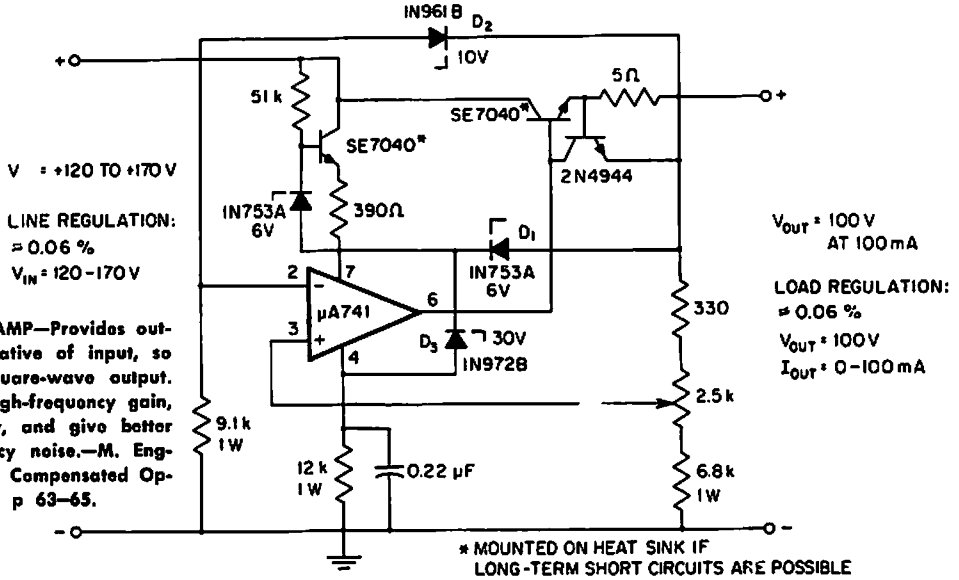
DOUBLING SQUARE WAVES—With 25-kHz 30-V p-p square-wave input, output is 50-kHz square wave of same amplitude, with better than 100-ns rise and fall times. Value of C2 depends on frequency; for 20-kHz input, use 0.02 μF.—C. R. Seo, Square-Wave Doubler Uses Four-Layer Diode, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 155.


RELAXATION OSC.
MONOSTABLE MULTIVIBRATOR
PS – 1
PRE-DRIVER
COMPLEMENTARY DRIVER
VEE
0 to +10 V
R1 2.5 M FREQ
R2 15 k
Q1 2N4871
C1 5 nF
R3 68
R6 250 k Width
R4 10 k
R7 5.6 k
R8 10 k
CF 50 pF
C3 1.5 nF
S1
1
2
Q2 MPS 6514
Q3 MPS6514
R9 10 k
R5 100
R11 2.2 k
MPS6562
R12 2.2 k
Q5
C4 1.5 nF
R10 22 k
Q4 MPS6514
R3 510 2 W
PS – 2
–22 V
D2 ¼MZ7AZ5
D1 1N4933
Q6 MPS6562
R14 1 k
2.2 nF
R16 2 W 100
Q8 2N3762
C7 2.2 nF
C9 0.1 μF
C11 500 μF
OUTPUT
C8 4.2 nF
RL
C6 1.5 nF
1 k R15
D3 1N4933
Q7 MPS 6560
R17 2 W 100
Q9 2N3734
D4 ¼MZ7AZ5
C10 0.1 μF
C12 500 μF
VEE
0 to –10 V

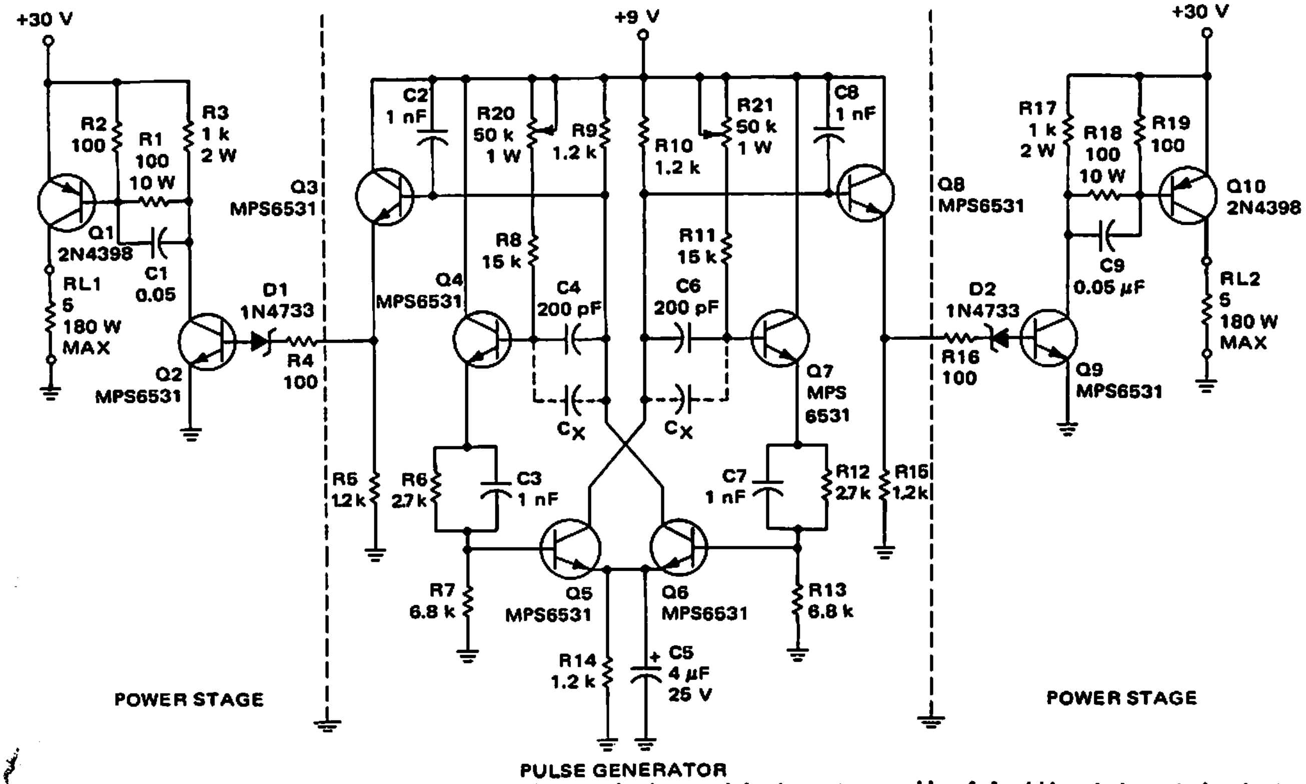
1-A PULSE GENERATOR—Output pulse can be positive, negative, or both, adjustable from zero to 10 V maximum, for maximum output of 20 V p-p at 1 A. Pulse width and frequency adjustments are provided. S1 inverts output pulse. Rise and fall times are 10 ns. —"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–32.


R1
560K
+200 TO 300 VOLTS
C1
.2
R2
560K
SW1
R3
100K
R5
100K
6.8K
R4
C2
.01
LTG-27-2
OUTPUT
LTG-27-2

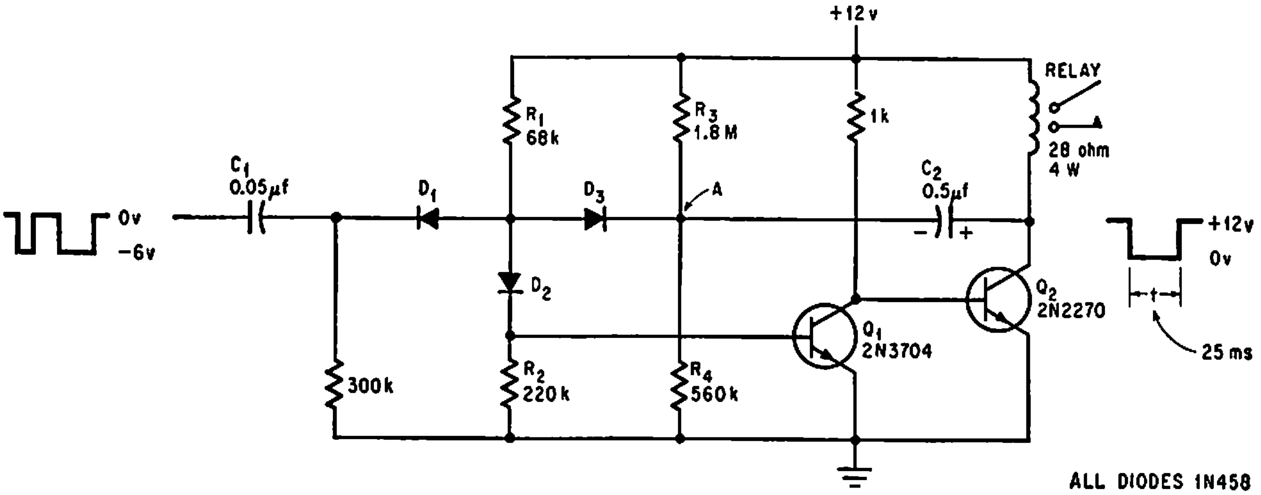
50-HZ SQUARE-WAVE—Uses three-element neon lamps. Closing SW1 makes cycle self-completing.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 37.


1N961B
D2
10V
+
5Ω
+
51 k
SE7040*
SE7040*
2N4944
V = +120 TO +170 V
LINE REGULATION:
≈0.06 %
VIN = 120-170 V
1N753A
6V
390Ω
D1
VOUT = 100 V
AT 100 mA
2
7
1N753A
6V
LOAD REGULATION:
≈0.06 %
VOUT = 100 V
IOUT = 0-100 mA
μA741
6
330
3
D3
30V
1N972B
4
2.5 k
9.1 k
1 W
12 k
1 W
0.22 μF
6.8 k
1 W
-
-
* MOUNTED ON HEAT SINK IF
LONG-TERM SHORT CIRCUITS ARE POSSIBLE

FULLY COMPENSATED OPAMP—Provides output proportional to derivative of input, so triangular input gives square-wave output. R1 is required to limit high-frequency gain, improve dynamic stability, and give better immunity to high-frequency noise.—M. English, Applications for Fully Compensated Op-Amp ICs, *EEE*, Jan. 1969, p 63–65.

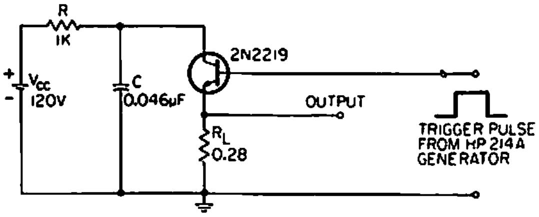

+30 V
+9 V
+30 V
R2
100
R1
100
10 W
R3
1 k
2 W
C2
1 nF
R20
50 k
1 W
R9
1.2 k
R10
1.2 k
R21
50 k
1 W
C8
1 nF
R17
1 k
2 W
R18
100
10 W
R19
100
Q3
MPS6531
Q8
MPS6531
Q10
2N4398
Q1
2N4398
C1
0.05
RL1
5
180 W
MAX
R8
15 k
R11
15 k
C9
0.05 μF
RL2
5
180 W
MAX
D1
1N4733
Q4
MPS6531
C4
200 pF
C6
200 pF
D2
1N4733
R4
100
Q2
MPS6531
CX
CX
Q7
MPS
6531
R16
100
Q9
MPS6531
R5
1.2 k
R6
2.7 k
C3
1 nF
C7
1 nF
R12
2.7 k
R15
1.2 k
R7
6.8 k
Q5
MPS6531
Q6
MPS6531
R13
6.8 k
R14
1.2 k
C5
4 μF
25 V
POWER STAGE
POWER STAGE
PULSE GENERATOR

ADJUSTABLE 6-A PULSE GENERATOR—Astable mvbr Q5-Q6 has independent controls for on and off times of rectangular pulses, over ranges that can be increased by increasing values of capacitors CX across C4 and C6. Pulse generator drives two power stages capable of furnishing 6 A to 5-ohm load.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–29.

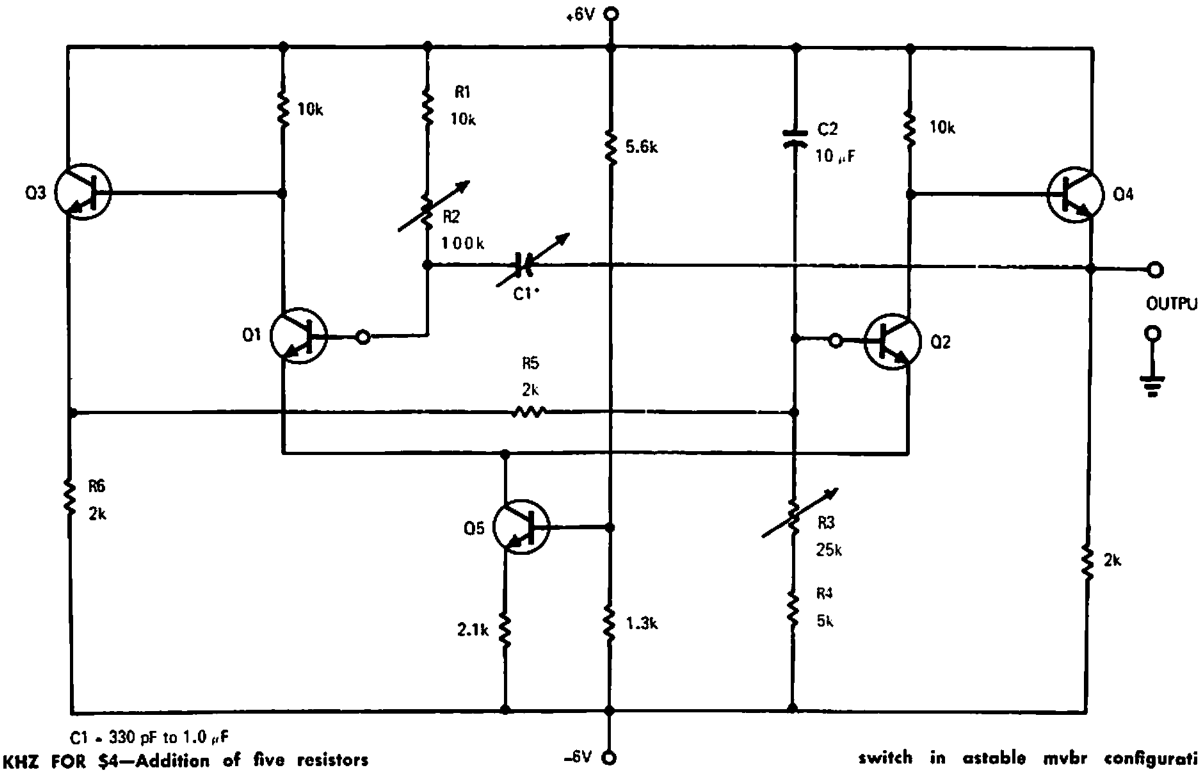

+12v
RELAY
28 ohm
4 W
R_1 68k
R_3 1.8 M
1k
C_1 0.05μf
D_1
D_3
A
C_2 0.5μf
0v
−6v
+12v
0v
D_2
Q_2 2N2270
Q_1 2N3704
25 ms
300k
R_2 220k
R_4 560k

ALL DIODES 1N458

SIMPLE PULSE STRETCHER—Generates 25-ms output pulse for driving 4-W relay momentarily, independently of amplitude or duration of input pulse. Eliminates transistor stage normally required for pulse stretching. To adjust ON time of relay, replace R2 with pot.—K. Wahl, Constant Relay On-Time for Any Input Pulse, *Electronics*, March 6, 1967, p 133.

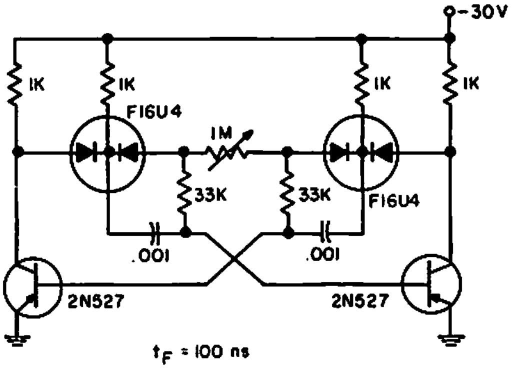

R
1K
2N2219
V_{CC} 120V
C 0.046μF
OUTPUT
R_L 0.28
TRIGGER PULSE FROM HP 214A GENERATOR

30-A PEAK PULSES AT 130 KHZ—Transistor is driven into second breakdown, to give 40-ns pulses at 5 A, with generating cycle completed before thermal buildup becomes excessive. Rise time of output pulse is less than 10 ns.—E. B. Hakim, Variable-Voltage Current Sink, *EEE*, March 1967, p 166–167.


+6V
10k
R1 10k
5.6k
C2 10 μF
10k
Q3
Q4
R2 100k
C1*
OUTPUT
Q1
Q2
R5 2k
R6 2k
Q5
R3 25k
R4 5k
2k
2.1k
1.3k
-6V

C1 - 330 pF to 1.0 μF

300 KHZ FOR $4—Addition of five resistors (R1-R5) and two capacitors (C1-C2) to μA730C IC differential amplifier gives inexpensive general-purpose pulse generator having frequency range extending to 300 kHz. Pulse rise and fall times are both under 200 ns. Output pulses are easily adjusted to switch above, below, or precisely at ground. Differential amplifier operates as current-mode switch in astable mvbr configuration. C1 determines frequency range, while R2 varies prr over 6:1 ratio.—C. Brogado, Converted Diff Amp Generates Pulses, *EDN*, June 15, 1970, p 57.

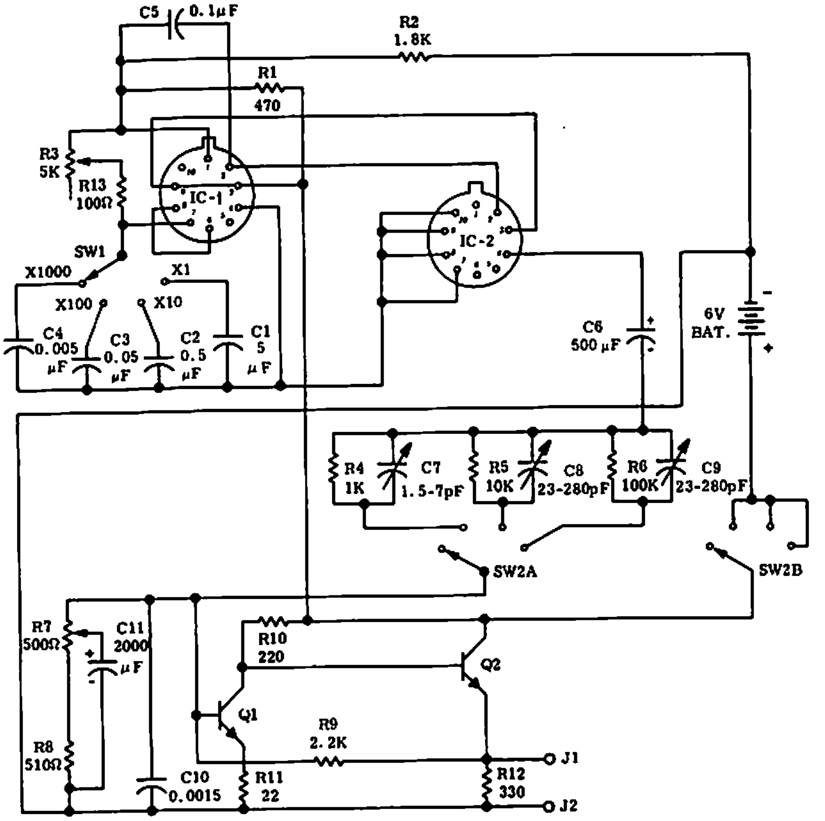

-30V
1K
1K
F16U4
1M
1K
1K
33K
33K
F16U4
.001
.001
2N527
2N527

$t_F = 100$ ns

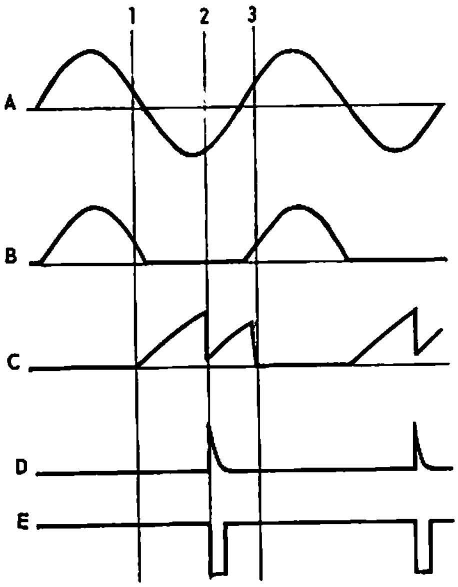
$4KH_z < f < 25KH_z$

SQUARENESS RATIO = 1600 @ $4KH_z$

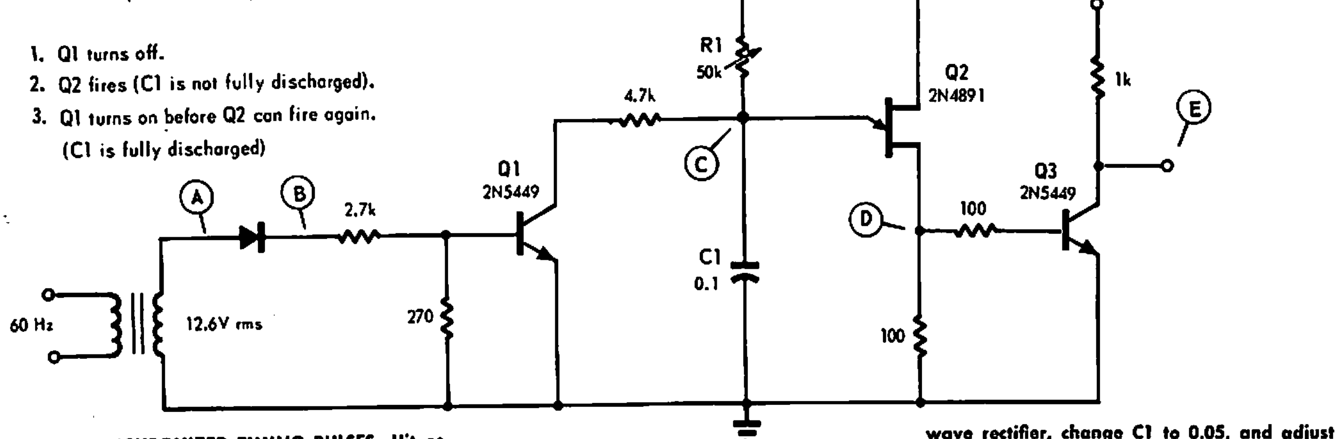
4–25 KHZ SQUARE-WAVE GENERATOR—Uses dual diodes having common cathodes. Provides excellent output waveform.—W. R. Spofford, Jr., Practical Circuit Applications for The New F16U Dual Diode, General Electric, Syracuse, N.Y., No. 90.53, 1965.


C5
0.1μF
R2
1.8K
R1
470
R3
5K
R13
100Ω
IC-1
IC-2
SW1
X1000
X1
X100
X10
C4
0.005 μF
C3
0.05 μF
C2
0.5 μF
C1
5 μF
C6
500 μF
6V
BAT.
R4
1K
C7
1.5-7pF
R5
10K
C8
23-280pF
R6
100K
C9
23-280pF
SW2A
SW2B
R7
500Ω
C11
2000 μF
R10
220
Q2
Q1
R8
510Ω
R9
2.2K
J1
C10
0.0015
R11
22
R12
330
J2

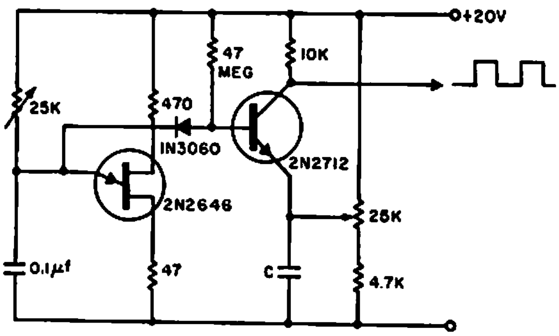
6–60,000 HZ SQUARE WAVE—Frequency is variable over four ranges: 6–60, 60–600, 600–6,000, and 6,000–60,000 Hz, and amplitude over three ranges: 1,000, 100, and 10 mV. IC-1, a Motorola HEP556, is at center of basic R-C oscillator which triggers IC-2, a HEP558 J-K flip-flop, to provide an almost perfect square wave. Two HEP50 transistors provide amplification. Article gives construction details. Designed for use with cro to check response of audio equipment.—"Integrated Circuit Projects," Motorola, Phoenix, Ariz., 1966, p 46–62.



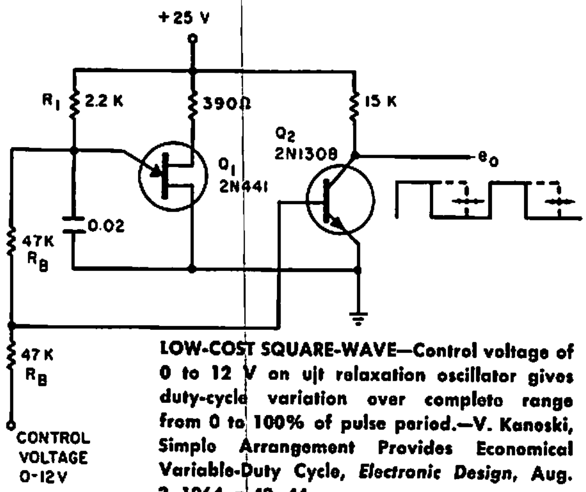
1. Q1 turns off.
2. Q2 fires (C1 is not fully discharged).
3. Q1 turns on before Q2 can fire again. (C1 is fully discharged)


+8V to +18V
R1
50k
Q2
2N4891
+5V
1k
4.7k
C
E
Q1
2N5449
Q3
2N5449
A
B
2.7k
D
100
C1
0.1
60 Hz
12.6V rms
270
100

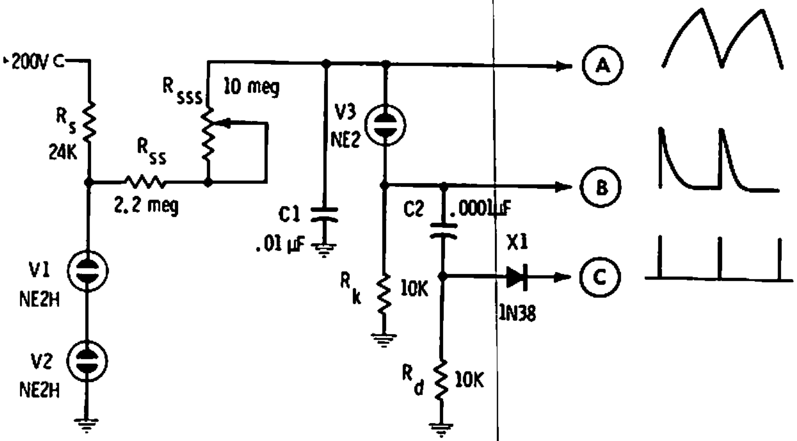
LINE-SYNCHRONIZED TIMING PULSES—Ujt oscillator Q2 generates sharp and clean 60-Hz timing pulse virtually unaffected by noise and transients on line. Only extremely severe noise on line may cause output pulse train to skip a beat. Invert output to obtain positive pulse. For 120-Hz output, use full-wave rectifier, change C1 to 0.05, and adjust bias resistors controlling Q1.—B. Heniford, UJT Generates Useful Timing Pulses, *EDN*, March 15, 1970, p 87–88.


+20V
25K
470
47 MEG
10K
IN3060
2N2712
2N2646
25K
0.1μf
47
C
4.7K

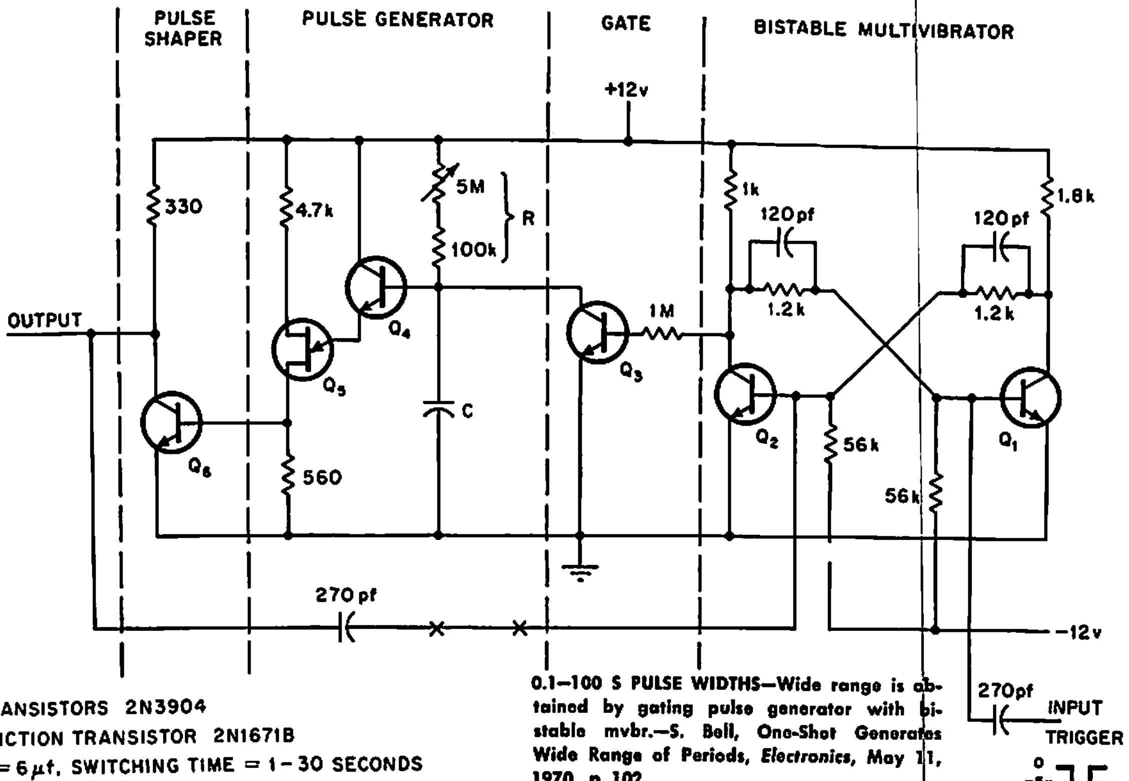
TWO-CONTROL UJT—Two pots provide control of frequency and duty cycle of square-wave output. Value of C affects rise and fall times, and can be between 0.01 and 50 μF.—J. H. Phelps, Unijunction Generator Has Variable Square-Wave Output, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 191.


+25 V
R1
2.2 K
390Ω
15 K
Q2
2N1308
e0
Q1
2N441
0.02
47K
RB
47 K
RB
CONTROL
VOLTAGE
0-12V

LOW-COST SQUARE-WAVE—Control voltage of 0 to 12 V on ujt relaxation oscillator gives duty-cycle variation over complete range from 0 to 100% of pulse period.—V. Kanoski, Simple Arrangement Provides Economical Variable-Duty Cycle, *Electronic Design*, Aug. 3, 1964, p 43–44.

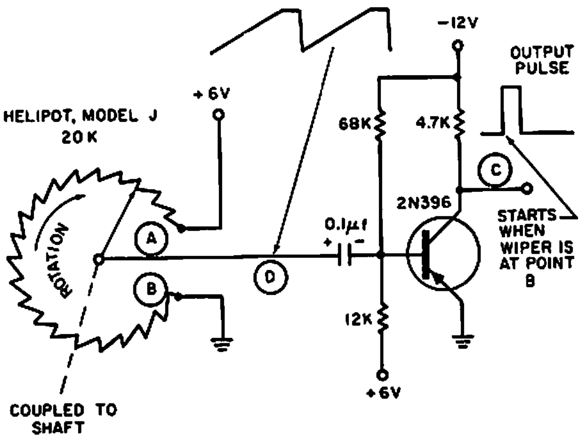

+200V
Rs
24K
Rsss
10 meg
Rss
2.2 meg
C1
.01 μF
V3
NE2
C2
.001μF
X1
1N38
Rk
10K
Rd
10K
V1
NE2H
V2
NE2H
A
B
C

40–180 HZ MULTIPLE OUTPUTS—Consists of neon regulated power supply and neon oscillator. Positive 1-μs pulse is available at C.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 40.

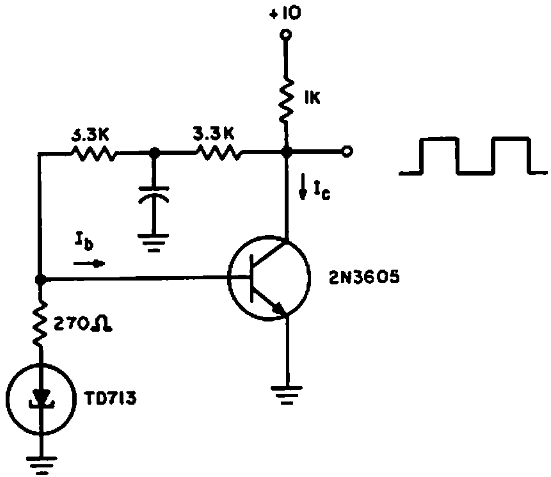

PULSE SHAPER
PULSE GENERATOR
GATE
BISTABLE MULTIVIBRATOR
+12v
330
4.7k
5M
100k
R
1k
120pf
1.8k
120pf
1.2k
1.2k
OUTPUT
Q4
Q5
Q6
Q3
1M
C
560
Q2
Q1
56k
56k
270 pf
-12v
270pf
INPUT
TRIGGER
0
-5v

ALL TRANSISTORS 2N3904
UNIJUNCTION TRANSISTOR 2N1671B
FOR C=6μf, SWITCHING TIME = 1-30 SECONDS

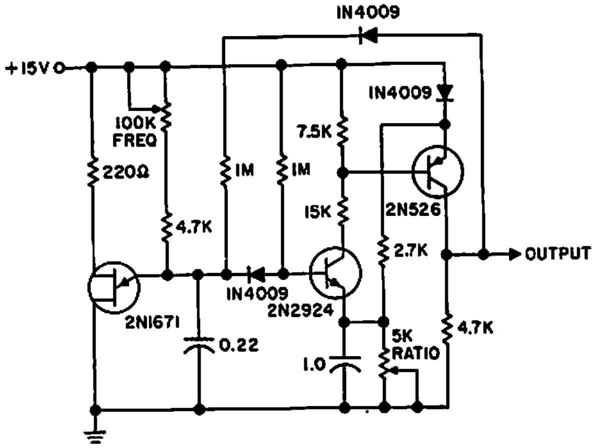
0.1–100 S PULSE WIDTHS—Wide range is obtained by gating pulse generator with bistable mvbr.—S. Bell, One-Shot Generates Wide Range of Periods, *Electronics*, May 11, 1970, p 102.


-12V
OUTPUT PULSE
HELIPOT, MODEL J 20K
+6V
68K
4.7K
C
ROTATION
2N396
STARTS WHEN WIPER IS AT POINT B
A
0.1µf
+
-
B
D
12K
+6V
COUPLED TO SHAFT

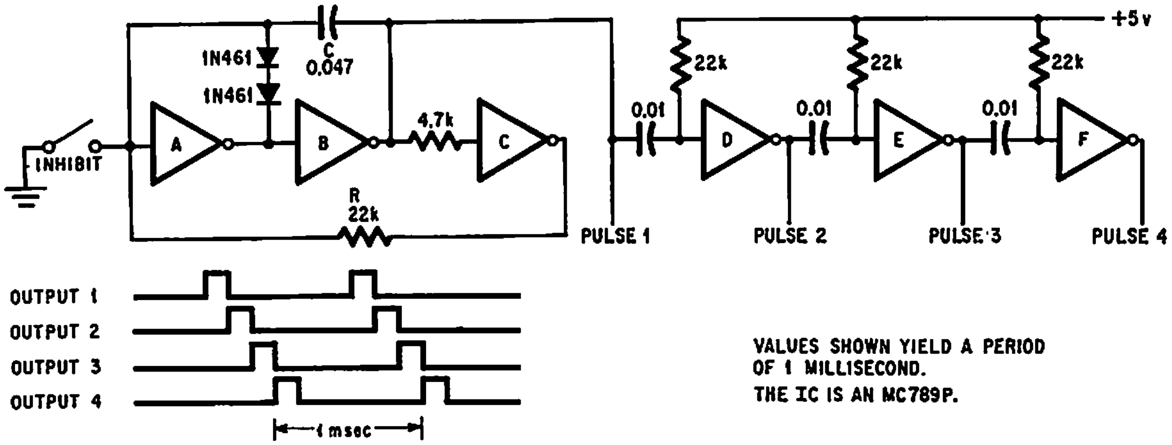
SHAFT ZERO-REFERENCE PULSE—Output pulse is generated when shaft of 360-deg pot is at zero. Leading edge of pulse coincides with position B of wiper arm. Applicable only to unidirectional drive, as by digital motor. Repeatability of pulse position is within 13.5 min of arc. Output pulse width is about 10 µs. Capacitor is charged during clockwise rotation from B to A. Charge is held until wiper arm crosses gap to B, then discharged to drive transistor into saturation and create output pulse.—W. E. Milroy, Shaft-Position Generator Provides Zero Reference, *Electronic Design*, March 15, 1965, p 64–65.


+10
IK
3.3K
3.3K
Ic
Ib
2N3605
270Ω
TD713

TUNNEL-DIODE ASTABLE—Simple free-running (astable) oscillator generates clean square wave. Frequency is determined by value of charging capacitor used.—W. R. Spofford, Jr., Applications For The New Low Cost TD 700 Series Tunnel Diodes, General Electric, Syracuse, N.Y., No. 90.66, 1967, p 9.

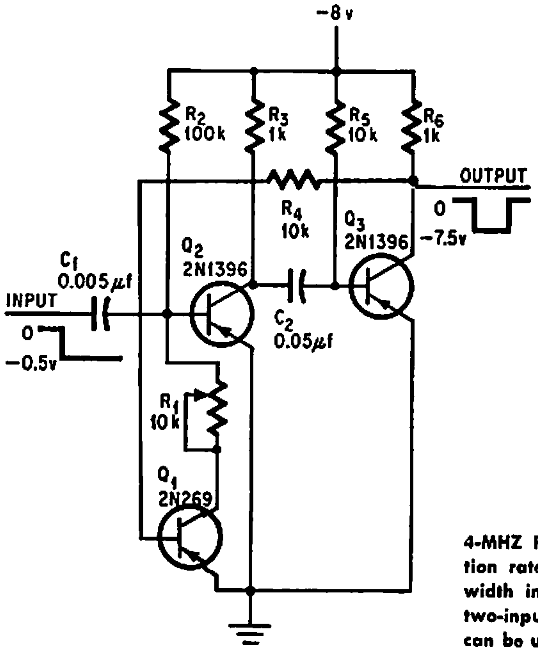

IN4009
+15V
IN4009
100K FREQ
7.5K
220Ω
IM
IM
15K
2N526
4.7K
2.7K
OUTPUT
IN4009
2N2924
2NI671
0.22
1.0
5K RATIO
4.7K

VARIABLE FREQUENCY AND DUTY CYCLE—Frequency range is 60 to 1,000 Hz, adjustable independently of 0—100% duty cycle range. Conventional ujt sawtooth followed by two transistors provides positive-going output, with rise and fall times about 1/500th of period of oscillation.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 7.

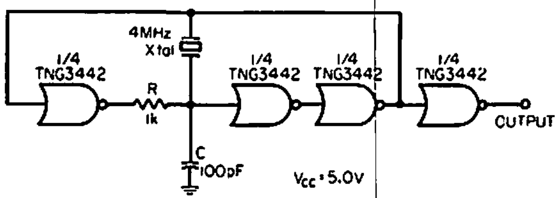

+5v
1N461
1N461
C 0.047
22k
22k
22k
0.01
0.01
0.01
4.7k
INHIBIT
A
B
C
D
E
F
R 22k
PULSE 1
PULSE 2
PULSE 3
PULSE 4
OUTPUT 1
OUTPUT 2
OUTPUT 3
OUTPUT 4
1 msec

VALUES SHOWN YIELD A PERIOD OF 1 MILLISECOND.
THE IC IS AN MC789P.

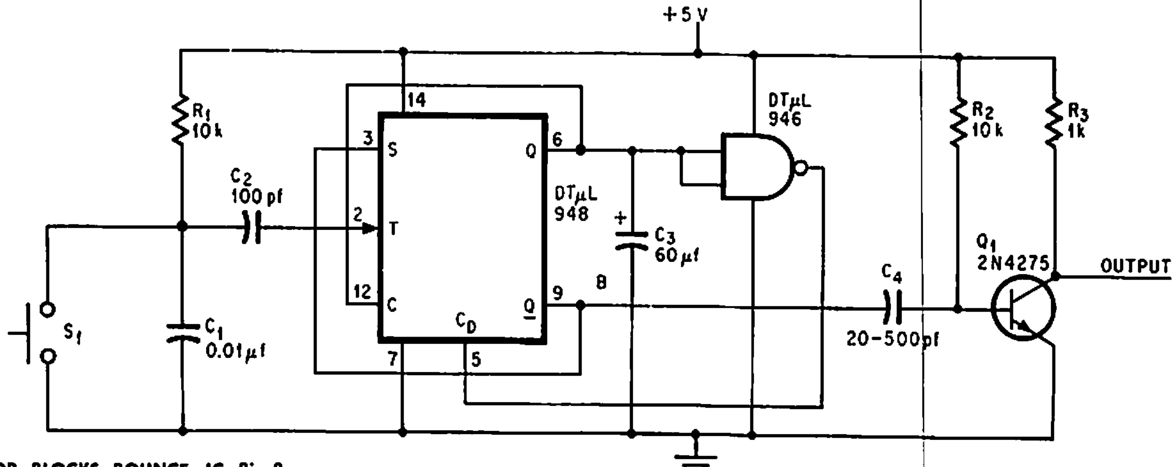
FOUR-PULSE SEQUENCE—Low-cost RTL hex-inverter IC delivers repeated sequence of four pulses, with equal or independently adjustable pulse widths. IC inverters A, B, and C form basic pulse generator. Inverters D, E, and F generate their pulses sequentially, with duration of each depending on RC network at inverter input. For values shown, duty cycle is 20%, leaving dead period before start of next four-pulse train. Pulse frequency can be up to a few MHz. Adding more hex-inverters increases number of pulses in train.—F. Cupp, 4-Pulse Sequence Generator Built With 1 Hex-Inverter, *Electronics*, Feb. 3, 1969, p 79—80.


-8v
R2 100k
R3 1k
R5 10k
R6 1k
OUTPUT
0
-7.5v
R4 10k
Q3 2N1396
Q2 2N1396
C1 0.005μf
INPUT
0
-0.5v
C2 0.05μf
R1 10k
Q1 2N269

STEP-FUNCTION TRIGGERING—Adding Q1 to feedback loop of mono mvbr permits triggering by step function, to generate variable-width trigger pulse for digital system. Step function is obtained from shaft encoder. Negative 0.5 V input step gives 7.5-V output pulse 0.25 μs wide.—R. J. Hoss, Pulse Generator Triggered by a Step Function, *Electronics*, March 31, 1969, p 87–88.


4MHz Xtal
1/4 TNG3442
R
1k
1/4 TNG3442
1/4 TNG3442
1/4 TNG3442
OUTPUT
C 100pF
Vcc=5.0V

4-MHZ PULSE TRAIN—Crystal controls repetition rate and R-C network determines pulse width in square-wave generator using quad two-input gate. Square input to first gate can be used for stop-start control. Will operate with crystals from 10 kHz to 10 MHz. Stability is better than 0.02% within temperature range of IC.—K. Yu, Crystal Controls Rep Rate of Simple IC Pulse Generator, *EEE*, Jan. 1968, p 116–117.

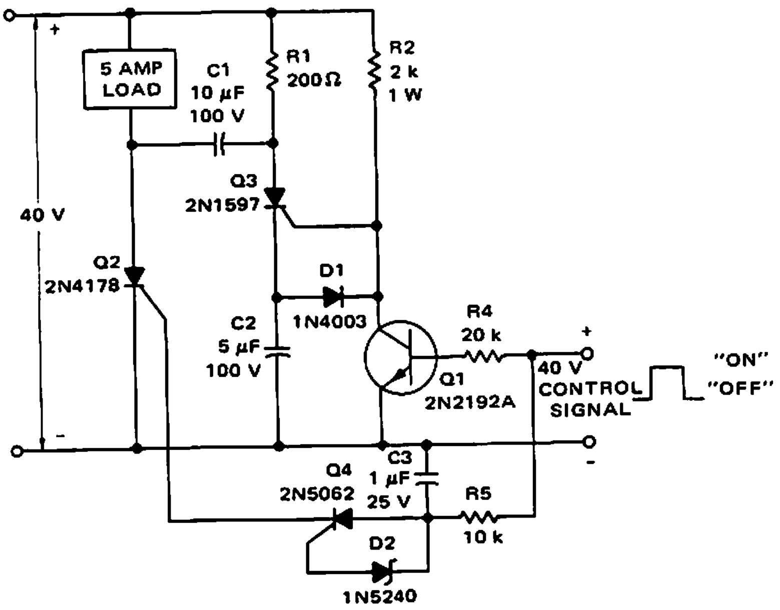

+5 V
R1 10k
C2 100 pf
14
3
S
Q
6
2
T
12
C
C_D
Q̄
9
7
5
DTμL 948
DTμL 946
+
C3 60μf
8
R2 10k
R3 1k
Q1 2N4275
OUTPUT
C4
20-500pf
S1
C1 0.01μf

FLIP-FLOP BLOCKS BOUNCE—IC flip-flop arrangement is used to inject narrow pulse into equipment under test by closing S1 manually. Spurious voltages caused by contact bounce in switch are isolated from output by flip-flop. Closing S1 discharges C1, triggering flip-flop and biasing Q1 into cutoff so collector is moved from ground up to 5 V to form leading edge of output pulse. After 100 ns, C4 discharges enough through R2 to make Q1 saturate and form falling edge of pulse.—L. V. Hendricks, Flip-Flop Isolates Pulse From Switch Bounce, *Electronics*, Aug. 19, 1968, p 84–85.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

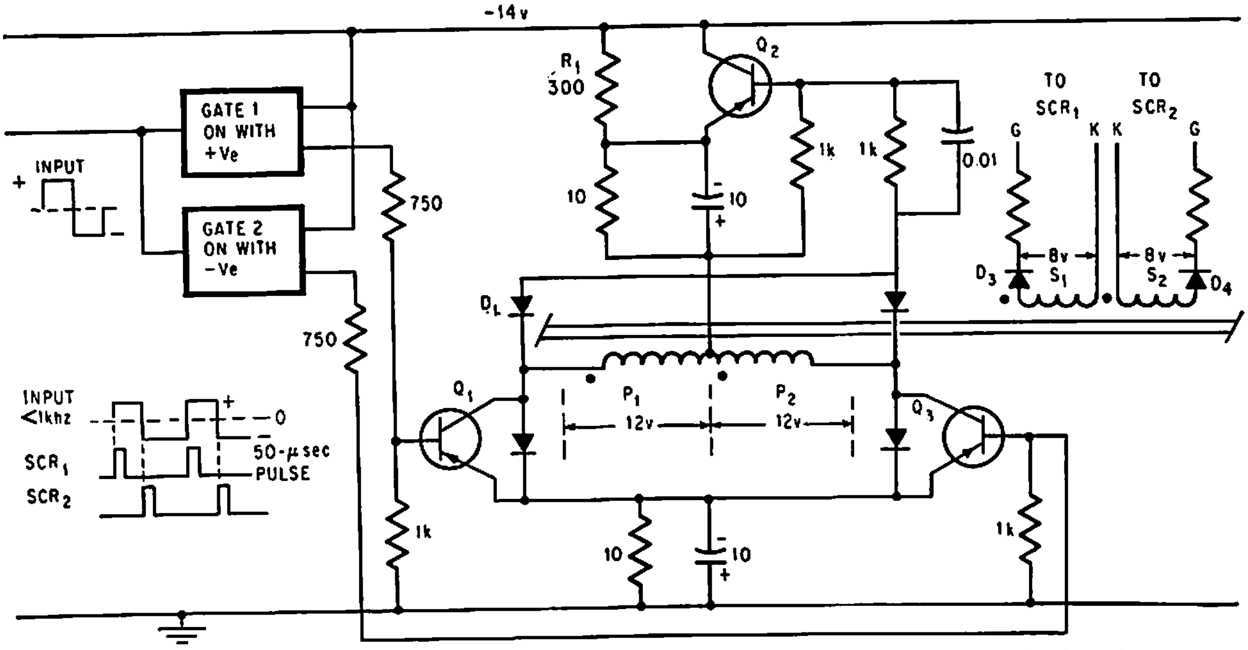
CHAPTER 80

Switching Circuits



+
5 AMP LOAD
C1 10 μF 100 V
R1 200Ω
R2 2 k 1 W
Q3 2N1597
40 V
Q2 2N4178
D1 1N4003
C2 5 μF 100 V
R4 20 k
+
40 V CONTROL SIGNAL
"ON"
"OFF"
Q1 2N2192A
-
-
Q4 2N5062
C3 1 μF 25 V
R5 10 k
D2 1N5240

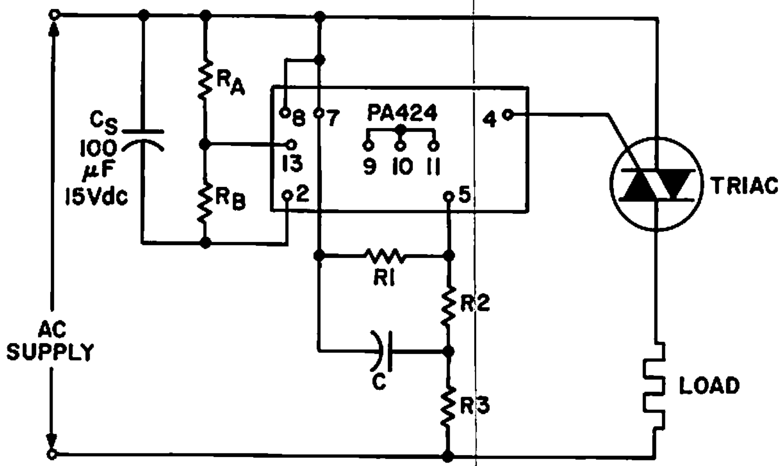
SCR STATIC D-C SWITCH—Control circuit turns on Q2 and load when control signal is applied. When signal is removed, Q2 opens and turns off load.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–12.



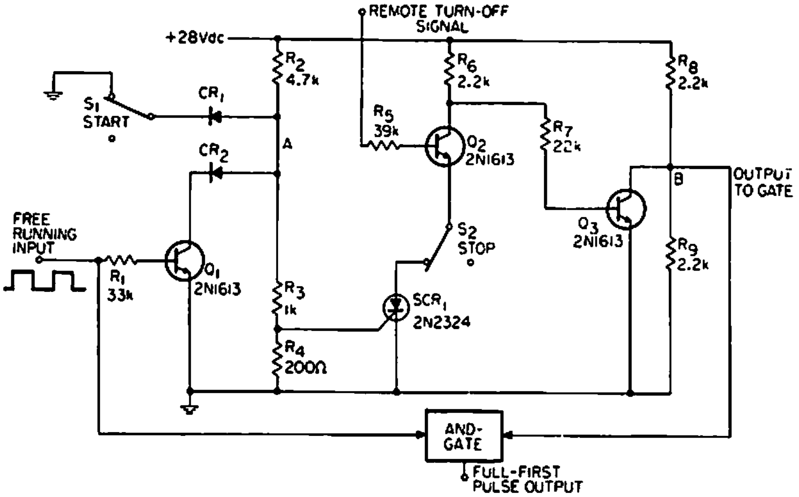
-14 v
GATE 1 ON WITH +Ve
GATE 2 ON WITH -Ve
INPUT
+
-
750
750
R1 300
10
Q2
1k
1k
0.01
10
TO SCR1
TO SCR2
G
K
K
G
D3
8v
S1
8v
S2
D4
D1
P1
P2
12v
12v
Q1
Q3
INPUT <1khz
+
0
SCR1
50-μsec PULSE
SCR2
1k
10
10
1k

SYMMETRICAL ALTERNATE FIRING OF SCR'S—High-power firing pulses are alternated between pair of scr's by three-transistor pulse circuit, with timing of pulses controlled by low-power rectangular-wave input. Circuit delivers exact pulse to one scr, stalls until next half-cycle, and then delivers identical pulse to other scr.—B. McConnell, Pulse Circuit Fires Scr Pair, *Electronics*, Oct. 31, 1966, p 71.

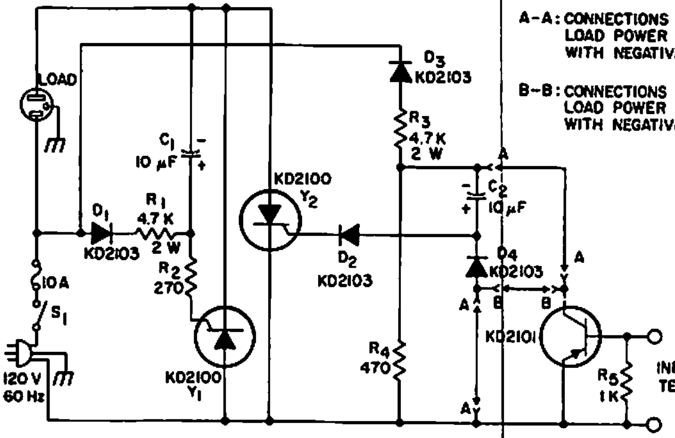
IC-TRIAC ZERO-VOLTAGE POWER SWITCH— Circuit provides for shifting triac gate pulse in time to ensure reliable latching with small load. Triac used should latch at minimum load current of 4.2 A. Table gives component values required for four different values of minimum load current and 120-V a-c supply.—R. W. Fox, Low Power Zero Voltage Switching Using the PA42A, General Electric, Syracuse, N.Y., No. 201.22, 1969.


CS
100 µF
15Vdc
RA
RB
8
7
PA424
4
13
9 10 11
2
5
TRIAC
RI
R2
C
R3
AC SUPPLY
LOAD

Load (watts)	R_1	R_2	R_3	C	Approx. Min. Pulse	Approx. Pulse Ø Shift
500	∞	10 K	0	0	100 µsec.	0
400	∞	7.5 K	2.2 K	0.01 µfd, 200 V	100 µsec.	25 µsec.
250	∞	7.5 K	2.2 K	0.022 µfd, 200 V	100 µsec.	50 µsec.
200	6.8 K	4.7 K	2.2 K	0.047 µfd, 200 V	150 µsec.	75 µsec.


REMOTE TURN-OFF SIGNAL
+28Vdc
S1 START
CR1
CR2
A
R2 4.7k
R6 2.2k
R8 2.2k
R5 39k
Q2 2N1613
R7 22k
Q3 2N1613
B
OUTPUT TO GATE
FREE RUNNING INPUT
R1 33k
Q1 2N1613
S2 STOP
R3 1k
SCR1 2N2324
R9 2.2k
R4 200Ω
AND-GATE
FULL-FIRST PULSE OUTPUT

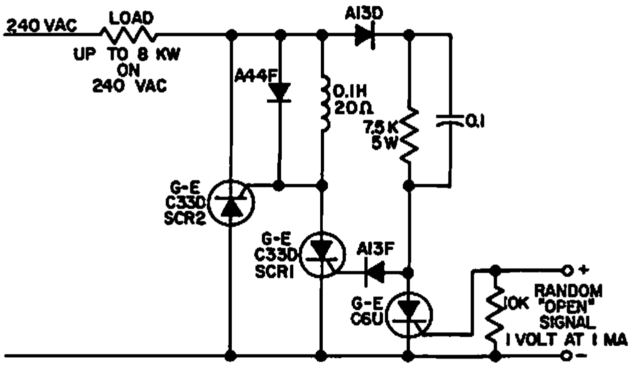
FIRST-PULSE PRESERVER— Switches free-running signal to load without interrupting first pulse, regardless of instant when start switch is actuated. Input square waves should be about 5 V p-p and wider than 50 µs. Frequency range is from near zero to about 1 kHz.—D. E. Manners, Switching Circuit Ensures Full First Pulse, *EEE*, Nov. 1967, p 126 and 128.


LOAD
D3 KD2103
R3 4.7 K 2 W
C1 10 µF
D1 KD2103
R1 4.7 K 2 W
R2 270
KD2100 Y2
D2 KD2103
C2 10 µF
D4 KD2103
10A
S1
120 V 60 Hz
KD2100 Y1
R4 470
A
B
KD2101
R5 1K
INPUT TERMINALS

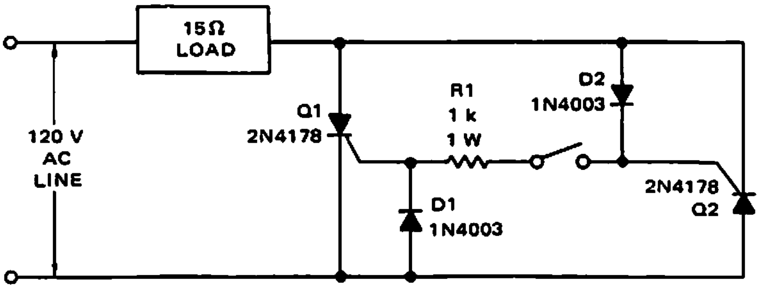
A-A: CONNECTIONS FOR LOAD POWER *OFF* WITH NEGATIVE SIGNAL

B-B: CONNECTIONS FOR LOAD POWER *ON* WITH NEGATIVE SIGNAL

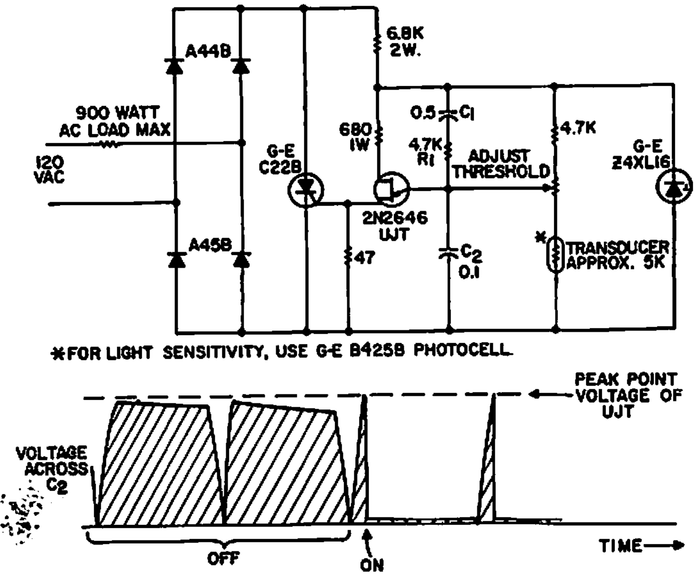
1-KW AUTOMATIC SYNCHRONOUS SWITCH— Either negative or positive 1-mA d-c input signal, depending on connections at AA and BB, applies power to load at next point in instantaneous line voltage that is low enough to prevent rfi generation.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 95.


240 VAC
LOAD
UP TO 8 KW ON 240 VAC
A13D
A44F
0.1H
20Ω
7.5K
5W
0.1
G-E C33D SCR2
G-E C33D SCR1
A13F
G-E C6U
10K
+
RANDOM "OPEN" SIGNAL
1 VOLT AT 1 MA
−

8-KW SYNCHRONOUS A-C SWITCH—In absence of switch-opening signal, scr's deliver full power to load, in full cycles and therefore with minimum rfi. Ideal for applications where magnetizing inrush current to transformers and motors causes nuisance fuse blowing, or where sensitive test equipment must be operated near switch location.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 10.

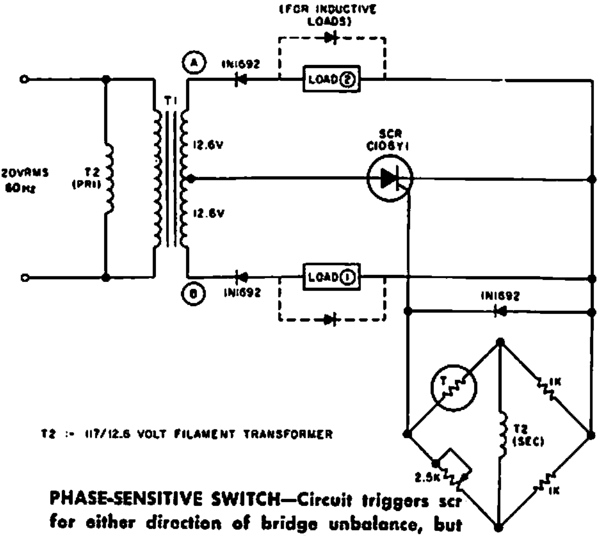

15Ω
LOAD
120 V
AC
LINE
Q1
2N4178
R1
1 k
1 W
D2
1N4003
D1
1N4003
2N4178
Q2

SCR STATIC A-C CONTACTOR—Small switch serves as static contactor for turning on one scr during positive half-cycles and other scr during negative half-cycles. When switch is opened, scr's remove load from line.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–9.


A44B
6.8K
2W.
900 WATT
AC LOAD MAX
120
VAC
G-E
C22B
680
1W
0.5
C1
4.7K
R1
ADJUST THRESHOLD
4.7K
G-E
24XL16
2N2646
UJT
A45B
47
C2
0.1
*
TRANSDUCER
APPROX. 5K
PEAK POINT VOLTAGE OF UJT
VOLTAGE ACROSS C2
OFF
ON
TIME

*FOR LIGHT SENSITIVITY, USE G-E B425B PHOTOCELL.

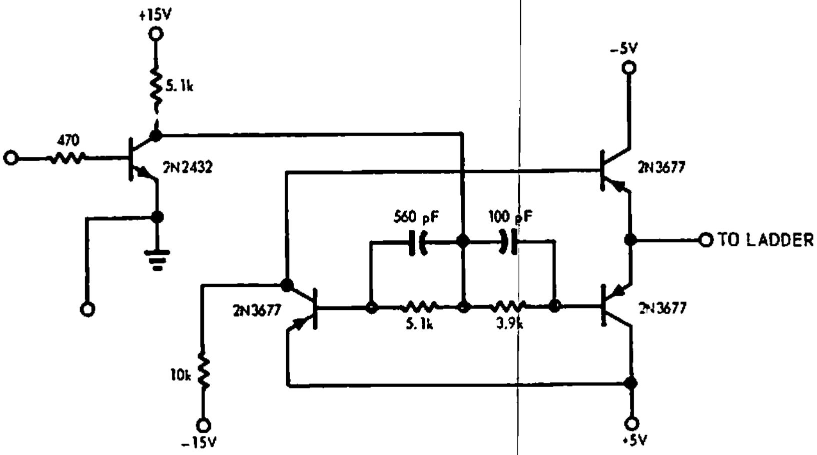
SNAP-ACTION A-C THRESHOLD SWITCH—R1 and C1 determine spread between pickup and dropout of a-c load up to 900 W. Can be used for temperature control, lighting control, and other applications, depending on type of transducer used.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 10.

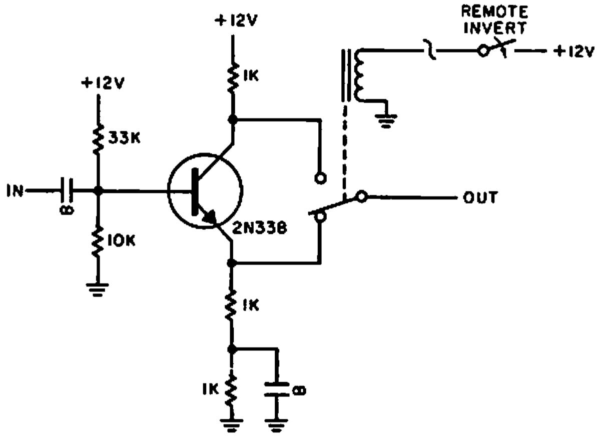

(FOR INDUCTIVE LOADS)
A
1N1692
LOAD ②
T1
12.6V
SCR
C106Y1
120VRMS
60Hz
T2
(PRI)
12.6V
LOAD ①
B
1N1692
1N1692
T
1K
T2
(SEC)
2.5K
1K

T2 :- 117/12.6 VOLT FILAMENT TRANSFORMER

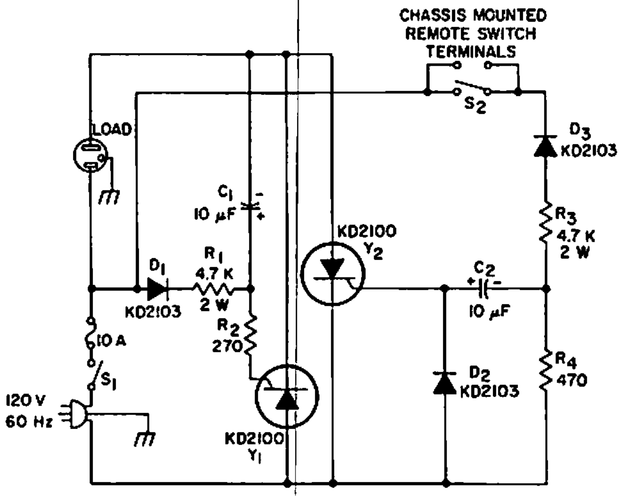
PHASE-SENSITIVE SWITCH—Circuit triggers scr for either direction of bridge unbalance, but transformer and steering diodes determine which of the two loads comes on for particular direction of unbalance. At balance, both loads are off. Ideal for monitoring or warning systems, where loads can be lamps labeled HIGH and LOW, relays providing corrective action, etc. Sensor may be photocell instead of thermistor shown.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 31.

HYBRID LADDER SWITCH—Trim value is 4 ohms in first three bits, and accuracy well within 1 mV. Has been used in 11-bit analog-digital converter, and time-shared as 9-bit successive-approximation 200-kHz analog-digital converter.—C. R. Luebke, Ladder Switch, *EDN*, Sept. 1, 1969, p 76.

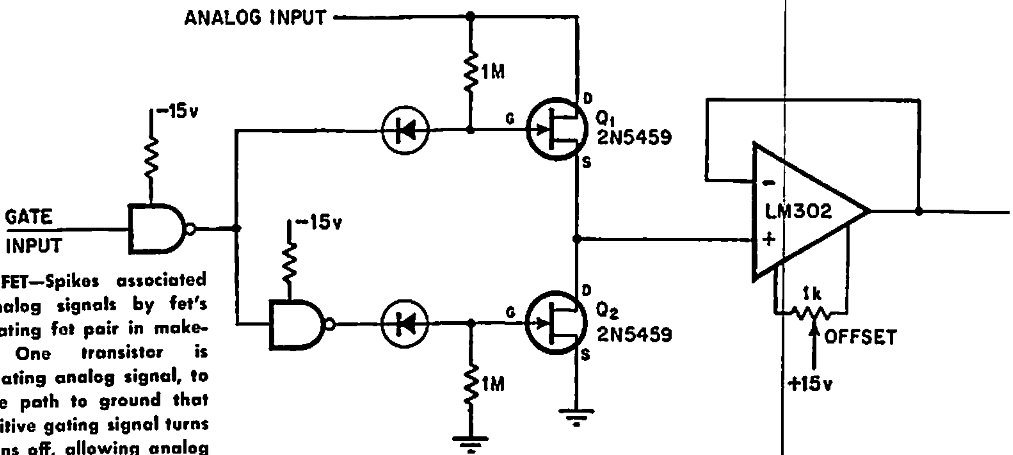

+15V
5.1k
470
2N2432
-5V
2N3677
560 pF
100 pF
TO LADDER
2N3677
5.1k
3.9k
2N3677
10k
-15V
+5V


+12V
1K
REMOTE INVERT
+12V
+12V
33K
IN
∞
2N338
OUT
10K
1K
1K
∞

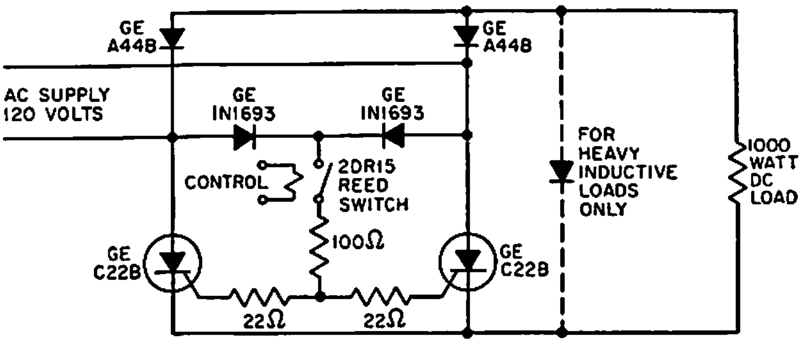
REMOTE-CONTROL PHASE SELECTOR—Relay and unity-gain transistor amplifier permit selection of a-c signal or 180-deg phase-inverted version while minimizing system noise of long signal paths.—M. I. Neidich, Remote Switching Technique Reduces System Noise, *Electronic Design*, Feb. 15, 1965, p 78–79.


CHASSIS MOUNTED REMOTE SWITCH TERMINALS
S2
D3 KD2103
LOAD
C1 10 µF
KD2100 Y2
R3 4.7 K 2 W
D1 KD2103
R1 4.7 K 2 W
C2 10 µF
R2 270
10 A
S1
120 V 60 Hz
D2 KD2103
R4 470
KD2100 Y1

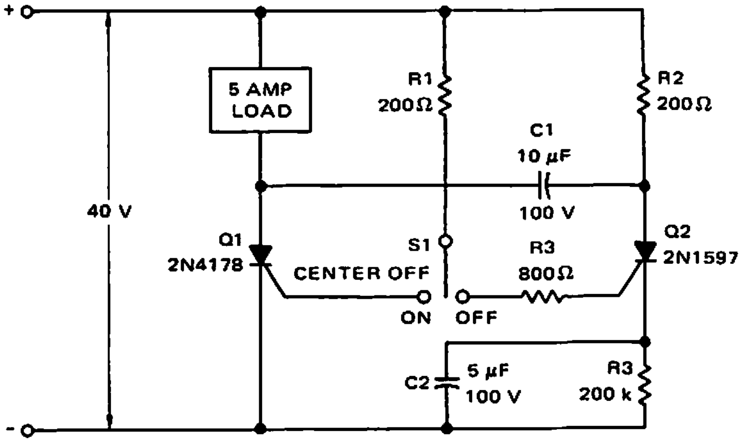
1-KW SYNCHRONOUS SWITCH—Provides switching without generation of rfi, using low-current switch S2 which may be remotely located.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 93.


ANALOG INPUT
1M
-15v
D
G
Q1 2N5459
S
GATE INPUT
-15v
-
LM302
+
1k
OFFSET
+15v
G
D
Q2 2N5459
S
1M

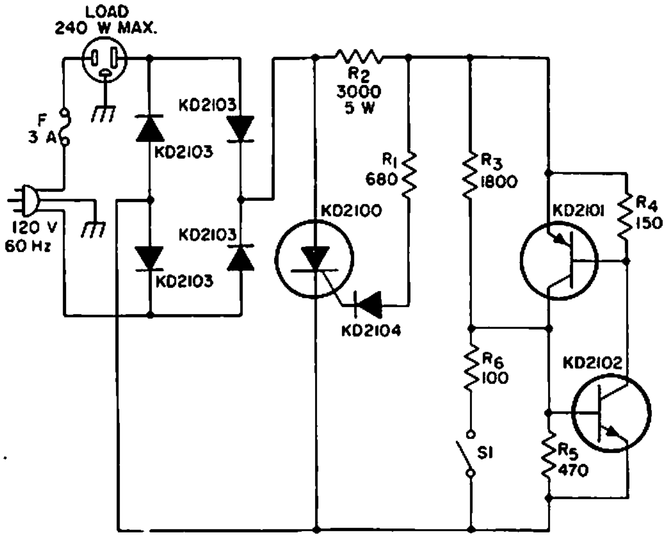
MAKE-BEFORE-BREAK FET—Spikes associated with switching of analog signals by fet's are overcome by operating fet pair in make-before-break mode. One transistor is switched on prior to gating analog signal, to provide low-impedance path to ground that minimizes spikes. Positive gating signal turns on Q1 while Q2 remains off, allowing analog signal to be transmitted through opamp to output. Negative gating signal opens analog switch by turning on Q2 before turning off Q1.—L. F. Halio, Make-Before-Break Mode Improves FET Switch, *Electronics*, April 27, 1970, p 90.


GE A448
GE A448
AC SUPPLY 120 VOLTS
GE IN1693
GE IN1693
CONTROL
2DR15 REED SWITCH
100Ω
GE C22B
GE C22B
22Ω
22Ω
FOR HEAVY INDUCTIVE LOADS ONLY
1000 WATT DC LOAD

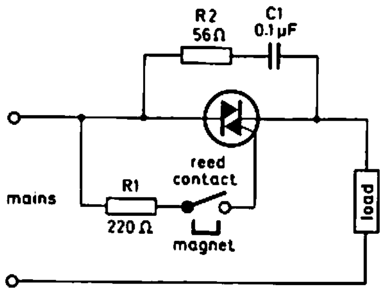
1-KW STATIC SWITCH—Operates from a-c line and provides 120 V d-c for 1,000-W load. Control signal applied to reed switch will turn load on or off in one cycle. Designed for applications having high duty cycle, such as motor controls for machine tools and conveyors, welding controls, battery chargers, temperature controls, and process controls.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 6.


+
-
40 V
5 AMP LOAD
R1 200Ω
R2 200Ω
C1 10 µF 100 V
Q1 2N4178
S1
CENTER OFF
ON
OFF
R3 800Ω
Q2 2N1597
C2 5 µF 100 V
R3 200 k

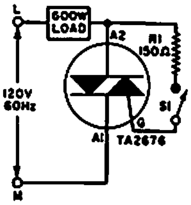
SCR STATIC D-C CONTACTOR—Requires only momentary contact of spring-loaded spdt switch for turning on or turning off 5-A d-c load. Once scr Q1 is turned on by gate current through R1, gate drive is no longer required and switch can be released. When switch is pushed to OFF position, scr Q2 receives gate current and comes on. C1 then discharges and turns Q1 off. C2 then charges to supply voltage and turns Q2 off. Q2 is much smaller than Q1 because it is used to commutate Q1 off.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–11.


LOAD 240 W MAX.
F 3 A
120 V 60 Hz
KD2103
KD2103
KD2103
KD2103
R_2 3000 5 W
R_1 680
KD2100
KD2104
R_3 1800
KD2101
R_4 150
KD2102
R_6 100
S1
R_5 470

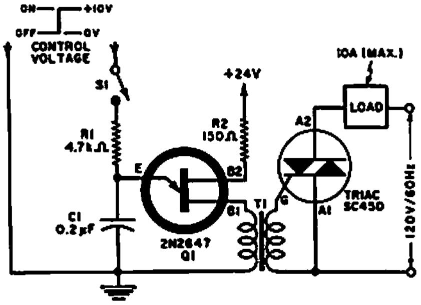
SYNCHRONOUS SWITCH—Prevents rfi by applying power to a-c loads up to 24 W only at near-zero points in a-c cycle. Triggering of scr occurs at 6.5 V. Regenerative-transistor switch triggers at 2.8 V with S1 open and 13.5 V with S1 closed. With S1 open, switch therefore conducts and blocks scr so load is off. When S1 is closed, scr conducts if supply voltage at that instant is less than 13.5 V, to apply power safely to load without rfi. If supply voltage is above 13.5 V, scr stays off for remainder of that input half-cycle, and is triggered only when voltage reaches 6.5 V on succeeding half-cycles.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 90.


R2
56Ω
C1
0.1μF
mains
R1
220Ω
reed
contact
magnet
load

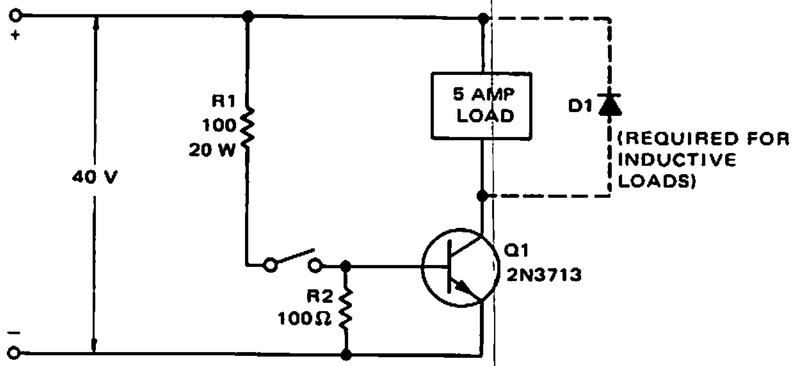
STATIC POWER SWITCH—Long-life reed relay serves as simple trigger for triac control of single-phase a-c load. Hermetic sealing of relay permits use in presence of gasoline vapor or in lines having explosive gases. Value of R1 in ohms should be about equal to a-c line voltage in volts, to give gate current of about 1 A for triac. R2 and C1 suppress transients.—Triacs—Operation and Use, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1969.


L
600W
LOAD
A2
R1
150Ω
120V
60Hz
S1
G
A1
TA2676
N

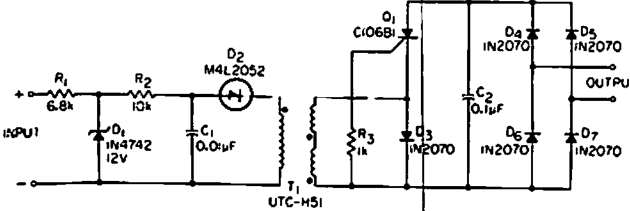
TRIAC FOR A-C LOADS—Power line triggers gated bidirectional controlled rectifier when S1 is closed. When S1 is opened, triac will cut off at next zero crossover of a-c line and remain off until S1 is again closed.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.


ON
+10V
OFF
0V
CONTROL
VOLTAGE
S1
+24V
10A (MAX.)
LOAD
R1
4.7kΩ
R2
150Ω
E
B2
A2
B1
T1
G
A1
TRIAC
SC450
C1
0.2μF
2N2647
Q1
120V/60Hz

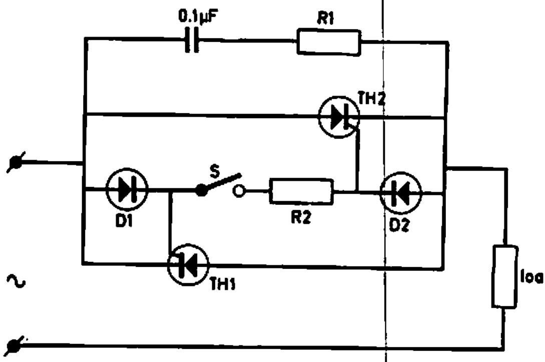
ISOLATED CONTROL—Transformer provides isolation of control circuit from a-c load. Closing S1 starts relaxation oscillator Q1 which operates in range of 600 to 6,000 Hz. First pulse of each half-cycle of a-c line causes triac to saturate for remainder of that half-cycle. Triac cuts off momentarily at first zero crossover of a-c line, but is triggered on again by the first pulse received from Q1 after the next half-cycle begins.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.


+
R1
100
20 W
40 V
5 AMP
LOAD
D1
(REQUIRED FOR
INDUCTIVE
LOADS)
Q1
2N3713
R2
100Ω
−

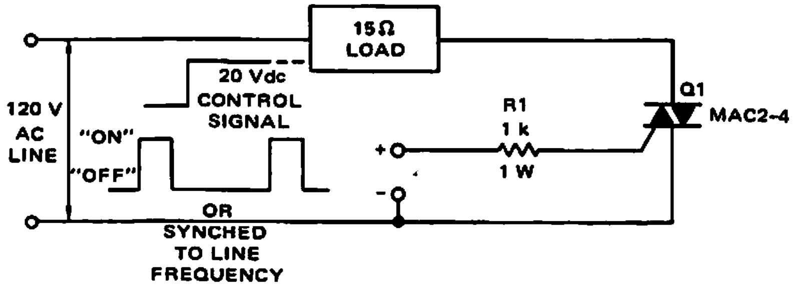
TRANSISTOR STATIC D-C CONTACTOR—Small switch, which can be remote from load, turns on transistor Q1 when closed. Will handle d-c loads up to 5 A.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–11.


+
R1
6.8k
R2
10k
D2
M4L2052
INPUT
D1
1N4742
12V
C1
0.01μF
−
T1
UTC-H51
Q1
C106B1
R3
1k
D3
1N2070
C2
0.1μF
D4
1N2070
D5
1N2070
D6
1N2070
D7
1N2070
OUTPUT

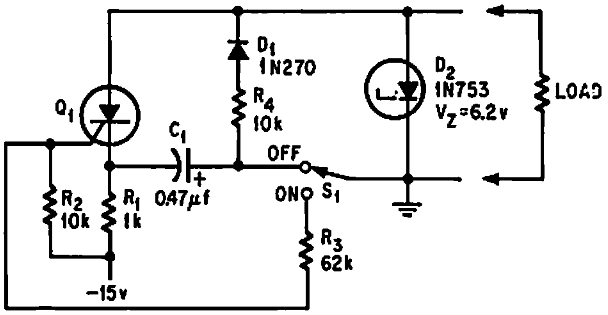
SIGNAL-POWERED SWITCH—D-c control voltage above 9.3 V at input turns on four-layer breakover diode D2 in simple relaxation oscillator circuit that induces train of pulses in secondary of T1, to gate scr on and apply power to load up to 1.5 A that scr places across a-c line. Pulse train ensures almost full firing of scr during each 60-Hz a-c cycle. Pulse transformer isolates voltage sensor from load. May be used to control alarm horn, lamp, or a-c relay.—P. A. Lajoie, Signal-Powered D-C Voltage Sensor Controls A-C Loads, *EEE*, Jan. 1968, p 117–118.


0.1μF
R1
TH2
S
D1
R2
D2
TH1
~
load

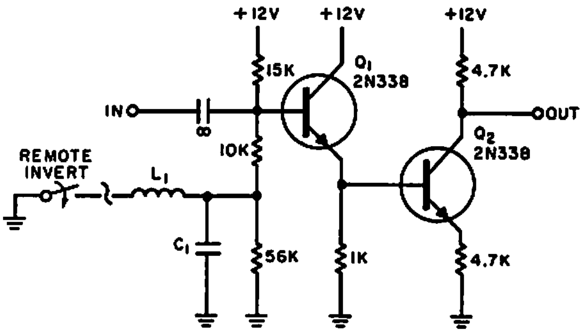
A-C STATIC CONTACTOR—Will give millions of operations silently, with minimum rfi and extremely low control power. Uses thyristors TH1 and TH2 connected in antiparallel, for handling load rated between about 0.5 and 35 kW; thus, for 25 A rms loads current, operating on 220 V a-c line, thyristor can be Philips BTX81-300R. Both diodes can be BA145, BY126, BYX10, or similar types. For 220-V line, R1 is 56 and R2 is 220; for 115-V line, R1 is 39 and R2 is 120. Switch may be reed-type, microswitch, or thermostat contact. —A. C. Static Contactor, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 20, 1968.


15Ω
LOAD
120 V
AC
LINE
"ON"
"OFF"
20 Vdc
CONTROL
SIGNAL
OR
SYNCHED
TO LINE
FREQUENCY
+
-
R1
1 k
1 W
Q1
MAC2-4

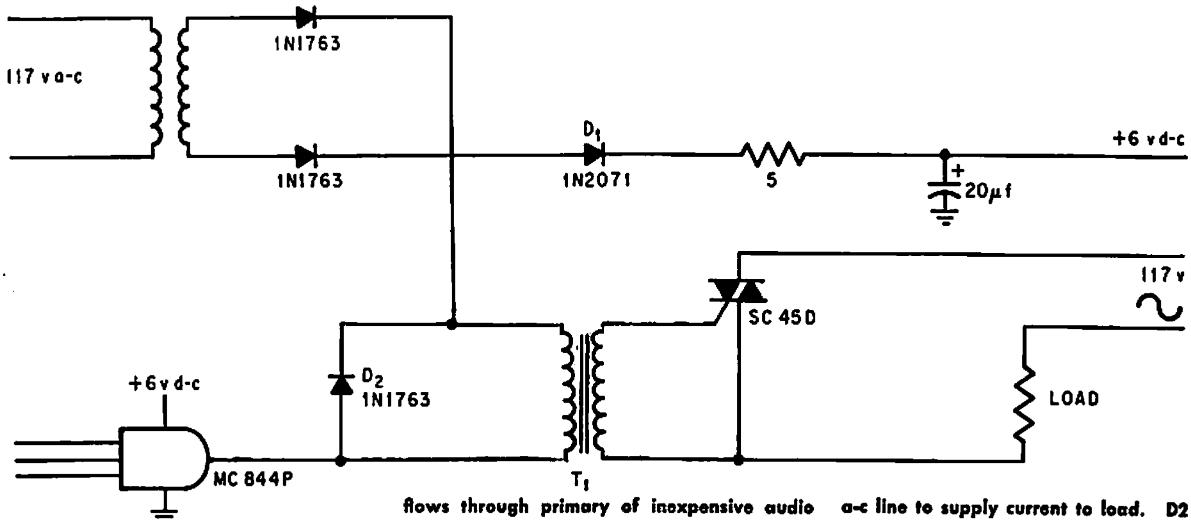
TRIAC A-C STATIC SWITCH—Triac remains on until control signal is removed, and turns off when current next drops to zero. Will handle reactive as well as resistive loads on 60-Hz a-c line.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–8.


Q1
D1
1N270
R4
10k
D2
1N753
V_Z=6.2v
LOAD
C1
+
0.47μf
OFF
ON
S1
R2
10k
R1
1k
R3
62k
-15v

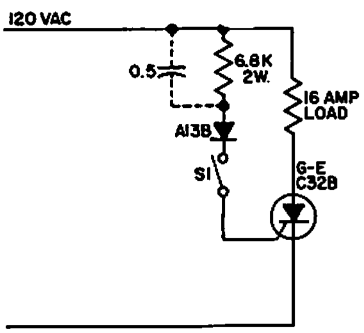
BOUNCE ELIMINATOR—Turning on scr Q1 simultaneously with closing of switch eliminates false triggering signal or noise caused by contact bounce. Scr consumes no quiescent power.—R. A. Wilson, SCR Takes Bounce Out of Switching, *Electronics*, Oct. 30, 1967, p 69.


+12V
+12V
+12V
15K
Q1
2N338
4.7K
IN
∞
OUT
10K
Q2
2N338
REMOTE
INVERT
L1
C1
56K
1K
4.7K

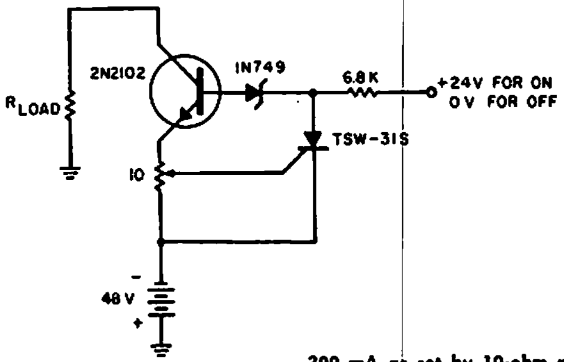
PHASE SELECTOR WITHOUT RELAY—Two-transistor circuit permits remote selection of a-c signal or 180-deg phase-inverted version without use of relay. When inversion is desired, switch is closed.—M. I. Neidich, Remote Switching Technique Reduces System Noise, *Electronic Design*, Feb. 15, 1965, p 78–79.


117 va-c
1N1763
1N1763
D1
1N2071
5
+6 vd-c
+
20μf
117 v
SC 45D
LOAD
+6 v d-c
D2
1N1763
MC 844P
T1

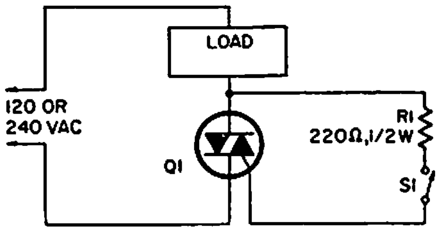
A-C CONTROL WITH GATE—When IC is gated on by three simultaneous inputs, current flows through primary of inexpensive audio transformer, inducing same half-wave rectified voltage in secondary for triggering triac into conduction every half-cycle and allowing a-c line to supply current to load. D2 shunts inductive spikes.—G. V. Wintross, IC Gate Controls Triac with Audio Transformer, *Electronics*, Aug. 5, 1968, p 106.


120 VAC
0.5
6.8K 2W
16 AMP LOAD
A13B
S1
G-E C32B

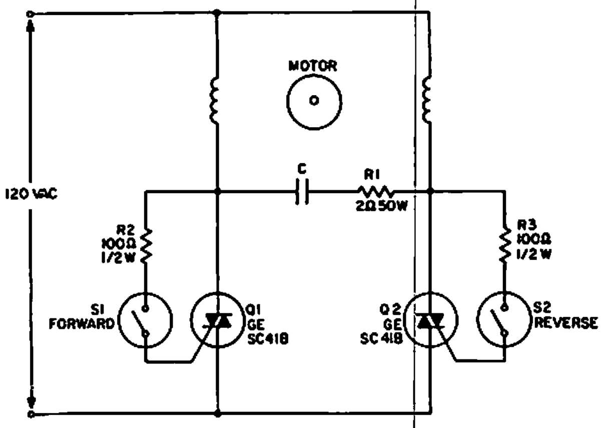
HALF-WAVE NORMALLY OPEN—Static power switch can be used for heater loads, limit switches, and other applications requiring switching of half-wave a-c power. Closing switch S1 fires scr and energizes load.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 6.


R_{LOAD}
2N2102
1N749
6.8K
+24V FOR ON
0V FOR OFF
TSW-31S
10
-
48 V
+

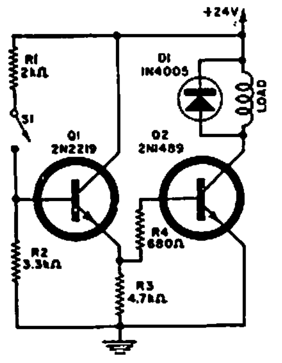
FAST-ACTING SCR—Simple scr circuit breaker operates in less than 2 μs to interrupt load current at any desired value between 100 and 300 mA as set by 10-ohm pot.—J. A. Means, SCR Circuit Breaker Has Fast Operation, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 220.


LOAD
120 OR 240 VAC
Q1
R1 220Ω,1/2W
S1

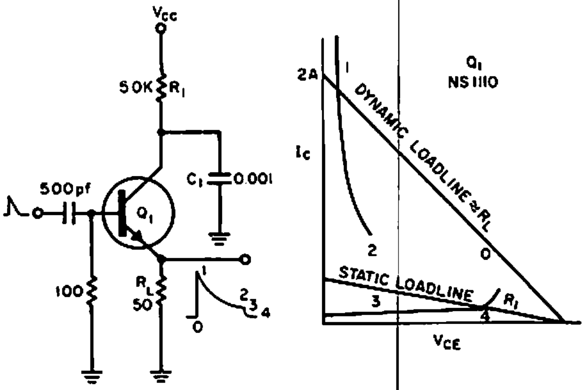
SELF-TRIGGERED TRIAC—When switch S1 is closed, triac is triggered on just after start of each half-cycle (at about 6 V). S1 may be relay contact, but must withstand full line voltage. Load can be up to 6 A. Use RCA 40429 for 120 V and 40430 for 240 V.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.


MOTOR
120 VAC
C
R1 2Ω 50W
R2 100Ω 1/2W
R3 100Ω 1/2W
S1 FORWARD
Q1 GE SC41B
Q2 GE SC41B
S2 REVERSE

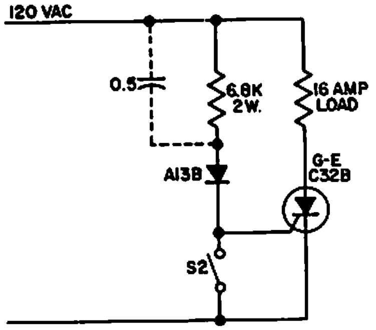
TRIAC AS STATIC REVERSING SWITCH—Pair of triacs serves as static switch, in place of contactors, for reversing-type psc motor, to provide rapid-response reversal. S1 and S2 can be reed switches, or triacs can be gated by other means. With appropriate firing circuit, arrangement can serve as motor overtemperature control that senses motor winding temperature directly.—"SCR Manual," 4th Edition, General Electric, 1967, p 222.


+24V
R1 2kΩ
S1
D1 1N4005
LOAD
Q1 2N2219
Q2 2N1489
R4 680Ω
R2 3.3kΩ
R3 4.7kΩ

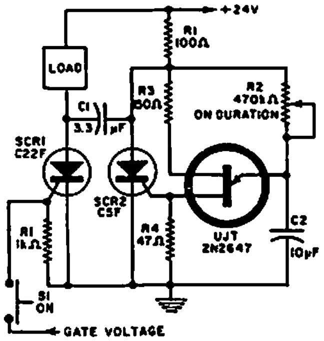
SOLENOID DRIVER—Will switch loads up to 5 A. Diode D1 protects Q2 by suppressing voltage transient developed when inductive load is de-energized.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.


V_{CC}
50K R_1
C_1 0.001
500pf
Q_1
100
R_L 50
1
0
2
3
4
2A
I_C
Q_1 NS1110
DYNAMIC LOADLINE ≈ R_L
STATIC LOADLINE
R_1
V_{CE}

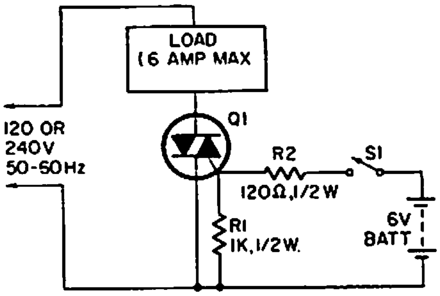
BASIC AVALANCHE—Can be used with any appropriate avalanche transistor meeting load requirements. Values shown are for NS1110, having load lines at right. C1 supplies rush of current for avalanche between point 0 and 1, but must be recharged between points 3 and 4 before circuit is ready for another avalanche. Can be used in pulse generators and voltage comparators.—B. H. Bell, Avalanche Circuits Are More Versatile Than You Think, *Electronic Design*, June 8, 1964, p 56–63.


120 VAC
0.5
6.8K
2W.
16 AMP
LOAD
A13B
G-E
C32B
S2

HALF-WAVE NORMALLY CLOSED—When switch is open, scr and load are energized. Closing of switch shorts out trigger to gate and opens scr, turning off load.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 6.

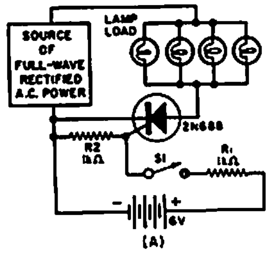

+24V
R1
100Ω
LOAD
C1
3.3 μF
R3
100Ω
R2
470kΩ
ON DURATION
SCR1
C22F
SCR2
C5F
R1
1kΩ
R4
47Ω
UJT
2N2647
C2
10μF
S1
ON
GATE VOLTAGE

TIMING SWITCH—Actuating S1 gates SCR1 on and energizes load, while commutating capacitor C1 charges through SCR1 and R1. Relaxation oscillator UJT produces one cycle of oscillation under this condition, duration of which is determined by setting of R2. At end of cycle, SCR2 is gated on, UJT is disabled, and SCR1 turned off.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.

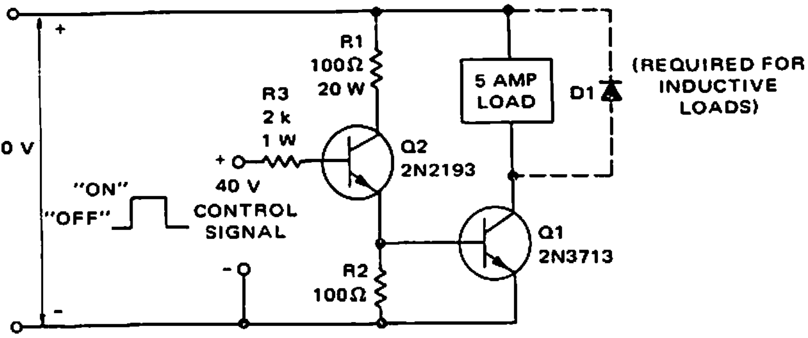

LOAD
(6 AMP MAX
120 OR
240V
50-60Hz
Q1
R2
S1
120Ω,1/2W
R1
1K,1/2W.
6V
BATT

Q1 = 40429 (RCA) ON 120 VAC
= 40430 (RCA) ON 240 VAC

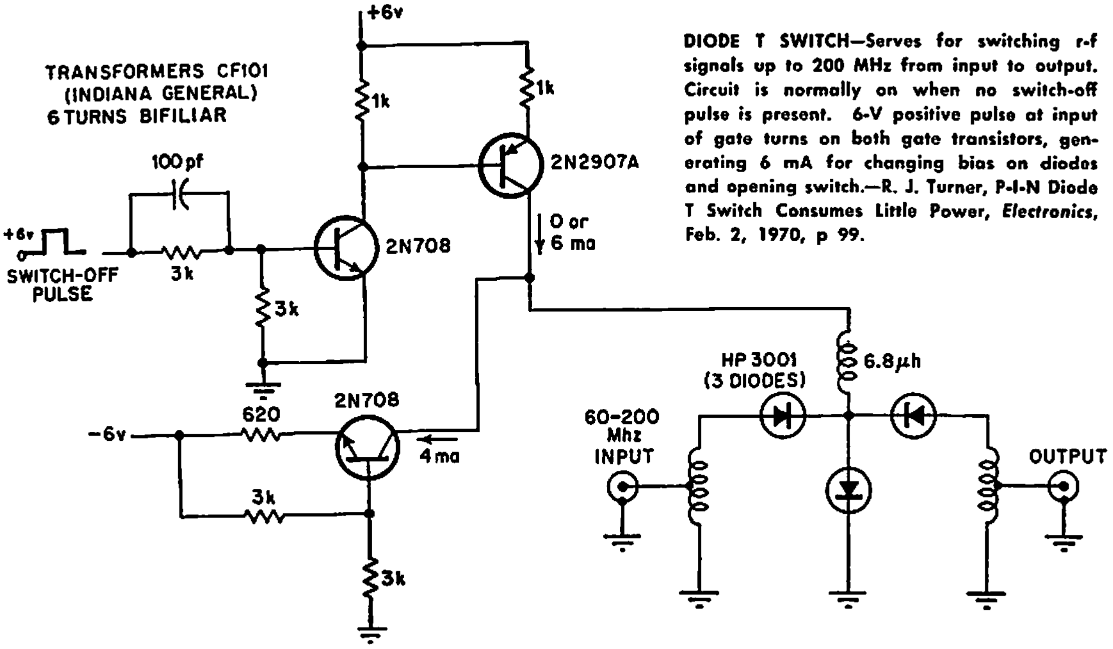
BASIC TRIAC SWITCH—Switch S1 handles only about 40 mA in triggering triac that carries 6-A load current. For 120 V a-c, use RCA 40429; for 240 V, use 40430. Will handle surge currents of cold incandescent lamps.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.


SOURCE
OF
FULL-WAVE
RECTIFIED
A.C. POWER
LAMP
LOAD
2N688
R2
1kΩ
S1
R1
1kΩ
-
+
6V
(A)

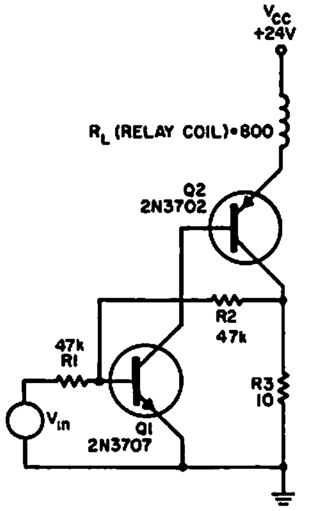
LAMP DRIVER—Gate drive of only 3 V at 40 mA on scr will handle lamp load of 35 A, provided lamp power source is full-wave rectified a-c, without filtering. When lamps are to be turned off, S1 is opened, and lamps are de-energized at next return of d-c waveform to zero.—A. Harris, Semiconductor Switching of Low-Power Circuits, *Electronics World*, June 1967, p 33–35.


+
40 V
-
R1
100Ω
20 W
R3
2 k
1 W
5 AMP
LOAD
D1
(REQUIRED FOR
INDUCTIVE
LOADS)
Q2
2N2193
+
40 V
"ON"
"OFF"
CONTROL
SIGNAL
-
Q1
2N3713
R2
100Ω

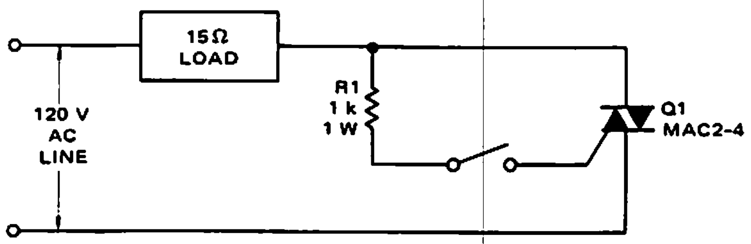
TRANSISTOR STATIC D-C SWITCH—Load is on only while control signal is present to turn on both transistors.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–12.


TRANSFORMERS CF101
(INDIANA GENERAL)
6 TURNS BIFILIAR
+6v
1k
1k
2N2907A
100 pf
+6v
SWITCH-OFF
PULSE
3k
2N708
0 or
6 ma
3k
2N708
620
-6v
4 ma
3k
3k
HP 3001
(3 DIODES)
6.8μh
60-200
Mhz
INPUT
OUTPUT

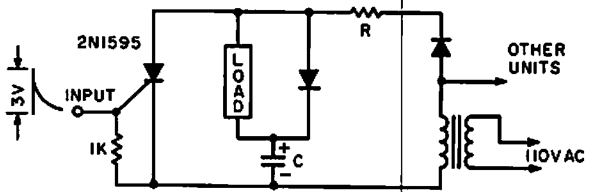
DIODE T SWITCH—Serves for switching r-f signals up to 200 MHz from input to output. Circuit is normally on when no switch-off pulse is present. 6-V positive pulse at input of gate turns on both gate transistors, generating 6 mA for changing bias on diodes and opening switch.—R. J. Turner, P-I-N Diode T Switch Consumes Little Power, *Electronics*, Feb. 2, 1970, p 99.


V_{CC}
+24V
R_L (RELAY COIL)•800
Q2
2N3702
R2
47k
47k
RI
R3
10
V_{in}
QI
2N3707

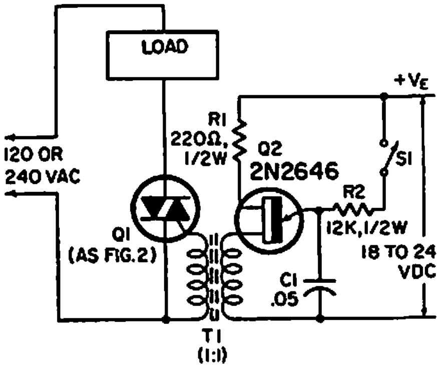
SNAP-ACTION SWITCH—Used for on-off control of relay or other load. Complementary silicon transistors behave like Schmitt trigger, with both turning on for 1.4 V d-c at input, and turning off at 1.1 V. When off, current drain is zero. If input is voltage drop across sensor, circuit may be used as simple and reliable temperature, photoelectric, or other control.—A. Anzani, On-Off Solid-State Switch Is Simple and Inexpensive, *Electronic Design*, Sept. 27, 1967, p 70.


15Ω
LOAD
120 V
AC
LINE
R1
1 k
1 W
Q1
MAC2-4

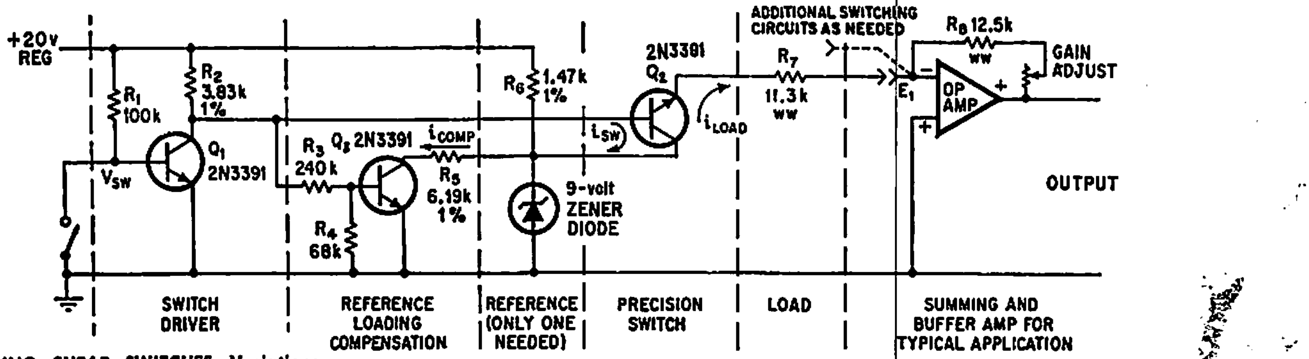
TRIAC STATIC A-C CONTACTOR—Small switch applies gate current to triac, to close load circuit. When switch is open, triac turns off when current next drops to zero. Will handle reactive and resistive loads.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–9.


2N1595
3V
INPUT
IK
LOAD
C
R
OTHER
UNITS
110VAC

UNIVERSAL SCR DRIVER—Used to drive 20-channel operations recorder having pen deflection coils operating from 24-V d-c source. When scr is fired by input pulse, C discharges through load and charging current source is clamped. Value of C is determined by load inductance; typical value is 100 μF. R is usually 50 ohms, chosen to give fast recharging of C.—J. Gray, Jr., SCR Circuit a Versatile Driver of Many Loads, *Electronic Design*, April 13, 1964, p 74.


LOAD
120 OR
240 VAC
RI
220Ω,
1/2W
Q2
2N2646
+V_E
SI
R2
12K,1/2W
18 TO 24
VDC
QI
(AS FIG.2)
CI
.05
TI
(1:1)

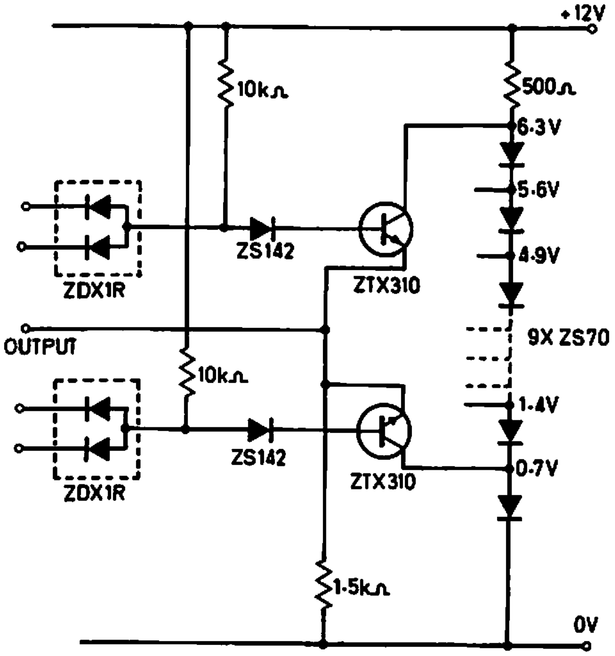
UJT-TRIGGERED TRIAC—When S1 is closed, ujt oscillator applies continuous train of trigger pulses to gate of triac Q1 through isolating transformer T1. With trigger at 2 kHz, triac is triggered on very shortly after start of each 60-Hz half-cycle, for full-wave control. Switch handles only 2 mA, and can be replaced by transistor driven by any type of transducer. Use RCA 40429 triac for 120 V and 40430 for 240 V.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.


+20v
REG
R_1
100k
R_2
3.83k
1%
V_{SW}
Q_1
2N3391
R_3
240k
Q_3 2N3391
i_{COMP}
R_5
6.19k
1%
R_4
68k
R_6
1.47k
1%
9-volt
ZENER
DIODE
i_{SW}
2N3391
Q_2
i_{LOAD}
ADDITIONAL SWITCHING
CIRCUITS AS NEEDED
R_7
11.3k
ww
R_8 12.5k
ww
E_1
OP
AMP
GAIN
ADJUST
OUTPUT
SWITCH
DRIVER
REFERENCE
LOADING
COMPENSATION
REFERENCE
(ONLY ONE
NEEDED)
PRECISION
SWITCH
LOAD
SUMMING AND
BUFFER AMP FOR
TYPICAL APPLICATION

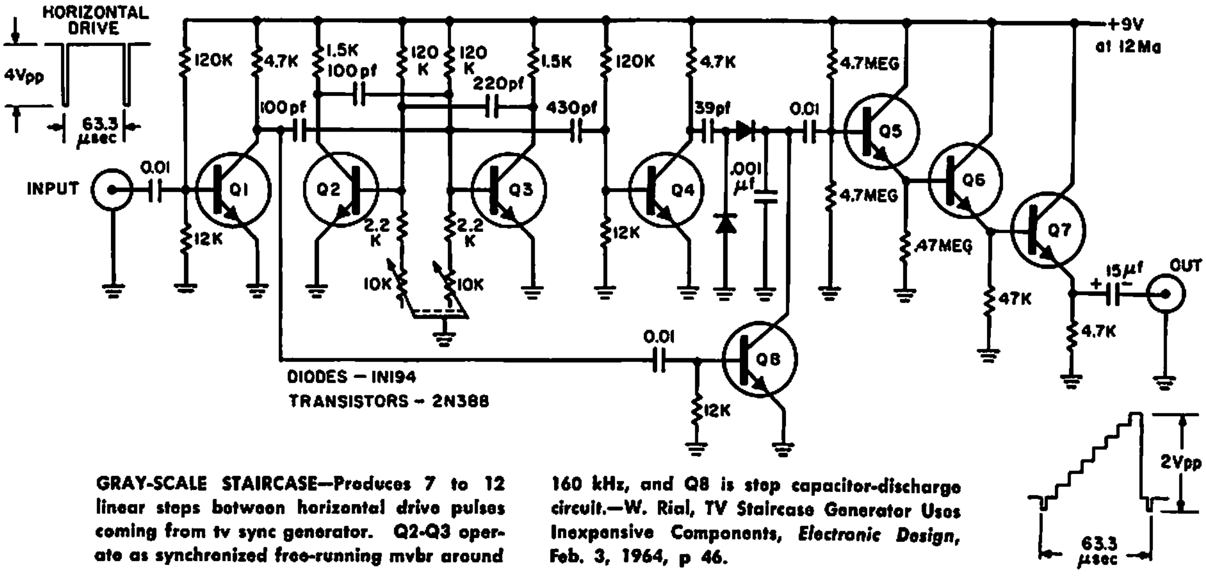
OVERCOMING CHEAP SWITCHES—Variations of up to 1,000 ohms in contact resistance of cheap switches have no effect on operation of circuit, in which Q2 connected in inverted mode acts as precision low-contact-resistance switch. Designed for applying precision reference voltage from 9-V zener to IC opamp.—G. R. Latham 4th, Inverted Transistor Switches Precision D-C Voltage, *Electronics*, Aug. 4, 1969, p 92–93.

CHAPTER 81

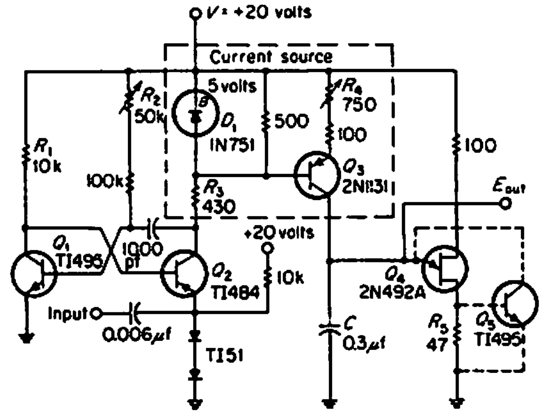
Staircase Generator Circuits


+12V
10kΩ
500Ω
6·3V
5·6V
4·9V
ZDX1R
ZS142
ZTX310
9X ZS70
OUTPUT
10kΩ
1·4V
ZDX1R
ZS142
ZTX310
0·7V
1·5kΩ
0V

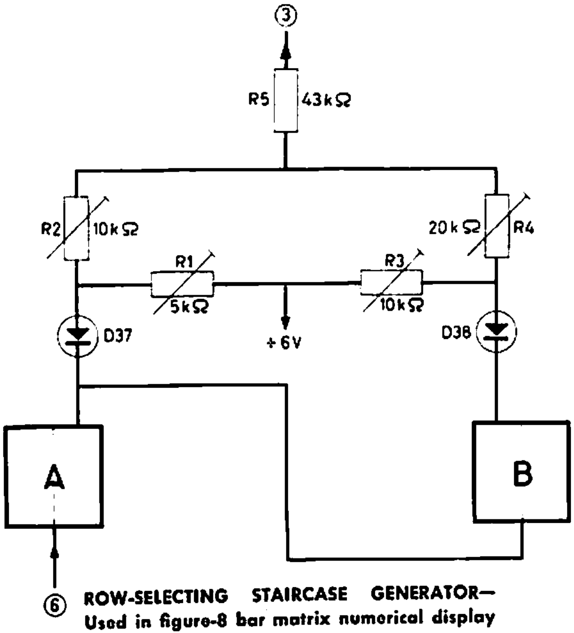
EQUAL STEPS—Reference chain of forward-biased diodes gives known equal steps of voltage, when reference points are connected sequentially to common load by switching transistors. Johnson decade counter is used with diode decoding to provide sequential switching.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 21.


HORIZONTAL DRIVE
4Vpp
63.3 μsec
INPUT
0.01
120K
12K
4.7K
Q1
100pf
1.5K
100pf
Q2
120 K
120 K
220pf
2.2 K
2.2 K
10K
10K
Q3
1.5K
430pf
120K
12K
Q4
4.7K
39pf
.001 μf
0.01
Q5
4.7MEG
4.7MEG
Q6
.47MEG
Q7
47K
+9V at 12Ma
15μf
OUT
4.7K
0.01
Q8
12K
DIODES – IN194
TRANSISTORS – 2N388
2Vpp
63.3 μsec

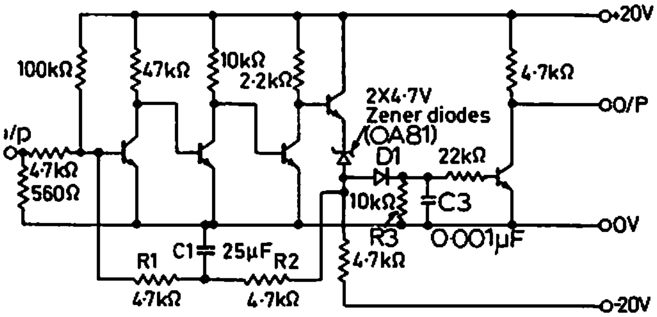
GRAY-SCALE STAIRCASE—Produces 7 to 12 linear steps between horizontal drive pulses coming from tv sync generator. Q2-Q3 operate as synchronized free-running mvbr around 160 kHz, and Q8 is step capacitor-discharge circuit.—W. Rial, TV Staircase Generator Uses Inexpensive Components, *Electronic Design*, Feb. 3, 1964, p 46.


V = +20 volts
Current source
5 volts
R2 50k
D1 IN751
500
R4 750
100
Q3 2N1131
R1 10k
100k
R3 430
100
Eout
Q1 TI495
1000 pf
Q2 TI484
+20 volts
10k
Q4 2N492A
Input
0.006μf
TI51
C 0.3μf
R5 47
Q5 TI495

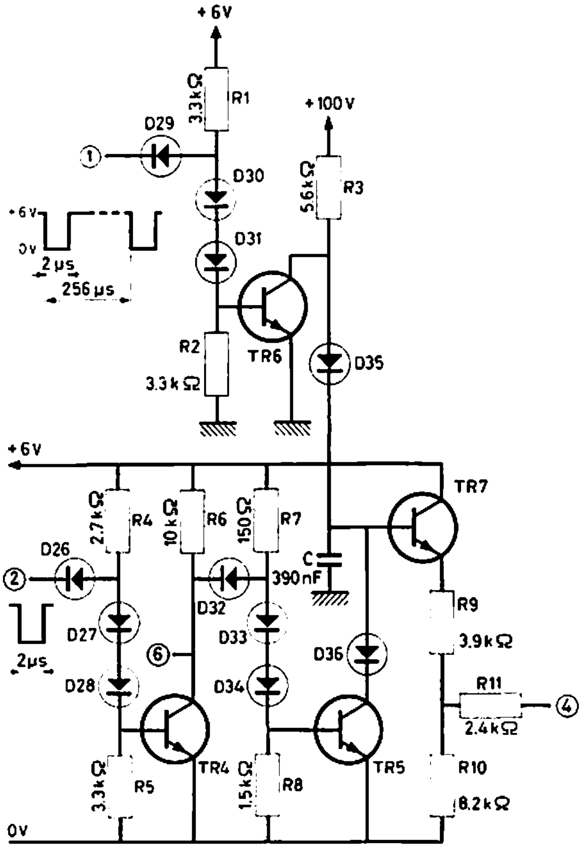
UJT STAIRCASE WITH COUNTER—Will operate at inputs up to 10 kHz. Negative input pulse triggers Q2 on for period set by R2, to furnish drive for current source Q3-D1 that charges C. At end of period, C discharges slowly until next negative pulse arrives. R4 determines height of each voltage step on C. When voltage is high enough to fire ujt Q4, C discharges and cycle repeats. Addition of Q5 discharges C faster, to double maximum operating frequency.—B. Crawford and R. T. Dean, The Unijunction Transistor in Relaxation Circuits, *Electro-Technology*, March 1964, p 40–45.


③
R5 43kΩ
R2 10kΩ
20kΩ R4
R1 5kΩ
R3 10kΩ
D37
+6V
D38
A
B
⑥

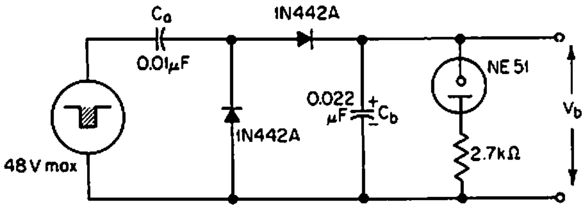
ROW-SELECTING STAIRCASE GENERATOR—Used in figure-8 bar matrix numerical display to step down crt beam one line and return it to left after every 12 generated characters. Circuit makes use of clock pulses (250 kHz) and control logic levels, as described in article. Flip-flops A and B give four possible output conditions, one for each row of characters displayed. Potentiometers adjust spacing between rows. Diodes are BAX13.—A. P. Tanis, Numerical Display with Bar Matrix Character Generator, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966–1967, p 73–83.


+20V
100kΩ
47kΩ
10kΩ
2·2kΩ
4·7kΩ
2X4·7V Zener diodes (OA81)
O/P
I/P
4·7kΩ
560Ω
D1
22kΩ
10kΩ
C3
R3
0·001μF
0V
R1
C1 25μF
R2
4·7kΩ
4·7kΩ
4·7kΩ
-20V

EQUAL-STEP LINEAR—Produces linear staircase voltage waveform for ultrasonic image converter using switching matrix and pulse techniques for reproducing object image on array of 100 transducer elements.—S. O. Harrold, Solid State Ultrasonic Camera, *Ultrasonics*, April 1969, p 95–101.

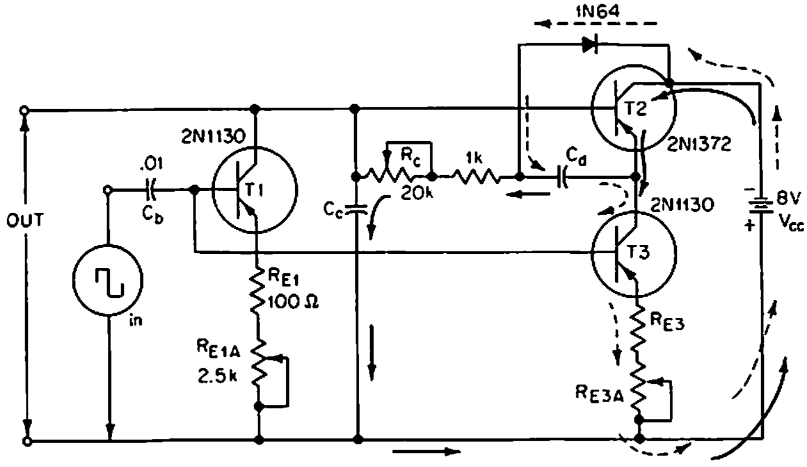

+6V
3.3kΩ R1
D29
①
D30
+100V
5.6kΩ R3
+6V
0V
2μs
256μs
D31
TR6
R2 3.3kΩ
D35
+6V
TR7
2.7kΩ R4
10kΩ R6
150Ω R7
D26
②
C 390nF
D32
D27
D33
R9 3.9kΩ
2μs
⑥
D36
R11 2.4kΩ
④
D28
D34
TR4
TR5
3.3kΩ R5
1.5kΩ R8
R10 8.2kΩ
0V

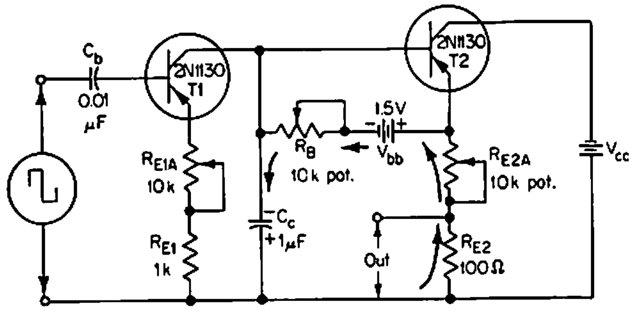
COLUMN-SELECTING STAIRCASE GENERATOR—Used in figure-8 bar matrix numerical display to shift crt beam one place to right after formation of each character. Sequence of gates identifies end of each character and triggers generator for producing next step of staircase. All transistors are BSX20 and all diodes BAX13.—A. P. Tanis, Numerical Display with Bar Matrix Character Generator, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966–1967, p 73–83.


Ca
0.01μF
1N442A
1N442A
0.022 μF
Cb
NE 51
2.7kΩ
Vb
48 V max

FOUR-STEP STAIRCASE—With neon lamp shown, firing at about 42 V, negative input pulse slightly greater than this value will require four chargings of Ca-Cb for series of four steps, with lamp firing on edge of fifth step to discharge capacitors and initiate new staircase.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 266.

THREE-TRANSISTOR LINEARIZING BOOTSTRAP—Used with staircase generator (not shown) to give essentially constant increase in pulse voltage increments, so corners of steps are on straight line. Solid arrows show path by which Cd discharges, and broken arrows show its charging path. T3 acts as switch. For optimum linearity, value of Cc in μF should be changed for each frequency band, as follows: 200–500 pps—1; 500–1,000—0.5; 1–20 kpps—0.1; 20–50—0.01; 50–100—0.001.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 292.

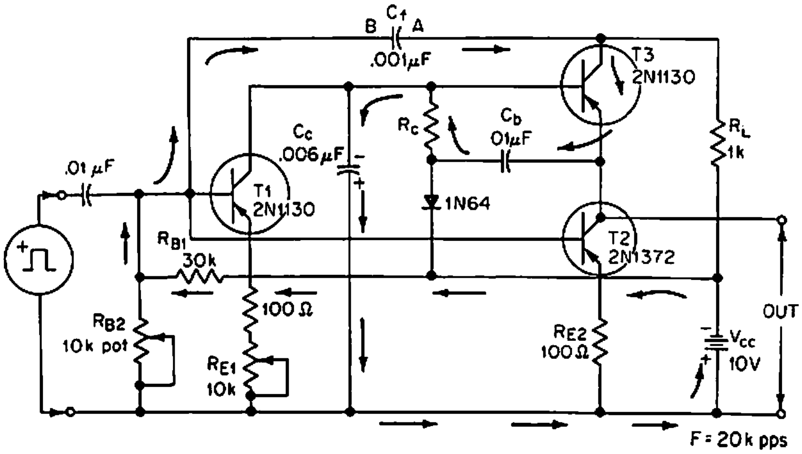

1N64
T2
2N1372
2N1130
T1
.01
Cb
Rc
20k
1k
Cd
Cc
2N1130
T3
8V
Vcc
OUT
in
RE1
100 Ω
RE1A
2.5k
RE3
RE3A

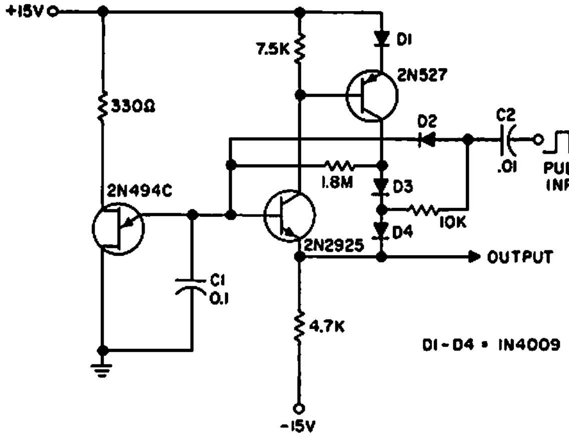

Cb
0.01 μF
2N1130
T1
2N1130
T2
1.5V
RB
Vbb
10k pot.
RE2A
10k pot.
Vcc
RE1A
10k
RE1
1k
Cc
1μF
Out
RE2
100Ω

Note: C_b should be changed to 150 pF for sweep F > 50 kilopulses

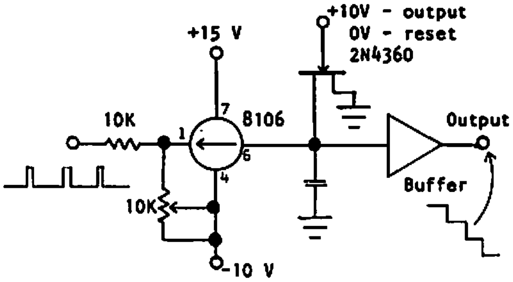
TWO-TRANSISTOR LINEARIZING BOOTSTRAP—Used with staircase generator (not shown) to give essentially constant increase in pulse voltage increments, so corners of steps are on straight line. Depends on variable voltage feedback from amplifier whose voltage gain is unity. Maximum sweep-period time varies with battery voltage, for which typical value is 10 V.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 289.

ONE-SHOT LINEARIZING BOOTSTRAP—Used with staircase generator to give equal increments, so corners of steps are on straight line. Solid arrows show path for Cf charging current; final value of this capacitor is best determined empirically while observing output waveform on scope.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 294.

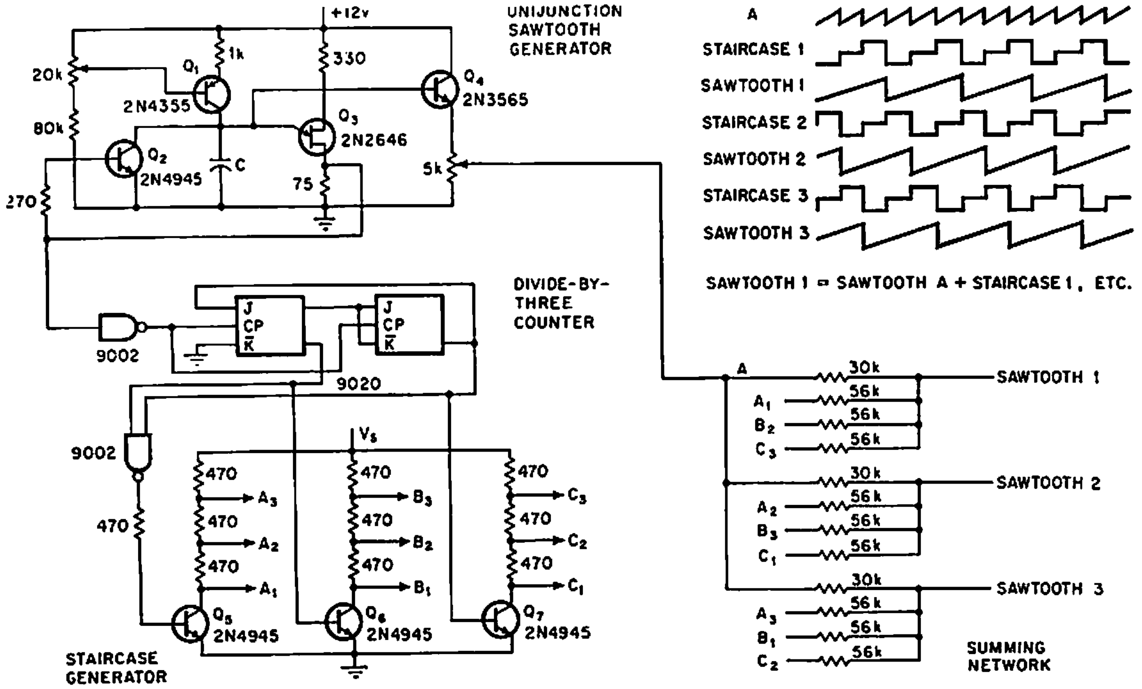

B
Cf
A
.001μF
T3
2N1130
Rc
Cb
01μF
Cc
.006μF
RL
1k
.01 μF
T1
2N1130
1N64
T2
2N1372
RB1
30k
100 Ω
OUT
RB2
10k pot
RE1
10k
RE2
100 Ω
Vcc
10V
F = 20k pps


+15V
330Ω
7.5K
D1
2N527
D2
C2
.01
PULSE INPUT
1.8M
D3
10K
D4
2N494C
2N2925
OUTPUT
C1
0.1
4.7K
D1-D4 = IN4009
-15V

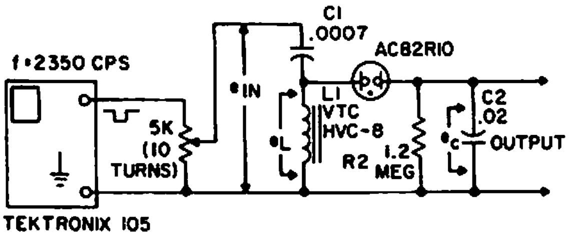
WIDE FREQUENCY RANGE—Npn-pnp emitter-follower output circuit gives high input impedance and low output impedance, to reduce droop in output voltage between pulses. Npn transistor bias is effectively bootstrapped on output, as also is diode-capacitor pump. Steps per cycle depend on ratio of C1 to C2 and amplitude of input pulse; for values shown, 12-V input gives 10 steps.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 6.


+10V - output
0V - reset
2N4360
+15 V
10K
8106
Output
Buffer
10K
-10 V

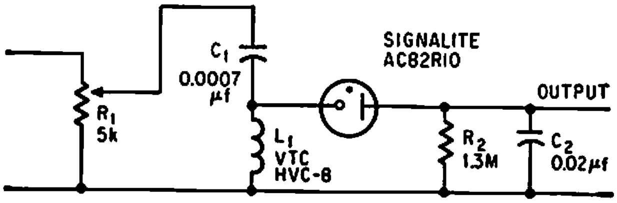
PULSE TRAIN GIVES STAIRCASE—Each input pulse produces current pulse at output of 8106 for charging capacitor in such a way that capacitor voltage increases linearly with each pulse to give staircase. Fet source follower or low-bias-current buffer amplifier must be used to isolate capacitor from low-impedance loads. For repetitive staircase, output voltage level is sampled and used to trigger fet switch that discharges capacitor. Staircase then builds up again from zero to same negative level.—Applying the Model 8106 Monolithic Precision Current Source, Optical Electronics, Tucson, Ariz., No. 10168.


+12v
UNIJUNCTION SAWTOOTH GENERATOR
20k
1k
330
Q1
2N4355
Q4
2N3565
80k
Q3
2N2646
Q2
2N4945
C
75
5k
270
DIVIDE-BY-THREE COUNTER
J
CP
K
9002
9020
9002
Vs
470
A3
A2
A1
B3
B2
B1
C3
C2
C1
Q5
2N4945
Q6
2N4945
Q7
2N4945
STAIRCASE GENERATOR
A
STAIRCASE 1
SAWTOOTH 1
STAIRCASE 2
SAWTOOTH 2
STAIRCASE 3
SAWTOOTH 3
SAWTOOTH 1 = SAWTOOTH A + STAIRCASE 1, ETC.
30k
56k
SAWTOOTH 1
SAWTOOTH 2
SAWTOOTH 3
SUMMING NETWORK

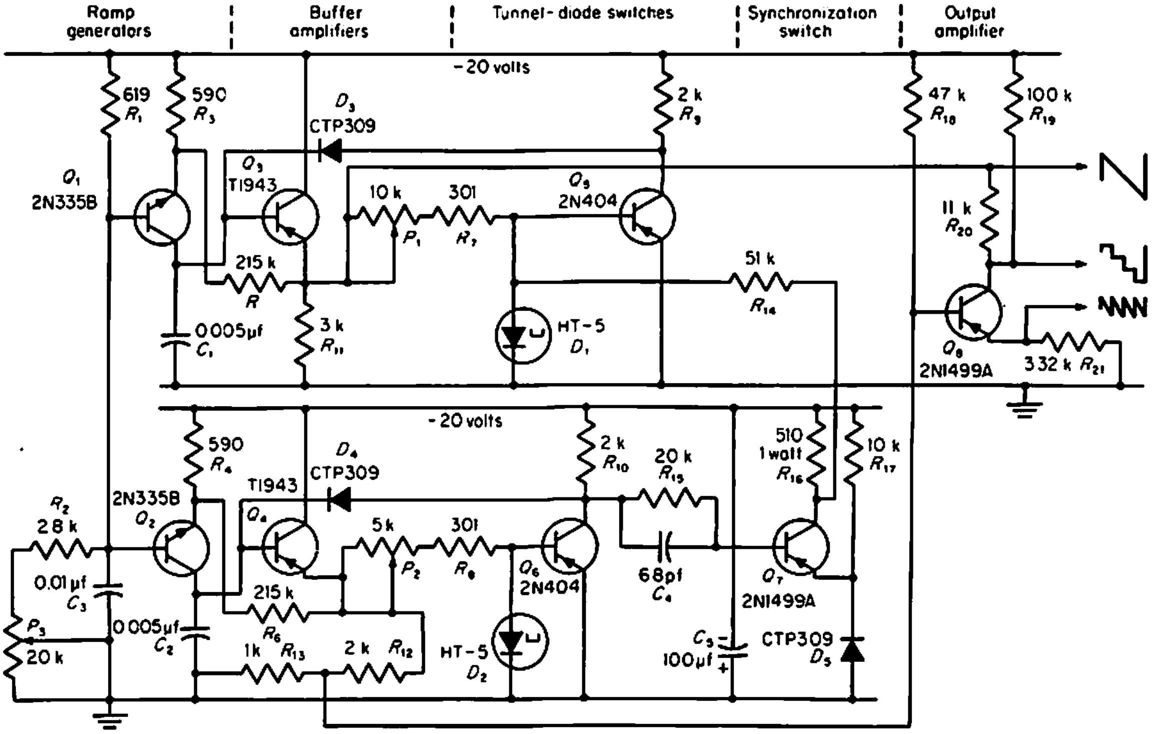
THREE-OUTPUT SAWTOOTH—Combined analog and digital circuit generates staircase whose equal-amplitude steps are added algebraically to ramps of sawtooth generator, for generating long sequential sawtooths in synchronism for crt displays, sweep circuits, and character generators. When ujt fires, counter starts and its outputs switch on Q5, Q6, and Q7 sequentially. Any number of sequential sawtooths may be produced.—E. G. Breeze, A Staircase and a Ramp Yield Multiple Sawtooths, *Electronics*, March 2, 1970, p 105.


f = 2350 CPS
5K (10 TURNS)
TEKTRONIX 105
C1 .0007
AC82R10
IN
L
L1 VTC HVC-8
R2 1.2 MEG
C
C2 .02
OUTPUT

NEON STAIRCASE—Less complex than similar circuits not using neons. May also be used as frequency divider. When input voltage of 54 V is introduced, 3 steps appear across C2. Reducing amplitude of square wave by varying 5K pot increases number of steps. Below 40 V, circuit operates as frequency divider separating out odd pulses.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 44–48.


R_1 5k
C_1 0.0007 μf
L_1 VTC HVC-8
SIGNALITE AC82R10
R_2 1.3M
C_2 0.02μf
OUTPUT

DUAL-FUNCTION NEON—Provides both frequency and voltage division with minimum components. In one mode, circuit divides input voltage into equal steps. In second mode, it acts as frequency divider in separating odd-numbered pulses in input train, eliminating need for decoding logic in binary systems. Mode of operation is determined by range of peak-to-peak input voltage; 32 to 40 gives frequency division, and 44 to 54 gives staircase generation with 4 to 13 steps. —A. B. Cistola, Neon Tube Staircase Generator Performs Two Jobs, *Electronics*, Dec. 26, 1966, p 74–75.


Ramp generators
Buffer amplifiers
Tunnel-diode switches
Synchronization switch
Output amplifier
-20 volts
619 R_1
590 R_3
Q_1 2N335B
Q_3 T1943
D_3 CTP309
10 k P_1
301 R_7
Q_5 2N404
2 k R_9
215 k R
0.005μf C_1
3 k R_{11}
HT-5 D_1
51 k R_{14}
47 k R_{18}
100 k R_{19}
11 k R_{20}
Q_8 2N1499A
332 k R_{21}
-20 volts
590 R_4
2N335B Q_2
T1943 Q_4
D_4 CTP309
R_2 28 k
0.01μf C_3
P_3 20 k
0.005μf C_2
215 k R_6
5k P_2
301 R_8
1k R_{13}
2 k R_{12}
Q_6 2N404
HT-5 D_2
2 k R_{10}
20 k R_{15}
68pf C_4
C_5 100μf
510 1 watt R_{16}
10 k R_{17}
Q_7 2N1499A
CTP309 D_5

1-MHZ TUNNEL-DIODE—Maximum amplitude of long ramp is 10 V, with duration variable between 20 μs and 2 ms. Steps are equal.—T. Mollinga, Tunnel-Diode Applications, *Electro-Technology*, Sept. 1964, p 48–53.

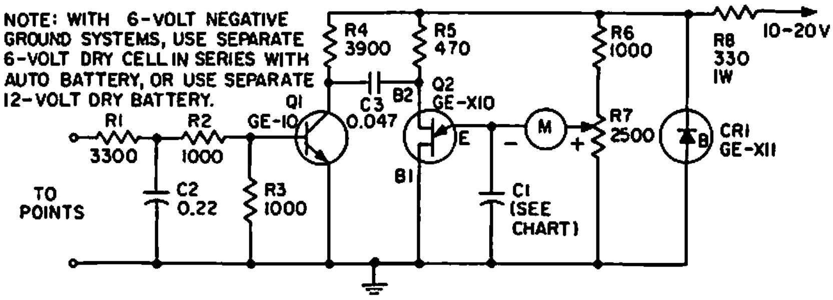
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

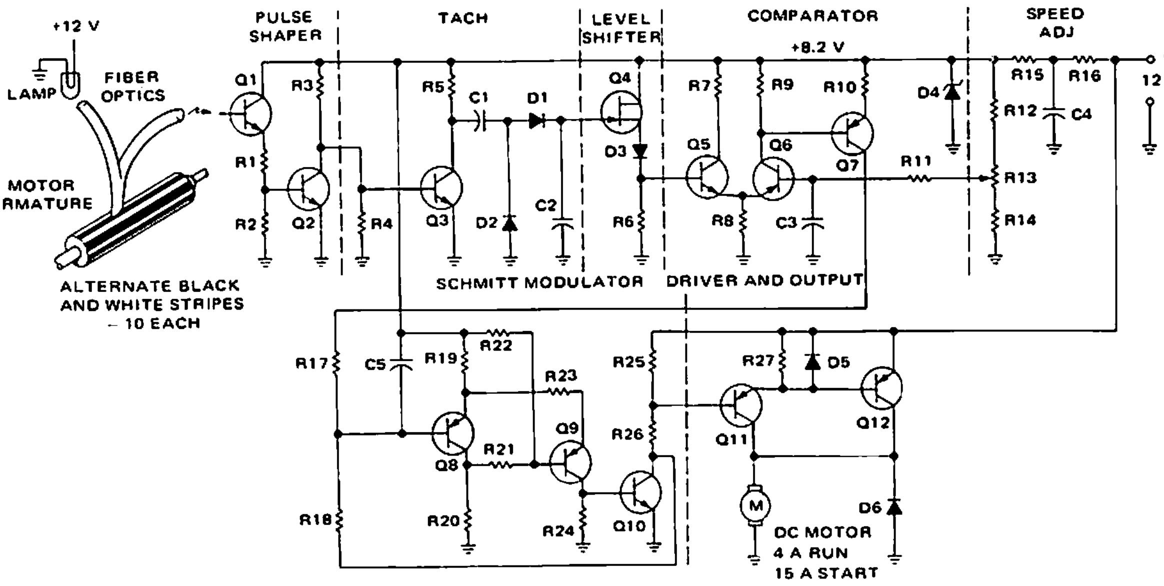
CHAPTER 82

Tachometer Circuits

	No. of Cylinders		
	4	6	8
C1 in mfd for 2-Cycle Engine	0.33	0.22	0.15
C1 in mfd for 4-Cycle Engine	0.68	0.47	0.33

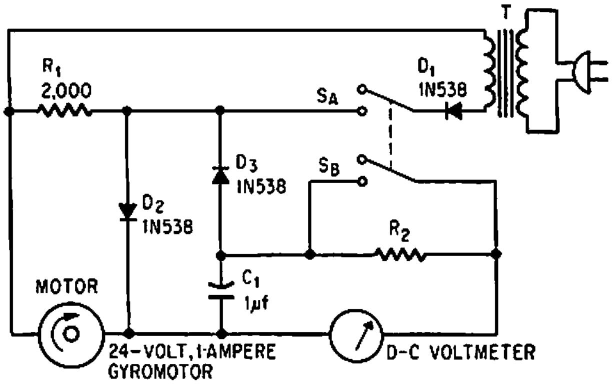
PRECISION TACHOMETER—Designed for 12-V negative-ground ignition system. Counts number of times distributor points close per minute, to give rpm. Uses 500-μA meter movement calibrated linearly in rpm. Zener X11, rated 8.2 V at 1 W, prevents battery and generator fluctuations from affecting accuracy.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 56.

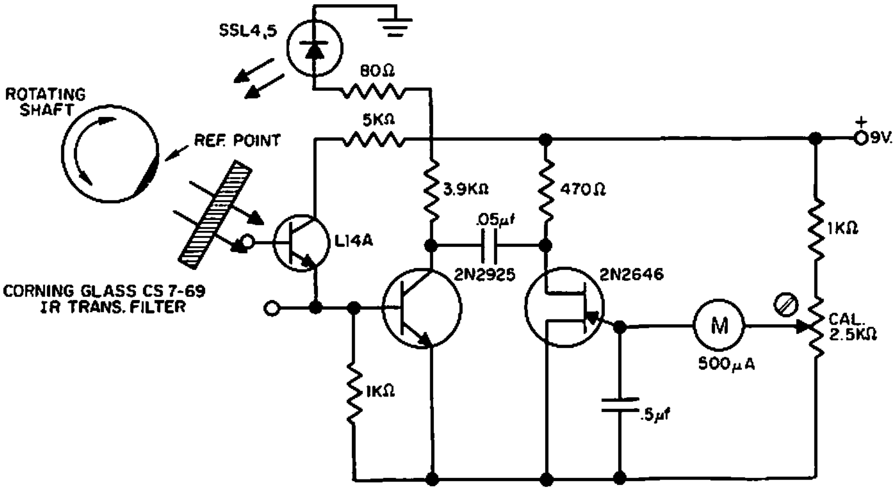

NOTE: WITH 6-VOLT NEGATIVE GROUND SYSTEMS, USE SEPARATE 6-VOLT DRY CELL IN SERIES WITH AUTO BATTERY, OR USE SEPARATE 12-VOLT DRY BATTERY.
R1 3300
R2 1000
Q1 GE-10
C2 0.22
R3 1000
TO POINTS
R4 3900
C3 0.047
R5 470
B2
Q2 GE-X10
B1
E
M
C1 (SEE CHART)
R6 1000
R7 2500
R8 330 1W
10-20V
CR1 GE-X11
B


+12 V
LAMP
FIBER OPTICS
MOTOR ARMATURE
ALTERNATE BLACK AND WHITE STRIPES – 10 EACH
PULSE SHAPER
TACH
LEVEL SHIFTER
COMPARATOR
SPEED ADJ
+8.2 V
Q1
R3
R1
R2
Q2
R4
R5
C1
D1
Q3
D2
C2
Q4
D3
R6
R7
R9
R10
Q5
Q6
Q7
R8
C3
D4
R11
R15
R16
R12
C4
R13
R14
12 V
SCHMITT MODULATOR
DRIVER AND OUTPUT
R17
C5
R19
R22
R23
Q8
R21
Q9
R18
R20
R24
Q10
R25
R26
R27
D5
Q11
Q12
M
D6
DC MOTOR 4 A RUN 15 A START

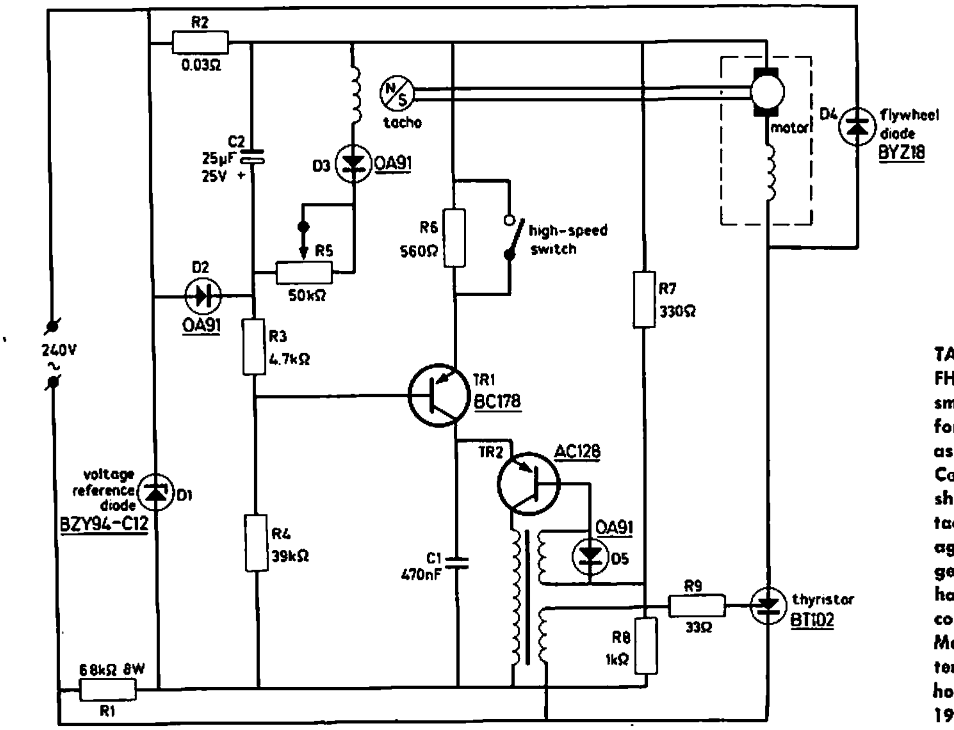
OPTICAL-FEEDBACK CONTROL—Armature of motor was painted with 20 alternating black and white stripes, and fiber optic system used to transmit reflected light to phototransistor Q1, to give chopping at frequency determined by speed of motor. Phototransistor output feeds through pulse shaper to tachometer circuit whose d-c output is proportional to input frequency and hence motor speed. Differential amplifier in comparator compares voltage from speed control R13 with output of tachometer level shifter and delivers error voltage for control of pulse width modulator (Schmitt) Q8-Q9 that drives motor through Darlington power amplifier Q11-Q12. Speed regulation is excellent.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 1–33.

P-M MOTOR SPEED—Counter-emf of permanent-magnet motor charges C1 between power pulses. Voltage across C1, equal to open-circuit counter-emf and proportional to motor speed, is read out on d-c voltmeter. Measuring circuit ignores resistance drop of load current.—J. B. Tiedemann, Permanent-Magnet Motor Measures Its Own Speed, *Electronics*, May 29, 1967, p 84–85.

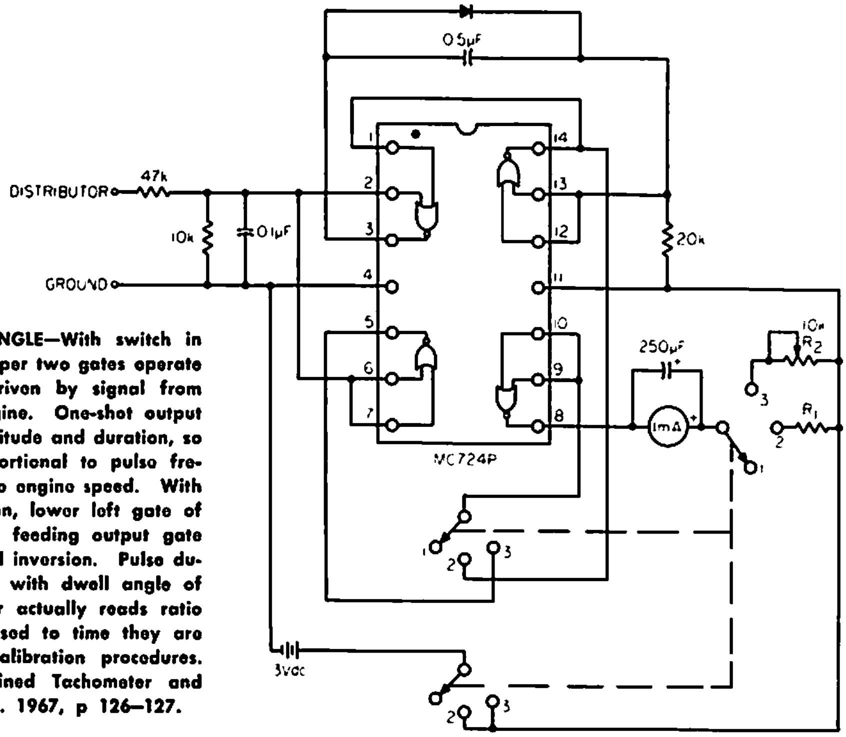

T
R1
2,000
D1
1N538
SA
SB
D3
1N538
D2
1N538
R2
C1
1μf
MOTOR
24-VOLT, 1-AMPERE GYROMOTOR
D-C VOLTMETER


SSL4,5
80Ω
ROTATING SHAFT
5KΩ
REF. POINT
+
9V.
3.9KΩ
470Ω
.05μf
L14A
2N2925
2N2646
1KΩ
CORNING GLASS CS 7-69 IR TRANS. FILTER
M
CAL. 2.5KΩ
500μA
1KΩ
.5μf

OPTICAL TACHOMETER—Dab of white paint on rotating shaft reflects light to L14A phototransistor when illuminated by solid-state lamp. Filter excludes ambient illumination that might falsely trigger L14A. Circuit converts light pulses to proportional current values indicated on microammeter calibrated in rpm. Will measure speeds as low as 60 rpm.—L. M. Hertz, Solid State Lamps—Part II, General Electric, Nela Park, Cleveland, Ohio, No. 3-0121, 1970, p 23.

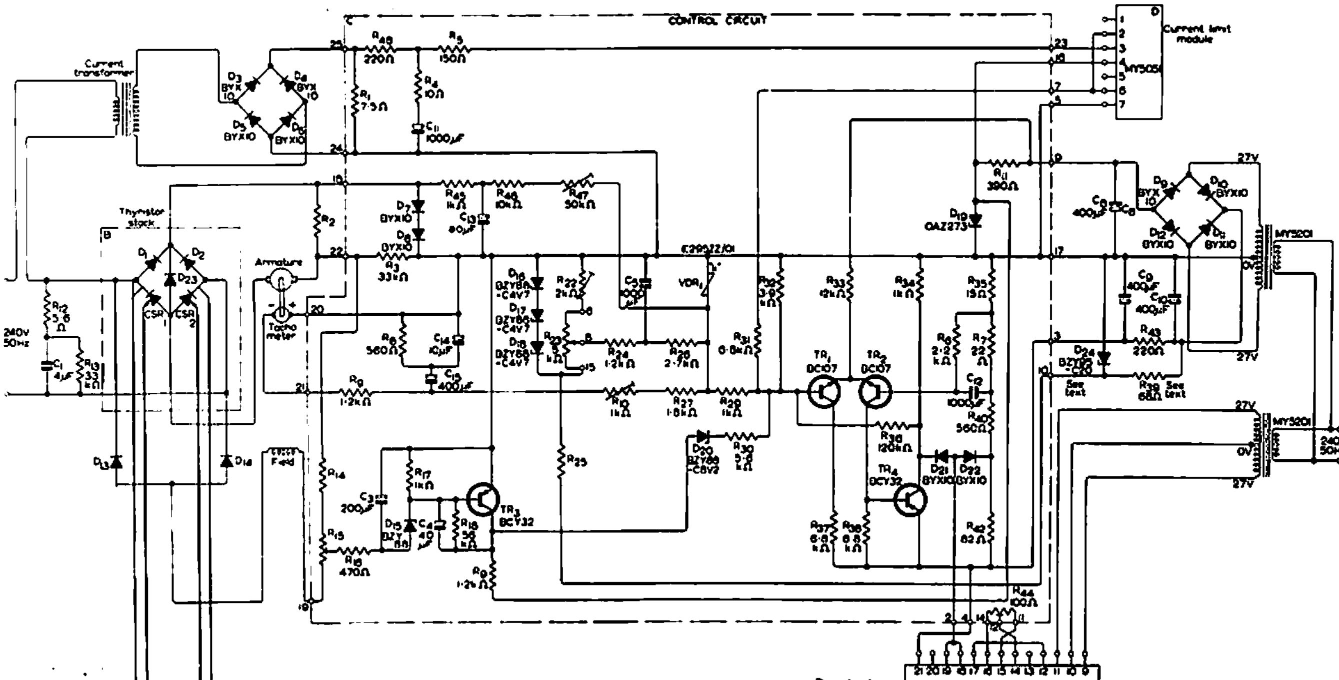

R2
0.03Ω
tacho
motor
D4
flywheel diode
BYZ18
C2
25μF
25V +
D3
OA91
R6
560Ω
high-speed switch
R5
50kΩ
D2
OA91
R7
330Ω
240V
R3
4.7kΩ
TR1
BC178
TR2
AC128
voltage reference diode
D1
BZY94-C12
R4
39kΩ
OA91
D5
C1
470nF
R9
33Ω
thyristor
BT102
R8
1kΩ
68kΩ 8W
R1

TACHOMETER-FEEDBACK CONTROL OF LARGE FHP MOTOR—Philips BT102 thyristor makes smooth, continuous speed control economical for larger fractional-horsepower motors such as are used in automatic washing machines. Ceramic magnetic material mounted on motor shaft induces pulses in adjacent coil to give tachometer feedback for stabilizing speed against variations in load. Thyristor is triggered by blocking oscillator at point in each half-cycle corresponding to setting of speed control R5, to give 30:1 speed range.—Series Motor Speed Control Systems with Tachometer, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Application No. 6, 1968.

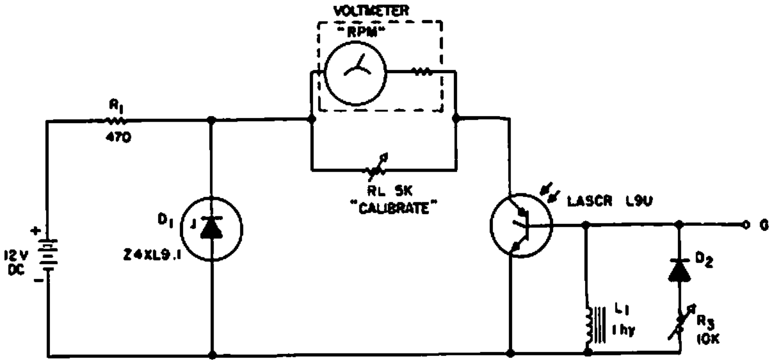

0.5μF
DISTRIBUTOR
47k
10k
0.1μF
GROUND
20k
MC724P
1
2
3
4
5
6
7
8
9
10
11
12
13
14
250μF
ImA
10k
R2
R1
3
2
1
3Vdc

SPEED AND DWELL ANGLE—With switch in tachometer position, upper two gates operate as one-shot trigger driven by signal from distributor of auto engine. One-shot output pulses have fixed amplitude and duration, so meter reading is proportional to pulse frequency and therefore to engine speed. With switch in dwell position, lower left gate of IC is used as inverter feeding output gate (lower right) for second inversion. Pulse duration at meter varies with dwell angle of distributor cam. Meter actually reads ratio of time points are closed to time they are open. Article gives calibration procedures. —S. J. Arnold, Combined Tachometer and Dwell Meter, *EEE*, Aug. 1967, p 126–127.

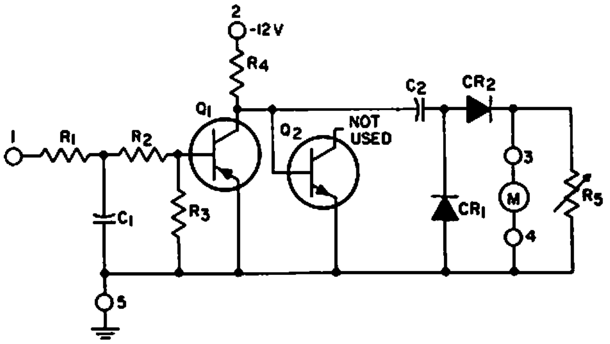
SWITCH POSITIONS: 1-OFF, 2-TACH, 3-DWELL


CONTROL CIRCUIT
C
Current transformer
D3 BYX10
D4 BYX10
D5 BYX10
D6 BYX10
R48 220Ω
R5 150Ω
R1 7.5Ω
R4 10Ω
C11 1000μF
Current limit module
D
MY5051
Thyristor stack
B
D1
D2
D23
CSR1
CSR2
Armature
Tacho meter
240V 50Hz
R12 5.6Ω
C1 4μF
R13 33kΩ
D13
D14
Field
R2
R3 33kΩ
D7 BYX10
D8 BYX10
R45 1kΩ
R46 10kΩ
R47 50kΩ
C13 40μF
C6 400μF
C14 10μF
C15 400μF
R9 1.2kΩ
R8 560Ω
R14
R15
R16 470Ω
C3 200μF
R17 1kΩ
D15
C4 40μF
R18 56kΩ
R19 1.2kΩ
TR3 BCY32
R25
VDR1
E29922/01
R31 6.8kΩ
R32 3.9kΩ
R33 12kΩ
R34 1kΩ
R35 13Ω
TR1 OC107
TR2 OC107
TR4 BCY32
R36 120kΩ
D21 BYX10
D22 BYX10
R37 6.8kΩ
R38 6.8kΩ
R41 82Ω
R44 100Ω
R11 390Ω
D19 OAZ273
C8 400μF
C9 400μF
R43 220Ω
D24 BZY88-C20
R39 68Ω
R40 560Ω
R6 2.2kΩ
R7 22Ω
C12 1000μF
D9 BYX10
D10 BYX10
D11 BYX10
D12 BYX10
27V
0V
MY5201
240V 50Hz
Thyristor trigger module
E
MY5011

TACHOMETER SPEED CONTROL—Error amplifier uses balanced input to reduce drift caused by temperature or supply voltage changes. Controls 5-hp d-c shunt motor operating from a-c line. Speed regulation is better than 1% at full speed from full load down to 20% load. Report gives design equations. D13 and D14 are Mullard BYX-22-800 or others to suit field current. B is Mullard thyristor stack, D is Mullard MY5051 current-limiting module, and E is Mullard MY5011 trigger module.—J. Merrett, Thyristor Speed Control Circuit Design for D. C. Shunt Motors Supplied from A. C. Mains, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 438, 1967.

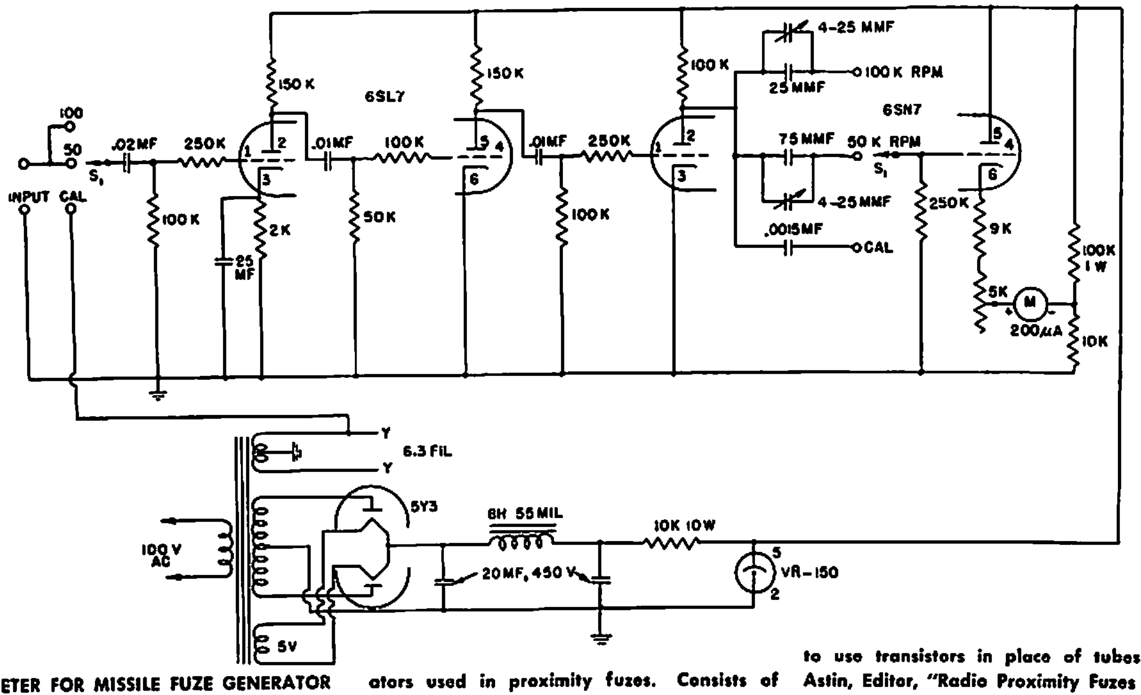

VOLTMETER
"RPM"
R1
470
RL 5K
"CALIBRATE"
D1
Z4XL9.1
12V
DC
LASCR L9U
G
D2
L1
1 hy
R3
10K

LASCR OPTICAL TACHOMETER—Trigger pulses may be either light on lascr or electrical pulses at G. Average anode current of lascr is proportional to repetition rate of pulses, permitting calibration of voltmeter in rpm.—E. K. Howell, The Light Activated SCR, General Electric, Syracuse, N.Y., No. 200.34, 1965.

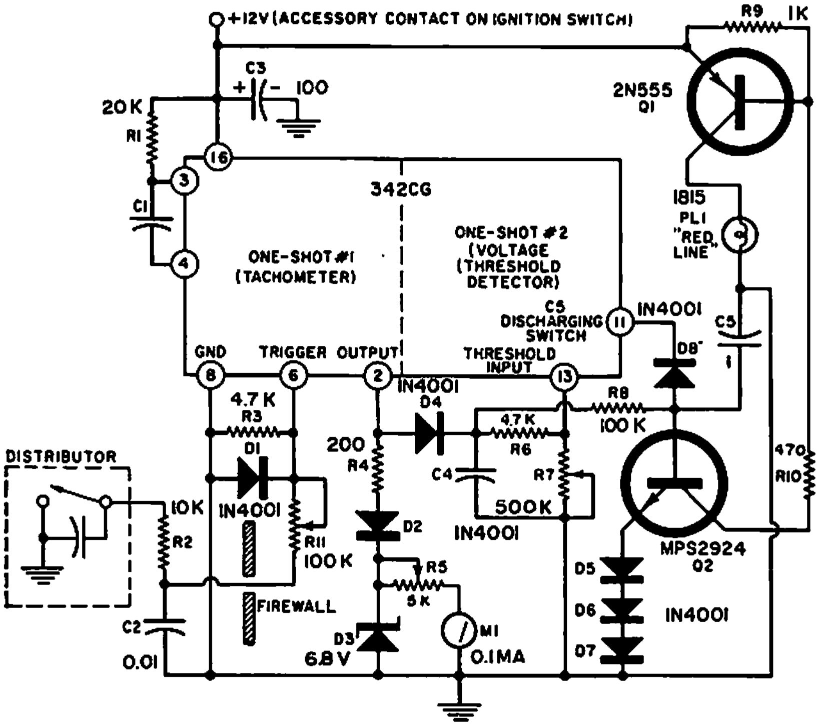

2
-12V
R4
C2
CR2
Q1
Q2
NOT USED
1
R1
R2
C1
R3
CR1
3
M
4
R5
5

POSITIVE-GROUND TACHOMETER—For auto engines having positive terminal of 12-V battery grounded to frame. Meter specified gives full-scale reading of about 10,000 rpm when pulses from distributor points are applied to terminal 1.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 111.

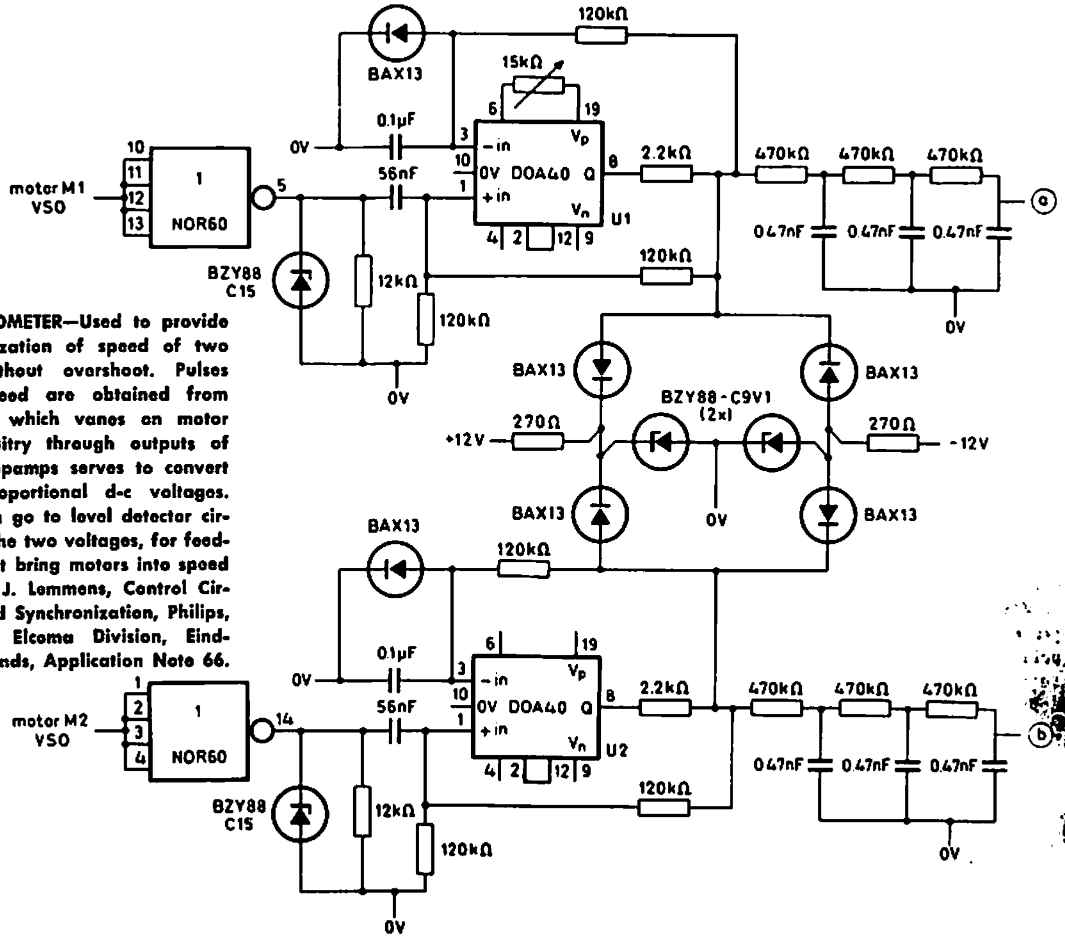
C_1 = 1 microfarad, 50 volts or greater
C_2 = 0.5 microfarad, 50 volts or greater
CR_1CR_2 = silicon rectifier, RCA SK3030
M = milliammeter, 0 to 1 milliampere range (see text)
Q_1 = transistor RCA SK3025 for positive ground, RCA SK3020 for negative ground
Q_2 = transistor, RCA SK3020
R_1 = 22,000 ohms, 1/2 watt, 10%
R_2 = 220 ohms, 1/2 watt, 10%
R_3 = 1500 ohms, 1/2 watt, 10%
R_4 = 330 ohms, 1/2 watt, 10%
R_5 = potentiometer, 1000 ohms, trimmer type, linear taper


100
50
S1
INPUT
CAL
.02MF
250K
100K
150K
6SL7
.01MF
100K
2K
25 MF
50K
150K
.01MF
250K
100K
100K
4-25 MMF
25 MMF
100 K RPM
6SN7
75 MMF
50 K RPM
S1
4-25 MMF
.0015MF
CAL
250K
9K
5K
M
200μA
100K 1W
10K
Y
6.3 FIL
Y
5Y3
6H 55 MIL
10K 10W
100 V AC
20MF, 450 V
VR-150
5V

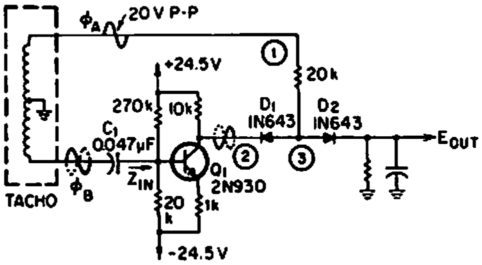
TACHOMETER FOR MISSILE FUZE GENERATOR—Circuit shown was most satisfactory of large number developed during World War II for measuring rotational speeds of generators used in proximity fuzes. Consists of amplifier, wave clipper, and vtvm reading average voltage across R-C network (proportional to speed). Can readily be adapted to use transistors in place of tubes.—A. V. Astin, Editor, "Radio Proximity Fuzes For Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 295.


+12V (ACCESSORY CONTACT ON IGNITION SWITCH)
R9 1K
C3 100
20K R1
C1
2N555 Q1
342CG
ONE-SHOT #1 (TACHOMETER)
ONE-SHOT #2 (VOLTAGE (THRESHOLD DETECTOR)
1815 PL1 "RED LINE"
C5 DISCHARGING SWITCH
IN4001 D8
C5
GND TRIGGER OUTPUT THRESHOLD INPUT
16 3 4 8 6 2 13 11
4.7K R3
D1 IN4001
IN4001 D4
4.7K R6
R8 100K
200 R4
C4
R7 500K
470 R10
DISTRIBUTOR
10K R2
R11 100K
D2 IN4001
R5 5K
MPS2924 Q2
D5 D6 D7 IN4001
FIREWALL
C2 0.01
D3 6.8V
M1 0.1MA

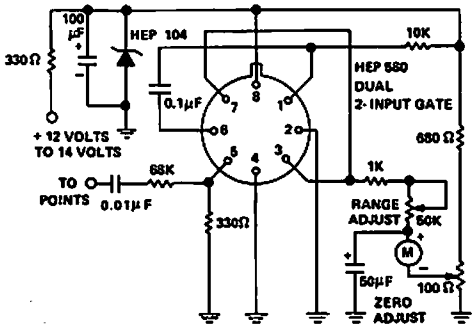
SHIFT-INDICATING TACHOMETER—Circuit turns on red warning lamp at pretetermined engine rpm value to tell driver to shift gears. Eliminates need for watching pointer of tachometer. Built around integrated circuit having two identical one-shot multivibrators. Can be calibrated with audio oscillator.—R. A. Hirschfeld, IC Engine Tachometer and "Red Line" Indicator, *Electronics World,* May 1967, p 37–39.


120kΩ
BAX13
15kΩ
0.1μF
0V
56nF
6 19 3 10 1 8
-in Vp
0V DOA40 Q
+in Vn
4 2 12 9
U1
2.2kΩ
470kΩ 470kΩ 470kΩ
0.47nF 0.47nF 0.47nF
a
motor M1 VSO
10 11 12 13
1 NOR60
5
BZY88 C15
12kΩ
120kΩ
BAX13
BZY88-C9V1 (2x)
+12V 270Ω
270Ω -12V
motor M2 VSO
1 2 3 4
1 NOR60
14
U2
b

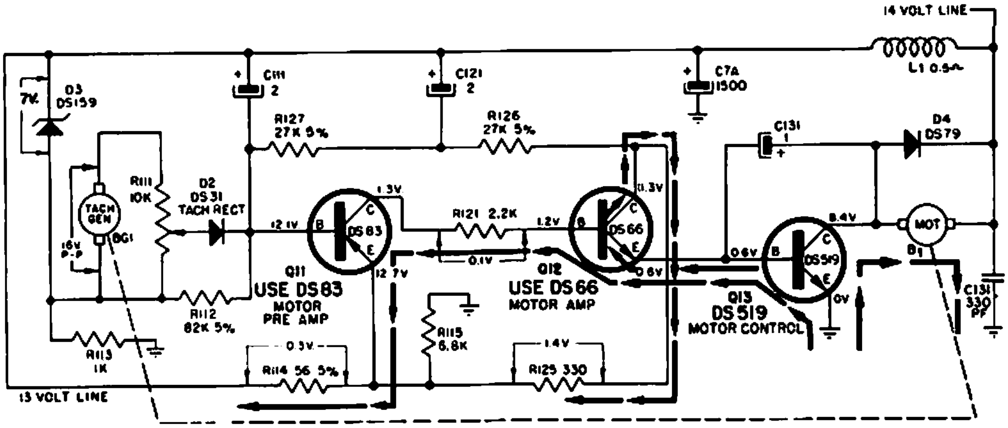
TWO-MOTOR TACHOMETER—Used to provide very fast synchronization of speed of two electric motors without overshoot. Pulses proportional to speed are obtained from coils (VSO) thrugh which vanes on motor shafts move. Circuitry through outputs of Philips DOA40 IC opamps serves to convert pulse rates to proportional d-c voltages. Points a and b then go to level detector circuit that compares the two voltages, for feeding logic circuits that bring motors into speed synchronization.—L. J. Lemmens, Control Circuit for Motor Speed Synchronization, Philips, Publications Dept., Elcoma Division, Eindhoven, The Netherlands, Application Note 66.


φA
20 V P-P
①
+24.5V
20k
270k
10k
C1
0.047μF
D1
IN643
D2
IN643
EOUT
②
③
Q1
2N930
ZIN
φB
TACHO
20 k
1k
-24.5V

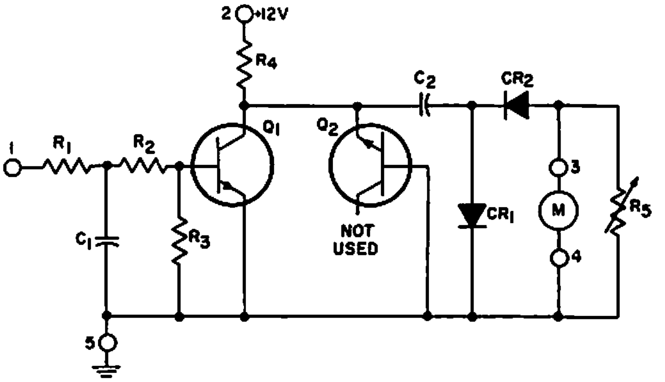
A-C TACH—Circuit detects whether there is 90-deg lead or lag between phases of two-phase tachometer, and can be used with peak detector and suitable threshold circuit to provide two discrete output logic levels that indicate direction of rotation.—T. B. Hooker, Phase Indicator for AC Tachometer, *EEE*, May 1969, p 118.


100 μF
HEP 104
10K
330Ω
HEP 580
DUAL
2-INPUT GATE
0.1μF
7
8
1
6
2
3
5
4
680 Ω
+ 12 VOLTS TO 14 VOLTS
68K
TO POINTS
0.01μF
1K
RANGE ADJUST
50K
330Ω
M
50μF
100 Ω
ZERO ADJUST

PRECISION IC TACHOMETER—Easily adjustable for different ranges and number of cylinders. Calibrating instructions are given.—"Tips on Using IC's," HMA-32, Motorola, Phoenix, Ariz., 1968.


14 VOLT LINE
L1 0.5Ω
C111 2
C121 2
C7A 1500
7V
D3 DS159
R127 27K 5%
R126 27K 5%
C131 1
D4 DS79
R111 10K
D2 DS31 TACH RECT
TACH GEN
16V P-P
BG1
1.3V
12.1V
B
C
E
DS83
R121 2.2K
1.2V
0.1V
DS66
11.3V
0.6V
8.4V
MOT
B1
DS519
0V
Q11
USE DS83
MOTOR PRE AMP
12.7V
Q12
USE DS66
MOTOR AMP
Q13
DS519
MOTOR CONTROL
C131 330 PF
R112 82K 5%
R115 6.8K
R113 1K
0.3V
R114 56 5%
1.4V
R125 330
13 VOLT LINE

TAPE PLAYER SPEED CONTROL—Tachometer on shaft of drive motor produces a-c voltage directly proportional to speed. Tachometer output is applied to speed control pot, then rectified and resulting d-c voltage applied to three-transistor d-c amplifier that changes voltage across motor as required to give desired speed.—New Motor Speed Control Circuit and Inverted Cam Mechanism, Delco Radio, Kokomo, Ind., Bulletin 6D-1970-1, Supplement No. 3, 1969, p G-19.


2
+12V
R4
C2
CR2
Q1
Q2
1
R1
R2
3
C1
R3
NOT USED
CR1
M
R5
4
5

NEGATIVE-GROUND TACHOMETER—Used to indicate speed in rpm of auto engines having 12-V storage battery with negative terminal grounded to frame. Pulses from distributor points are applied to terminal 1 to turn Q1 on and off as points open and close. Meter deflection is proportional to rate of closing. Q2 acts as zener to make circuit insensitive to voltage variations. R5 is used when calibrating tachometer. Meter specified will have full-scale reading of 8,000 to 10,000 rpm.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 111.

C_1 = 1 microfarad, 50 volts or greater

C_2 = 0.5 microfarad, 50 volts or greater

CR_1CR_2 = silicon rectifier, RCA SK3030

M = milliammeter, 0 to 1 milliampere range (see text)

Q_1 = transistor RCA SK3025 for positive ground, RCA SK3020 for negative ground

Q_2 = transistor, RCA SK3020

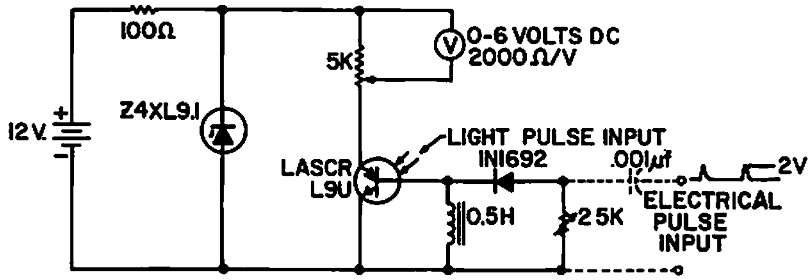
R_1 = 22,000 ohms, 1/2 watt, 10%

R_2 = 220 ohms, 1/2 watt, 10%

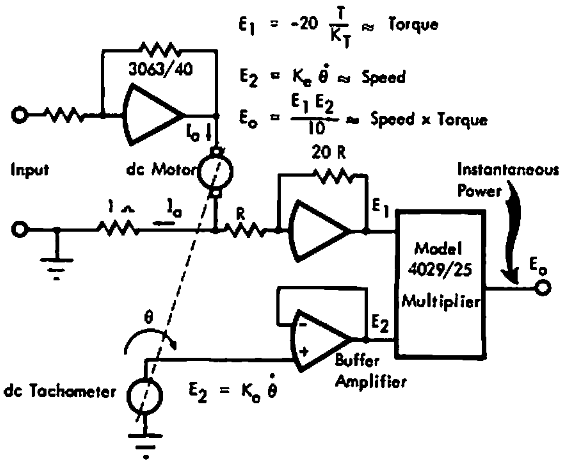
R_3 = 1500 ohms, 1/2 watt, 10%

R_4 = 330 ohms, 1/2 watt, 10%

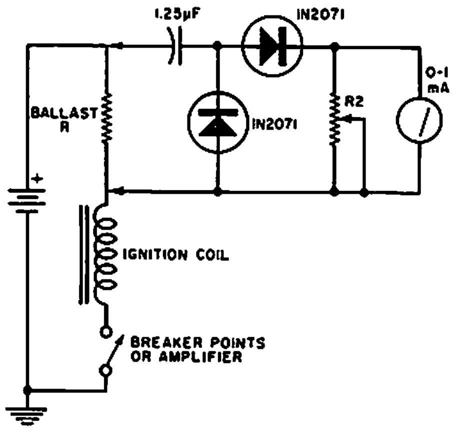
R_5 = potentiometer, 1000 ohms, trimmer type, linear taper


100Ω
5K
V
0-6 VOLTS DC
2000Ω/V
12V.
+
Z4XL9.1
LASCR
L9U
LIGHT PULSE INPUT
1N1692
.001μf
2V
0.5H
25K
ELECTRICAL
PULSE
INPUT

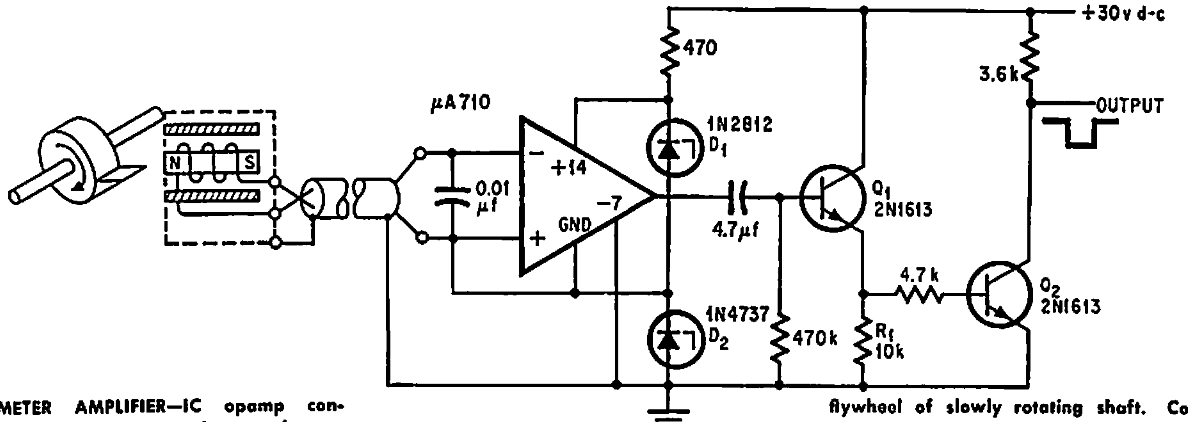
LASCR TACHOMETER—Light-activated scr serves as low-current gate-turnoff switch, triggered either by light or electrical pulse. Meter reading depends on repetition rate of triggering pulses. Voltmeter should be set for full-scale deflection when trigger rate is high enough so average current and peak current of scr are equal. Further increase in trigger rate then gives pulse-skipping or frequency-dividing action in which lascr conducts only on alternate pulses. This gives automatic 2:1 change in range.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 25.


E1 = -20 T/K_T ≈ Torque
E2 = K_e θ̇ ≈ Speed
Eo = E1 E2 / 10 ≈ Speed x Torque
3063/40
Input
dc Motor
Ia
1 Ω
Ia
R
20 R
E1
Model
4029/25
Multiplier
Instantaneous
Power
Eo
E2
θ
Buffer
Amplifier
dc Tachometer
E2 = K_e θ̇

MOTOR SPEED-TORQUE PRODUCT—Uses Burr-Brown 4029/25 quarter-square multiplier-divider to give instantaneous product of motor speed and torque, as required for measuring instantaneous output power. D-c tachometer on motor shaft gives speed in electrical form, and current through p-m d-c servomotor serves as other input because it is linearily proportional to torque. Article gives relevant equations.—Quarter-Square Multiplier/Dividers, Burr-Brown Research, Tucson, Ariz., PDS-201C, 1969, p 7.


1.25μF
IN2071
BALLAST
R
IN2071
R2
0-1
mA
+
IGNITION COIL
BREAKER POINTS
OR AMPLIFIER

BALLAST-RESISTOR DRIVE FOR TACHOMETER—Clean voltage pulse of 4 to 12 V is available from 1-ohm ballast resistor used in every 12-V automotive ignition system, in form of length of resistance wire connected between ignition switch and positive terminal of ignition coil. Value of calibration potentiometer R2 depends on meter used. Circuit eliminates transient errors, so linearity is limited only by that of meter used.—R. L. Carroll, New Approach to Engine Tachometers, *Electronics World*, Sept. 1967, p 71.

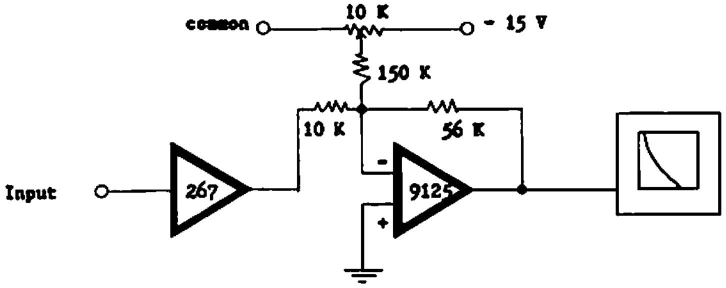

+30v d-c
470
3.6k
OUTPUT
μA710
1N2812
D1
N
S
0.01
μf
-
+14
-7
+
GND
4.7μf
Q1
2N1613
4.7 k
Q2
2N1613
1N4737
D2
470k
R1
10k

TACHOMETER AMPLIFIER—IC opamp connected for gain of 1,000 delivers pulse capable of driving Q1 into saturation, as required for emitter-follower Q2 to produce 30-V negative output pulse. Input is voltage induced in relay coil by triangular magnet on flywheel of slowly rotating shaft. Core of coil is Alnico magnet.—G. D. Morant, Op Amp Boosts Pick-up Voltage, *Electronics*, Aug. 5, 1968, p 108.

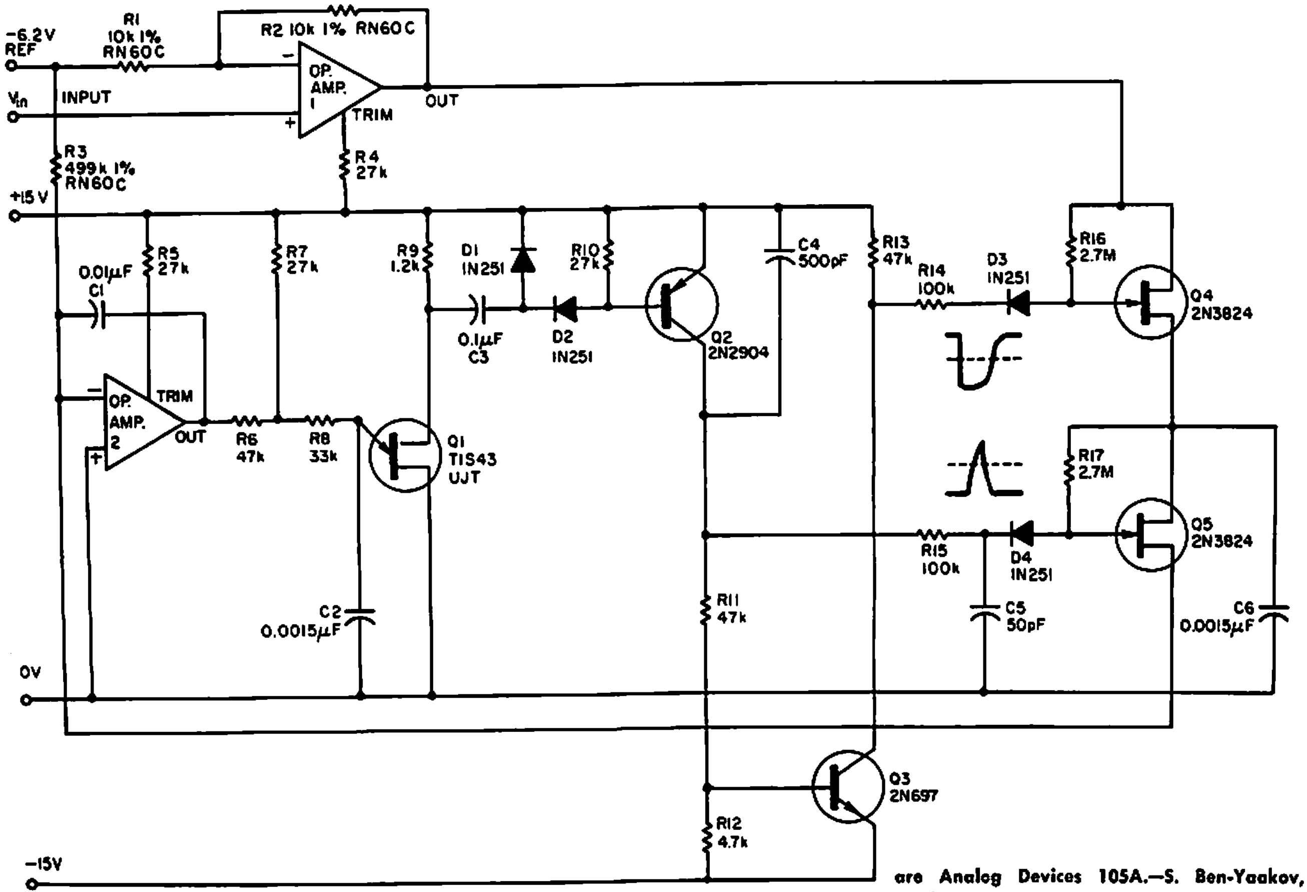
CHAPTER 83

Telemetry Circuits

STRIP-CHART DRIVE—May be used also with X-Y and T-Y recorders. Values shown are for 1 V full-scale. For telemetry systems requiring 5 V full-scale, increase feedback resistor to 270K plus 10K in series. Uses OEI Model 267 logamp to drive opamp. System accuracy is within 2%.—Using Low Cost Logarithmic Amplifiers in Data Recording, Optical Electronics, Tuscon, Ariz., No. 10080.

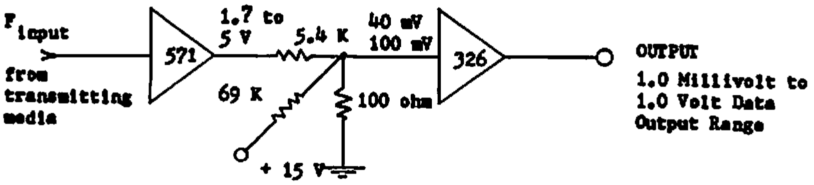


common
10 K
- 15 V
150 K
10 K
56 K
Input
267
9125
-
+

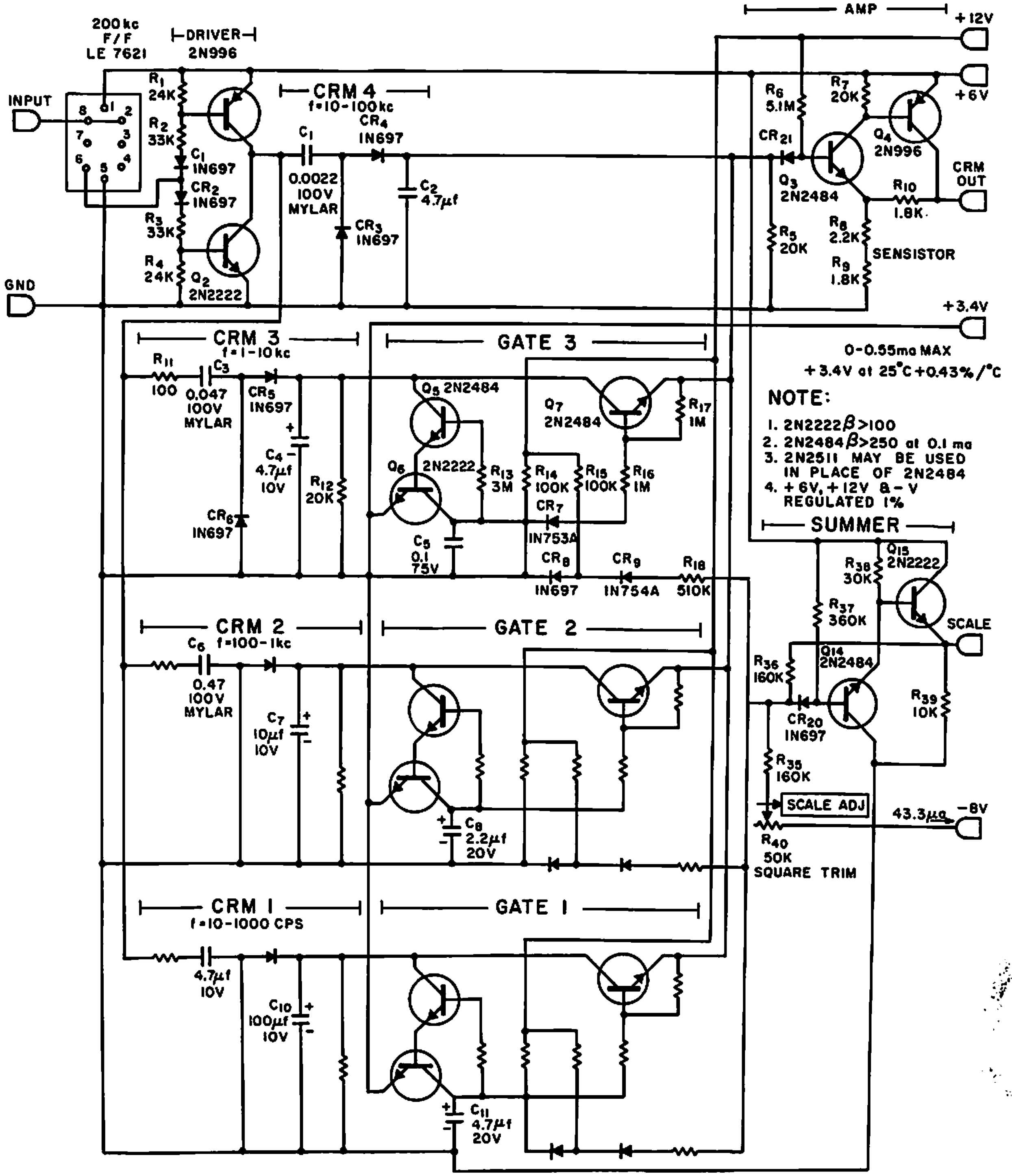


-6.2V REF
R1 10k 1% RN60C
R2 10k 1% RN60C
Vin
INPUT
OP. AMP. 1
OUT
TRIM
R3 499k 1% RN60C
R4 27k
+15 V
0.01μF C1
R5 27k
R7 27k
R9 1.2k
D1 IN251
R10 27k
C4 500pF
R13 47k
R14 100k
D3 IN251
R16 2.7M
Q4 2N3824
0.1μF C3
D2 IN251
Q2 2N2904
OP. AMP. 2
TRIM
OUT
R6 47k
R8 33k
Q1 TIS43 UJT
R17 2.7M
Q5 2N3824
R15 100k
D4 IN251
R11 47k
C2 0.0015μF
C5 50pF
C6 0.0015μF
0V
Q3 2N697
R12 4.7k
-15V

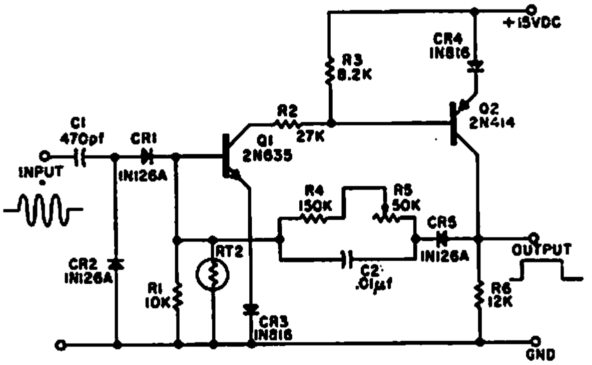
ANALOG-PERIOD CONVERTER—Converts input voltage to sawtooth whose period is linear function of input voltage over input signal range of −1 V to +1 V. With opamp (serving as summing amplifier) omitted, circuit is analog-frequency converter. Opamps are Analog Devices 105A.—S. Ben-Yaakov, Analog-To-Period Converter Can Simplify Telemetry Systems, *Electronic Design*, Aug. 16, 1969, p 240 and 242.


F input from transmitting media
571
1.7 to 5 V
5.4 K
69 K
+ 15 V
40 mV 100 mV
100 ohm
326
OUTPUT
1.0 Millivolt to 1.0 Volt Data Output Range

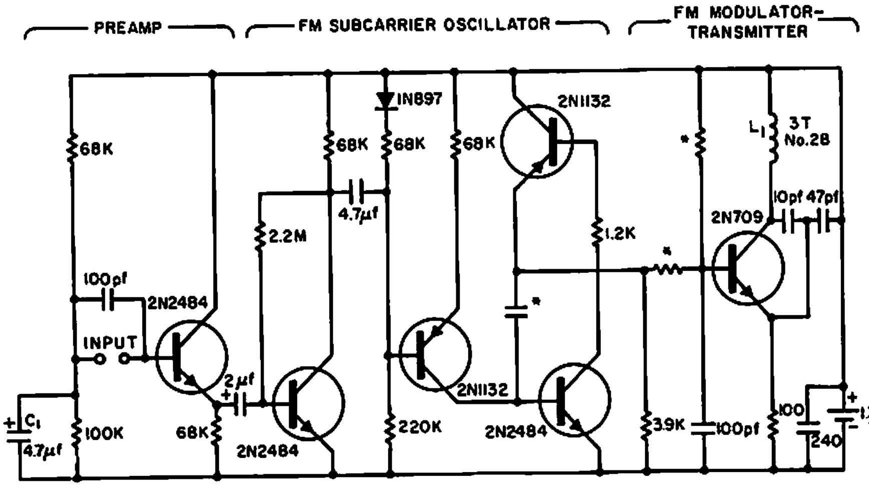
IC RECEIVER—Sinusoidal input from telemetry transforming media goes to Model 571 IC frequency-to-voltage transducer, and resulting logarithmically compressed signal is converted back to original data voltage input in Model 326 antilogarithmic amplifier.—A Wide Dynamic Range Telemetry System, Optical Electronics, Tucson, Ariz., No. 10062.


200kc F/F LE 7621
DRIVER 2N996
INPUT
GND
R1 24K
R2 33K
C1 IN697
CR2 IN697
R3 33K
R4 24K
Q2 2N2222
CRM 4 f=10-100kc
C1 0.0022 100V MYLAR
CR4 IN697
CR3 IN697
C2 4.7µf
AMP
+12V
+6V
R6 5.1M
R7 20K
CR21
Q3 2N2484
Q4 2N996
R10 1.8K
CRM OUT
R5 20K
R8 2.2K
R9 1.8K
SENSISTOR
+3.4V
0-0.55ma MAX
+3.4V at 25°C+0.43%/°C
NOTE:
1. 2N2222β>100
2. 2N2484β>250 at 0.1 ma
3. 2N2511 MAY BE USED IN PLACE OF 2N2484
4. +6V, +12V & -V REGULATED 1%
CRM 3 f=1-10kc
R11 100
C3 0.047 100V MYLAR
CR5 IN697
C4 4.7µf 10V
CR6 IN697
R12 20K
GATE 3
Q5 2N2484
Q6 2N2222
R13 3M
C5 0.1 75V
Q7 2N2484
R17 1M
R14 100K
R15 100K
R16 1M
CR7 IN753A
CR8 IN697
CR9 IN754A
R18 510K
SUMMER
Q15 2N2222
R38 30K
R37 360K
SCALE
Q14 2N2484
R36 160K
CR20 IN697
R39 10K
R35 160K
SCALE ADJ
43.3µa
-8V
R40 50K SQUARE TRIM
CRM 2 f=100-1kc
C6 0.47 100V MYLAR
C7 10µf 10V
GATE 2
C8 2.2µf 20V
CRM 1 f=10-1000 CPS
4.7µf 10V
C10 100µf 10V
GATE 1
C11 4.7µf 20V

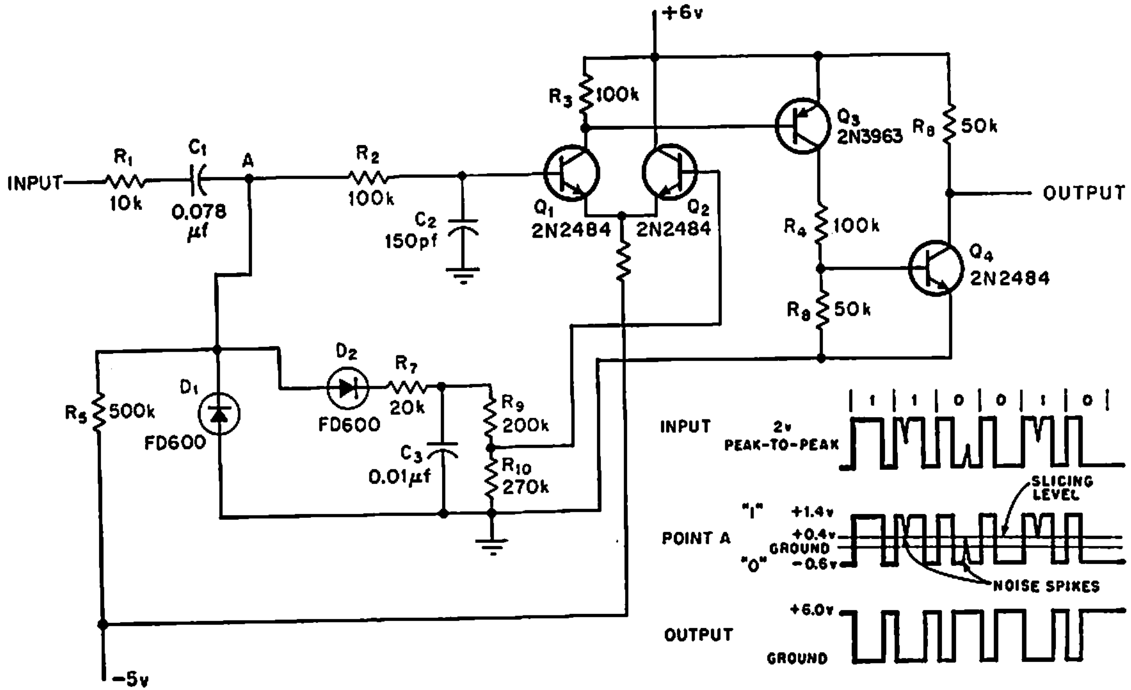
FOUR-DECADE CRM—Improves utilization of two telemetry channels. One channel is switched from one count-rate meter (CRM) to next as input rate changes, while other channel indicates which meter is being read out. Eliminates decrease in resolution that would occur if one rate meter covered entire range. Circuit consumes little power and is unaffected by wide temperature swings. Decade inputs are connected in parallel, while outputs are paralleled through OR gates so only highest is read out into telemetry system. Frequency coverage is 10 pps to 100 kHz.—S. Thomas, N-Decade Count-Rate Meter, *Electronic Design*, March 15, 1965, p 34–39.


+15VDC
CR4
IN816
R3
8.2K
R2
27K
Q2
2N414
C1
470pf
CR1
INPUT
IN126A
Q1
2N635
R4
150K
R5
50K
CR5
IN126A
OUTPUT
CR2
IN126A
R1
10K
RT2
C2
.01μf
R6
12K
CR3
IN816
GND

REGENERATIVE SWITCH—Removes sine-wave carrier in f-m/f-m telemetry, leaving only required pulse modulation waveform for use in digital circuits. Values shown are for 20-kHz carrier and digital transfer rate of 2.5 kHz. Filter in feedback circuit keeps hysteresis low.—W. S. Silbert, Regenerative Switch Demodulates Sinusoid, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 195–196.

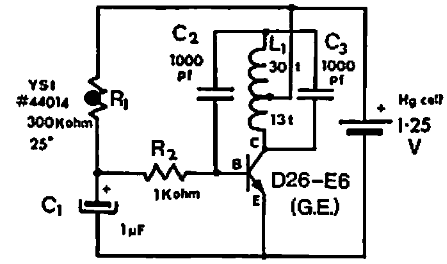

PREAMP
FM SUBCARRIER OSCILLATOR
FM MODULATOR-TRANSMITTER
68K
100pf
2N2484
INPUT
C1
4.7μf
100K
2μf
68K
2N2484
2.2M
68K
4.7μf
IN897
68K
220K
68K
2N1132
2N1132
2N2484
2N1132
1.2K
*
*
*
L1
3T
No.28
10pf
47pf
2N709
3.9K
100pf
100
240
1.35 V

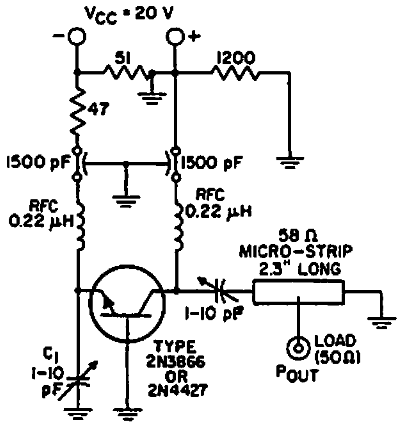
BIOPOTENTIALS—F-m telemetry circuit has 20-meg input impedance for nerve signals and 0.5–120 Hz response. Used in research for measuring signals along various paths linking retina of eye with brain. Values of asterisked components depend on desired battery life and transmitting range.—D. Harnar, Bio-Engineering Scores Wider Successes, *Electronic Design*, Dec. 21, 1964, p 6–9.


+6v
R3
100k
Q3
2N3963
R8
50k
INPUT
R1
10k
C1
0.078 μf
A
R2
100k
C2
150pf
Q1
2N2484
Q2
2N2484
OUTPUT
R4
100k
Q4
2N2484
R8
50k
R5
500k
D1
FD600
D2
FD600
R7
20k
C3
0.01μf
R9
200k
R10
270k
-5v
INPUT
2v PEAK-TO-PEAK
1 1 1 0 0 1 0
POINT A
"1"
+1.4v
+0.4v
GROUND
"0"
-0.6v
SLICING LEVEL
NOISE SPIKES
OUTPUT
+6.0v
GROUND

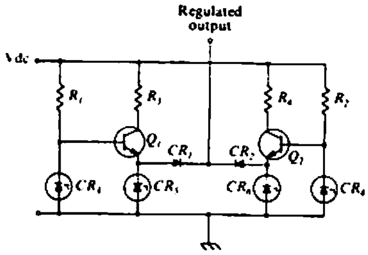
NOISE SUPPRESSOR—Provides 8-dB improvement in signal-to-noise ratio for 4-kHz input signals by driving output to full value whenever input varies from its nominal level by only few millivolts.—J. Schlageter, Telemetry Signal Conditioner Centers Its Slicing Level, *Electronics*, June 8, 1970, p 97.

LIZARD TEMPERATURE TELEMETER—Tiny pulsed Hartley oscillator operating at low duty cycle has average battery drain of 110 μA, giving transmitting life of 130 days with 350 mA-hr mercury cell. Pulse rate is controlled by temperature-sensing resistor R1. Transmitted signal has narrow bandwidth in range of 0.5 to 2 MHz.—H. Spencer, Thermally Stable Telemeter for Thermoregulation Studies, *Science*, Aug. 1968, p 574–575.


C2
1000 pf
L1
30 t
13 t
C3
1000 pf
YSI #44014
R1
300Kohm 25°
R2
1Kohm
C1
1μF
B
C
E
D26-E6 (G.E.)
Hg cell
1·25 V

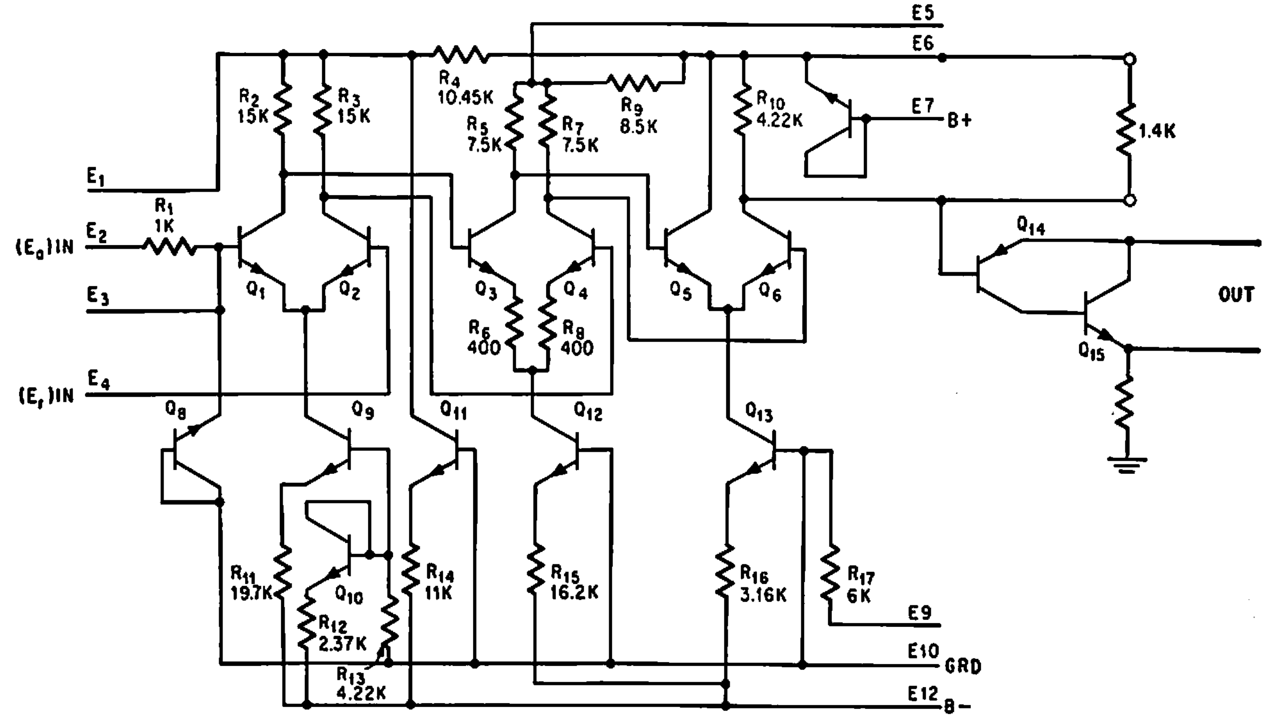

VCC = 20 V
51
1200
47
1500 pF
1500 pF
RFC 0.22 μH
RFC 0.22 μH
58 Ω MICRO-STRIP 2.3" LONG
1-10 pF
LOAD (50Ω)
POUT
C1 1-10 pF
TYPE 2N3866 OR 2N4427

500-MHZ MICROSTRIPLINE OSCILLATOR—Provides 1 W when operating from 20-V d-c supply, for use as telemetering transmitter, radiosonde, artillery fuze, beacon, or remote sensor. Taps on output stripline can provide matching to wide range of loads.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 346.

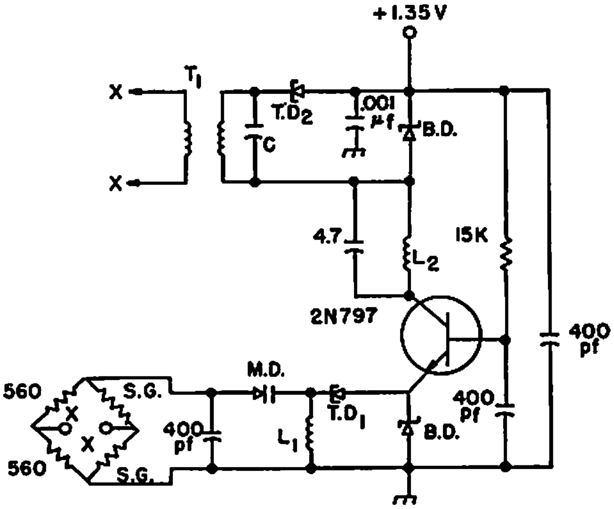

Regulated output
+ Vdc
R1
R3
R4
R2
Q1
Q2
CR1
CR2
CR5
CR3
CR4
CR6

	6.8V Regulator	12V Regulator
Input Supply	+ 28 V dc	+ 28 V dc
Q_1, Q_2	DEP08B	DEP08B
CR_1, CR_2	1N645	1N645
CR_3, CR_4	1N756A	1N965B
CR_5, CR_6	1N3018B	1N2979B
R_1, R_2	4300 Ω, ½W	1600 Ω, ½W
R_3, R_4	910 Ω, 2W	300 Ω, 3W

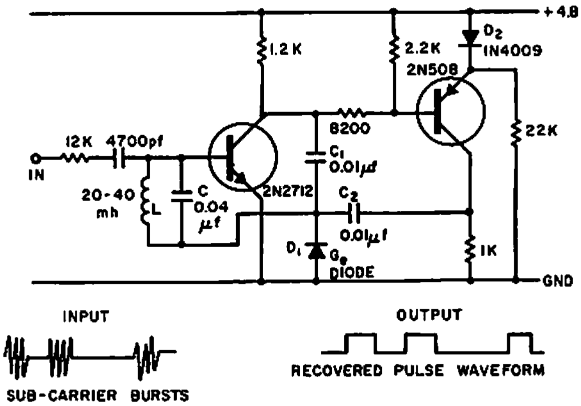
FAIL-SAFE DESIGN—Achieves high reliability through redundancy. Regulated output remains constant if any single component fails or if one of many combinations of multiple failures occurs, with no excessive voltages on circuit. Intended for power supplies at relay stations, satellite equipment, and remote unattended communication and data telemetry stations.—"Selected Electronic Circuitry," NASA SP-5046, 1966, Government Printing Office, Washington, D.C., p 36.


E5
E6
E7
B+
1.4K
R2 15K
R3 15K
R4 10.45K
R5 7.5K
R7 7.5K
R9 8.5K
R10 4.22K
E1
R1 1K
(E0)IN E2
E3
(Ef)IN E4
Q1
Q2
Q3
Q4
Q5
Q6
R6 400
R8 400
Q14
OUT
Q15
Q8
Q9
Q11
Q12
Q13
R11 19.7K
Q10
R12 2.37K
R13 4.22K
R14 11K
R15 16.2K
R16 3.16K
R17 6K
E9
E10
GRD
E12
B−

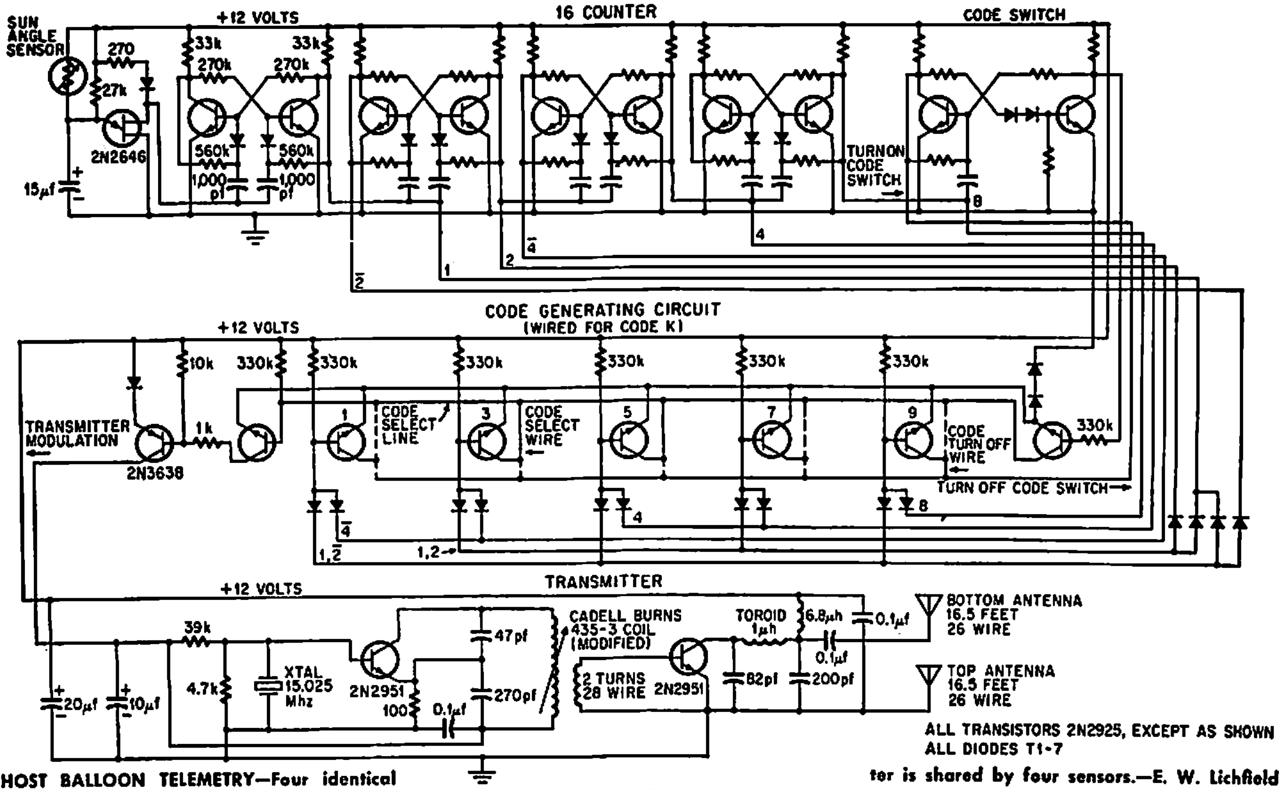
DIFFERENTIAL COMPARATOR—Combination of custom monolithic IC and outboarded level shift resolves signal differences in telemetry system and provides linear output level indicating which of two input voltages is greater. IC uses three cascaded direct-coupled differential amplifier stages working into single-ended output. External 1.4K load resistor and pnp level-shift stage Q14-Q15 help maintain minimum overall gain of 15,000. Article describes other TRW custom IC's used in same system.—D. P. Schulz and D. J. Dooley, Integrating Space Telemetry Systems with Compatible Thin Films on Silicon, *Electronics*, June 26, 1967, p 111–122.


+1.35V
T1
X
X
T.D2
C
.001 μf
B.D.
4.7
L2
15K
2N797
400 pf
M.D.
T.D1
560
S.G.
X
X
400 pf
L1
B.D.
400 pf
560
S.G.

22-KHZ IMPLANT TRANSMITTER—Used to monitor intestinal pressures in animals. Strain gages (in bridge) are sutured to small intestine, and degree of balance of bridge arm is used to modulate subcarrier that in turn modulates carrier oscillator. Signal is picked up by f-m receiver having subcarrier filter, a-m detector, and recorder.—W. H. Ko and M. R. Neuman, Implant Biotelemetry and Microelectronics, *Science*, April 1967, p 351–360.

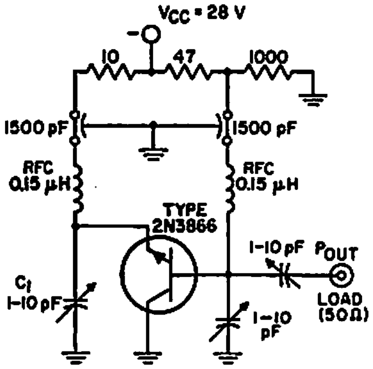

+4.8V
1.2K
2.2K
D2 1N4009
2N508
12K
4700pf
IN
8200
22K
C1 0.01μf
20-40 mh
L
C 0.04 μf
2N2712
C2
0.01μf
D1
Ge DIODE
1K
GND
INPUT
OUTPUT
SUB-CARRIER BURSTS
RECOVERED PULSE WAVEFORM

4-KHZ SUBCARRIER BURST REGENERATION—Frequency-selective L-C input network with 100-Hz passband recognizes only desired pulse modulation of 4-kHz subcarrier. Circuit delivers clean regenerated pulse. D2 provides 0.5-V threshold against noise pulses. —J. H. Phelps, Selective Circuit Provides High Pulse Regeneration, *Electronic Design*, March 16, 1964, p 103.


SUN ANGLE SENSOR
+12 VOLTS
270
27k
2N2646
15μf
33k
270k
270k
33k
560k
560k
1,000 pf
1,000 pf
16 COUNTER
TURN ON CODE SWITCH
CODE SWITCH
8
4
2
1
4̄
2̄
CODE GENERATING CIRCUIT (WIRED FOR CODE K)
+12 VOLTS
10k
330k
330k
330k
330k
330k
330k
330k
1
3
5
7
9
CODE SELECT LINE
CODE SELECT WIRE
CODE TURN OFF WIRE
TRANSMITTER MODULATION
1k
2N3638
TURN OFF CODE SWITCH
4̄
4
8
1,2̄
1,2
TRANSMITTER
+12 VOLTS
39k
4.7k
20μf
10μf
XTAL 15.025 Mhz
2N2951
100
0.1μf
47pf
270pf
CADELL BURNS 435-3 COIL (MODIFIED)
2 TURNS 28 WIRE
2N2951
TOROID 1μh
6.8μh
82pf
0.1μf
200pf
0.1μf
BOTTOM ANTENNA 16.5 FEET 26 WIRE
TOP ANTENNA 16.5 FEET 26 WIRE

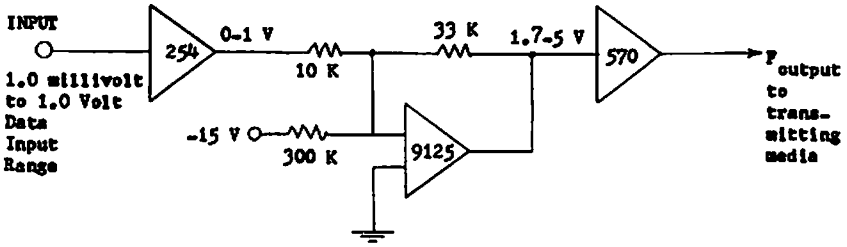
ALL TRANSISTORS 2N2925, EXCEPT AS SHOWN
ALL DIODES T1-7

GHOST BALLOON TELEMETRY—Four identical flip-flops in 16-counter, five NAND gates, and mvbr switch serve as code generating and repeating circuits for Project GHOST (Global HOrizontal Sounding Technique). Circuit operates on maximum power of 150 mA at 12 V generated by solar-cell panel. Transmitter is shared by four sensors.—E. W. Lichfield and R. W. Frykman, Ghost Balloons Riding the Skies Will Report the World's Weather, *Electronics*, No. 28, 1966, p 98–106.


VCC = 28 V
10
47
1000
1500 pF
1500 pF
RFC
0.15 µH
RFC
0.15 µH
TYPE
2N3866
1-10 pF
POUT
LOAD
(50Ω)
Ct
1-10 pF
1-10
pF

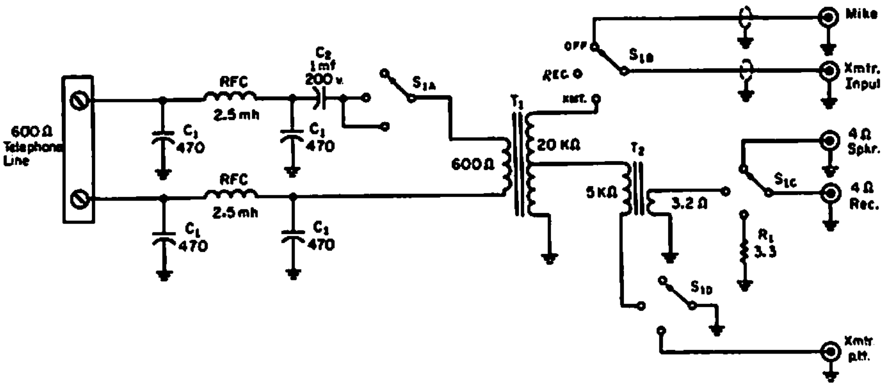
1,000-MHZ LUMPED-CONSTANT OSCILLATOR—Simple circuit delivers 0.5 W at 700 to 1,000 MHz, for use as low-power transmitter in telemetry and other applications.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 347.

THREE-IC TRANSMITTER—Input signal is compressed in OEI Model 254 IC logamp and resulting signal with 3:1 dynamic range fed to OEI Model 570 voltage-to-frequency IC transducer to give proportional sinusoidal output for transmitting over telephone lines, a-m or f-m radio link, laser beam, or light beam. Model 9125 opamp establishes proper voltage levels for 570. Upper limit of frequency response is 1 kHz.—A Wide Dynamic Range Telemetry System, Optical Electronics, Tucson, Ariz., No. 10062.


INPUT
1.0 millivolt to 1.0 Volt Data Input Range
254
0-1 V
10 K
33 K
1.7-5 V
570
F output to trans-mitting media
-15 V
300 K
9125

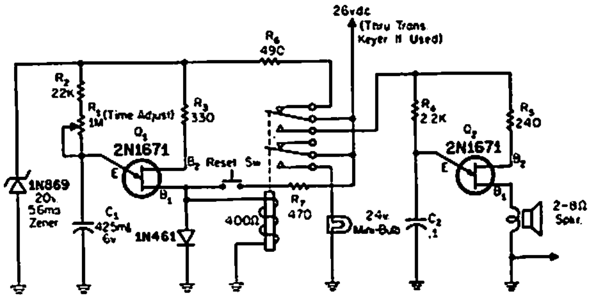
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 84
Telephone Circuits



600Ω Telephone Line
RFC 2.5mh
RFC 2.5mh
C2 1mf 200v
C1 470
C1 470
C1 470
C1 470
S1A
T1
600Ω
20 KΩ
OFF
REC
XMT
S1B
Mike
Xmtr. Input
4Ω Spkr.
4Ω Rec.
S1C
T2
5KΩ
3.2Ω
R1 3.3
S1D
Xmtr ptt.

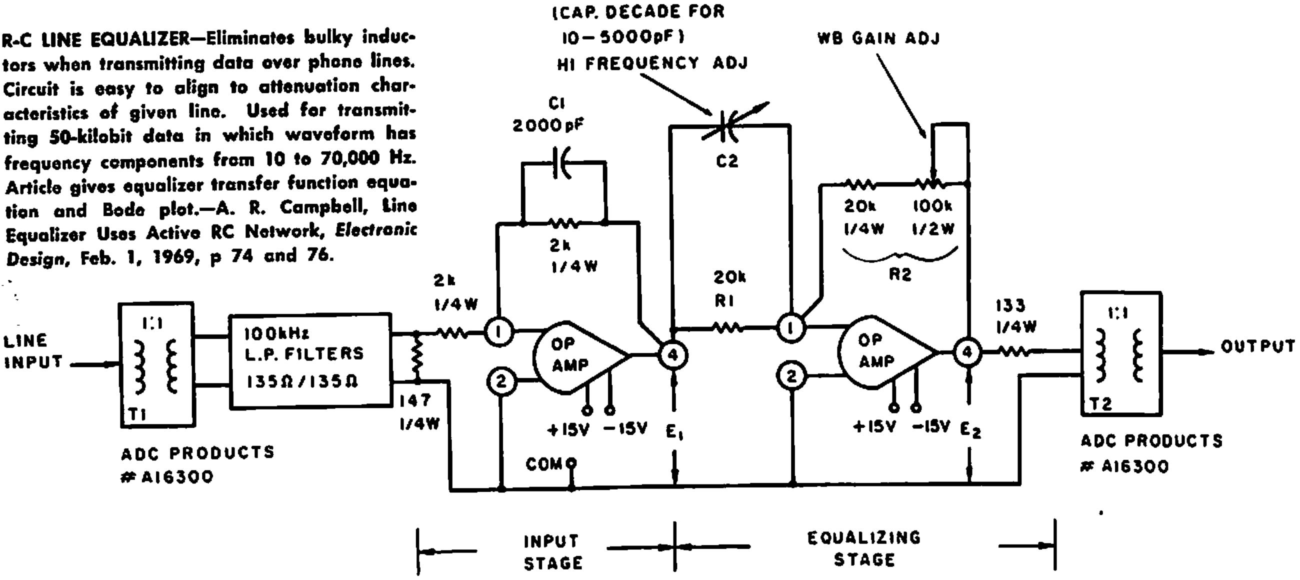
MANUAL PHONE PATCH—Prevents tripping of transmitter at wrong time, with resultant doubling and need for repeats during excitement of carrying on radio conversation from remote telephone. Parts values are not critical, except for transformers that must provide required impedance match.—G. L. Erland, A Junk Box Phone Patch, CQ, Oct. 1969, p 47–48.



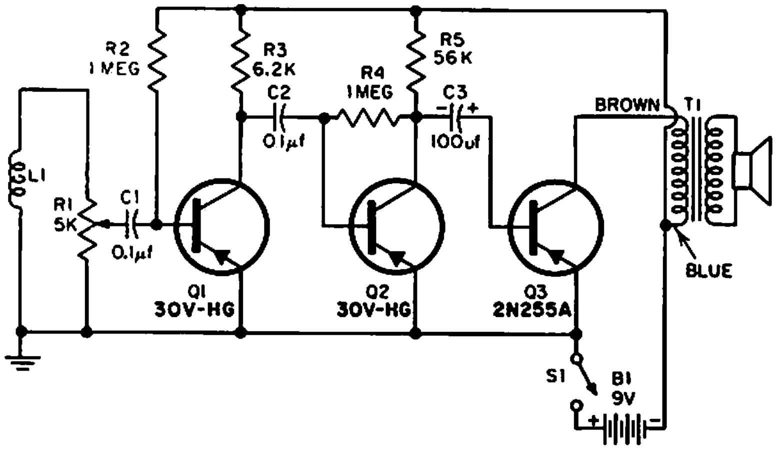
26vdc (Thru Trans Keyer If Used)
R6 490
R2 22K
R1 1M (Time Adjust)
R3 330
Q1 2N1671
B2
E
B1
Reset Sw
1N869 20v 56ma Zener
C1 425mf 6v
1N461
400Ω
R7 470
24v Min-Bulb
R4 2.2K
Q2 2N1671
R5 240
C2 .1
2-8Ω Spkr.

PHONE-PATCH TIMER—High-accuracy circuit can be set to produce speaker beep and warning light flash at any rate from one per second to one every 12 minutes. Can be set as 10-minute reminder for identifying amateur radio call, 3-minute reminder for long-distance phone calls, and as beep generator required by law for recording phone conversations. Reset switch may be used at any time to initiate new timing interval.—J. Ouellette, The Ten Minute Minder, CQ, May 1965, p 60.

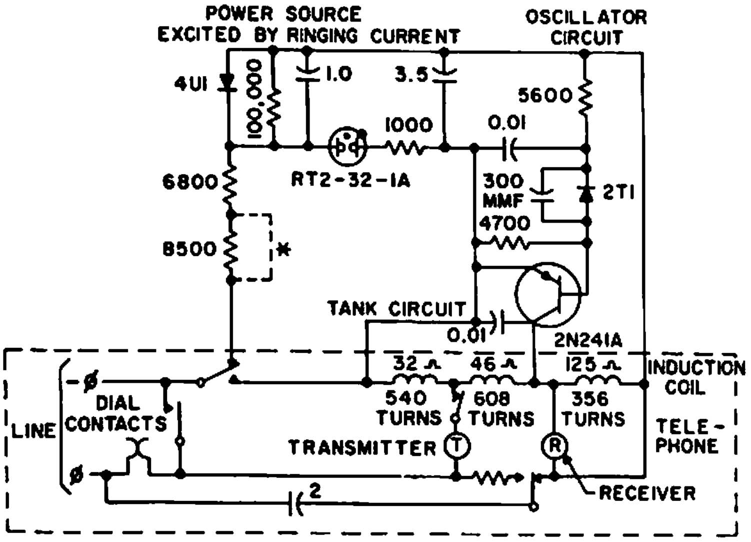
R-C LINE EQUALIZER—Eliminates bulky inductors when transmitting data over phone lines. Circuit is easy to align to attenuation characteristics of given line. Used for transmitting 50-kilobit data in which waveform has frequency components from 10 to 70,000 Hz. Article gives equalizer transfer function equation and Bode plot.—A. R. Campbell, Line Equalizer Uses Active RC Network, *Electronic Design*, Feb. 1, 1969, p 74 and 76.



(CAP. DECADE FOR 10–5000pF) HI FREQUENCY ADJ
WB GAIN ADJ
C1 2000pF
C2
2k 1/4W
20k R1
20k 1/4W
100k 1/2W
R2
LINE INPUT
1:1
T1
ADC PRODUCTS # A16300
100kHz L.P. FILTERS 135Ω/135Ω
2k 1/4W
147 1/4W
OP AMP
OP AMP
+15V −15V
E1
E2
COM
133 1/4W
T2
OUTPUT
INPUT STAGE
EQUALIZING STAGE

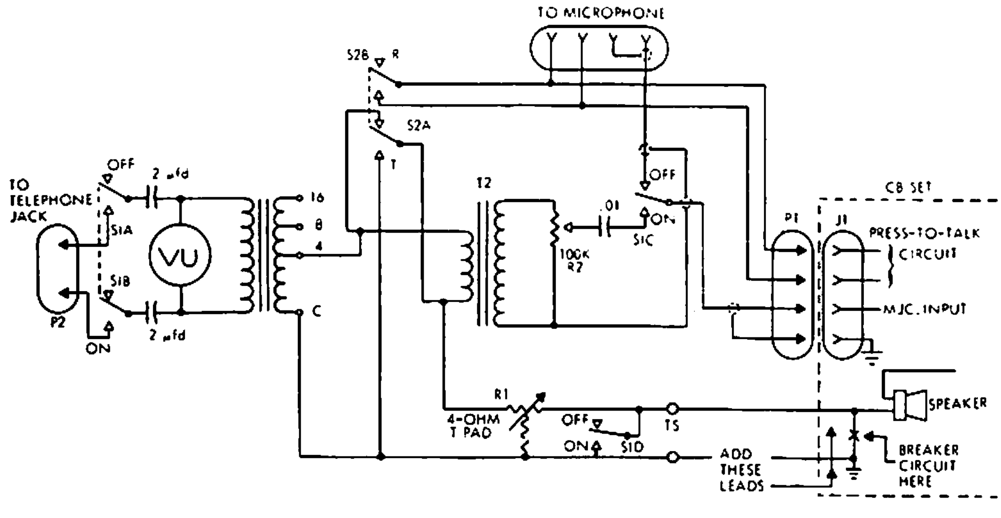

R2
1 MEG
R3
6.2K
C2
0.1µf
R4
1MEG
R5
56K
C3
100uf
BROWN
T1
L1
R1
5K
C1
0.1µf
Q1
30V-HG
Q2
30V-HG
Q3
2N255A
BLUE
S1
B1
9V

TELEPHONE AMPLIFIER—Used for listening to both sides of telephone conversation on loudspeaker. L1 is commercial induction coil made for telephone pickup, placed near telephone set or telephone line (Radio Shack No. 44-533). T1 is transistor audio output transformer with 500-ohm primary and 8-ohm secondary, driving small 8-ohm speaker.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 24.

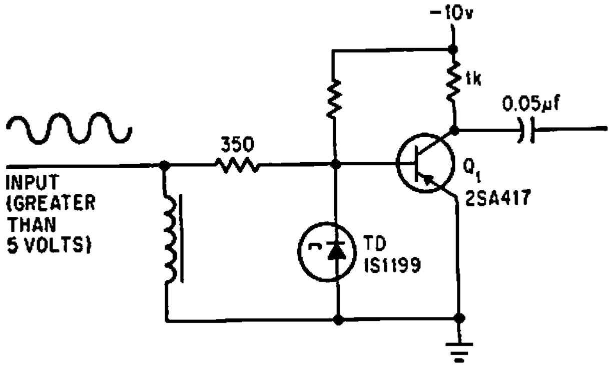

POWER SOURCE
EXCITED BY RINGING CURRENT
OSCILLATOR
CIRCUIT
4U1
100,000
1.0
3.5
5600
1000
0.01
RT2-32-1A
6800
300
MMF
2T1
4700
8500
*
TANK CIRCUIT
0.01
2N241A
32 Ω
46 Ω
125 Ω
INDUCTION
COIL
LINE
DIAL
CONTACTS
540
TURNS
608
TURNS
356
TURNS
TELE-
PHONE
TRANSMITTER
T
R
RECEIVER
2

✱ INSERT JUMPER TO DECREASE LEVEL

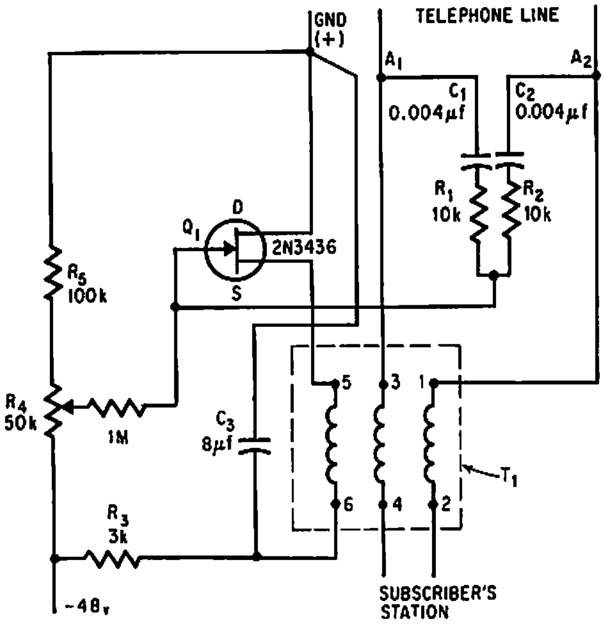
SOLID-STATE TONE RINGER—Used in Ericfon one-piece telephone to give pleasant warbling tone instead of nerve-jangling sound of standard bell. Ringing 20-Hz voltage rectified by power source is applied to transistor oscillator via neon lamp. Oscillator produces sine-wave output of variable amplitude which causes diaphragm of receiver to vibrate, generating tone.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 98.


TO MICROPHONE
S2B
R
S2A
T
TO
TELEPHONE
JACK
OFF
2 µfd
S1A
VU
S1B
2 µfd
P2
ON
16
8
4
C
T2
.01
OFF
ON
S1C
100K
R2
CB SET
P1
J1
PRESS-TO-TALK
CIRCUIT
MIC. INPUT
R1
4-OHM
T PAD
OFF
ON
S1D
TS
SPEAKER
ADD
THESE
LEADS
BREAKER
CIRCUIT
HERE

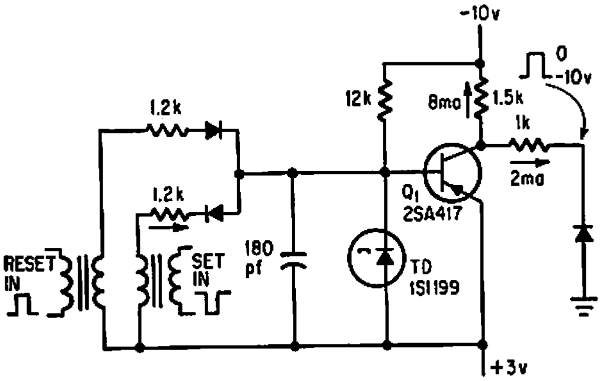
CB PHONE PATCH—Can be connected to telephone line through telephone jack, or through protective network furnished by telephone company. If person at distant telephone is called conventionally by phone and switch S1 is closed, that person can transmit and receive over station equipment connected to phone patch.—Phone Patch, CB *Magazine*, July 1969, p 16, 34–36, and 38.


-10v
1k
0.05μf
350
INPUT (GREATER THAN 5 VOLTS)
Q_1
2SA417
TD
IS1199

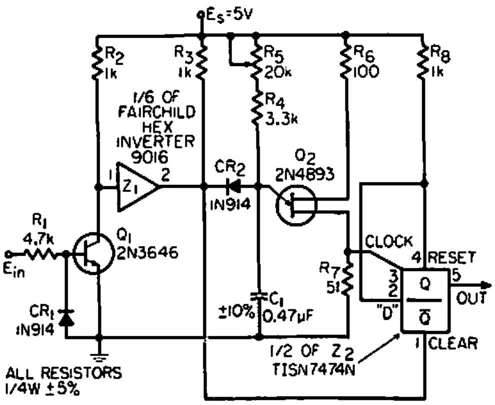
TUNNEL-DIODE PCM SHAPER—Similar to Schmitt trigger, but simpler, more stable, and requires less power. Operation is monostable. Used in Japanese PCM-24 telephone system.—H. Inose and H. Fujisaki, Japanese Stay with PCM to Meet Mushrooming Growth in Telephony, *Electronics*, Dec. 12, 1966, p 134–147.


GND (+)
TELEPHONE LINE
A_1
A_2
C_1 0.004μf
C_2 0.004μf
R_1 10k
R_2 10k
D
Q_1
2N3436
S
R_5 100k
R_4 50k
1M
C_3 8μf
R_3 3k
5
3
1
6
4
2
T_1
-48v
SUBSCRIBER'S STATION

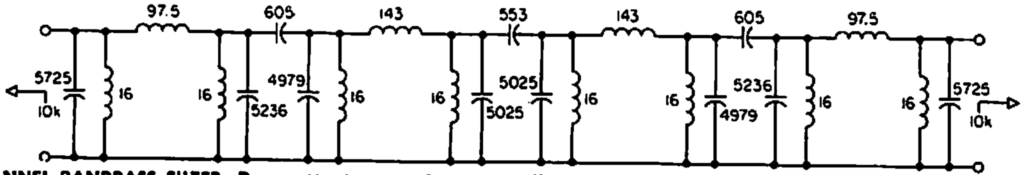
PHONE NOISE CANCELLER—Feedback circuit shown is inserted in telephone line at subscriber's location to cancel large noise voltages induced by power lines. Circuit senses, amplifies, and reintroduces these longitudinal noise voltages 180 deg out of phase to give cancellation.—R. G. Stoneman, Feedback Eliminates Noise in Telephone Circuit, *Electronics*, Nov. 27, 1967, p 82.


-10v
0
-10v
12k
8ma
1.5k
1k
2ma
1.2k
1.2k
Q_1
2SA417
RESET IN
SET IN
180 pf
TD
IS1199
+3v

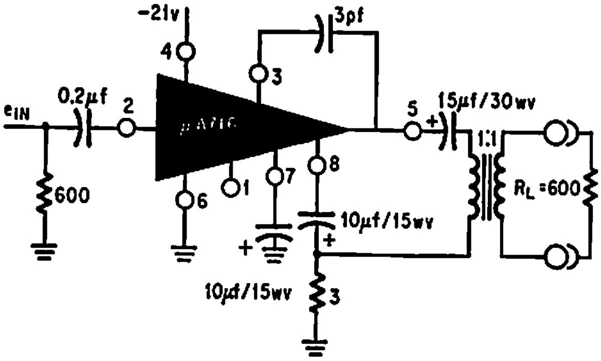
PCM SWITCHING—Transistor-tunnel diode combination provides high-speed switching along with memory, in Japanese PCM-24 telephone system in which speech signals are sampled 8,000 times a second. A set signal switches tunnel diode to high-voltage state, where it remains after set pulse is removed. Reset signal switches diode to low-voltage state, where it remains after reset pulse is removed. —H. Inose and H. Fujisaki, Japanese Stay with PCM to Meet Mushrooming Growth in Telephony, *Electronics*, Dec. 12, 1966, p 134–147.


E_S=5V
R_2 1k
R_3 1k
R_5 20k
R_6 100
R_8 1k
R_4 3.3k
1/6 OF FAIRCHILD HEX INVERTER 9016
1
Z_1
2
CR_2 1N914
Q_2 2N4893
R_1 4.7k
E_{in}
Q_1 2N3646
CR_1 1N914
R_7 51
±10%
C_1 0.47μF
CLOCK
4 RESET
3
2
"D"
Q
$\bar{Q}$
5
OUT
1 CLEAR
1/2 OF Z_2 TISN7474N
ALL RESISTORS 1/4W ±5%

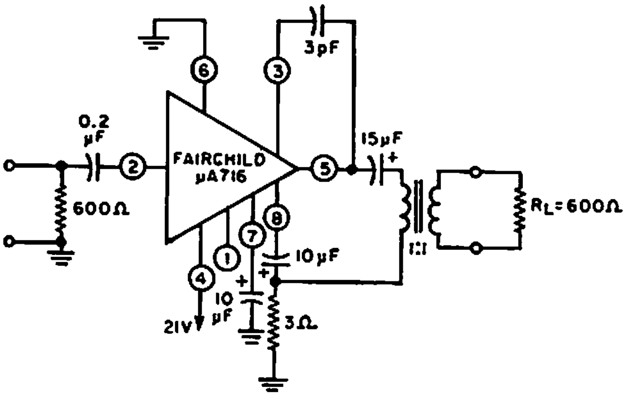
DATAPHONE CARRIER DELAY—Gives adjustable delay of up to 9 ms for leading edge of input pulse when carrier-detect line from Dataphone comes on, to avoid noise that normally appears during first 4 ms due to line deflections. Advantages are low cost, noise immunity, and ability to provide delays up to several seconds without need for large capacitors.—D. J. Duffy, Delayed-Action Data Receiver, *EEE*, Oct. 1968, p 127–128.


97.5
605
143
553
143
605
97.5
5725
10k
16
4979
5236
5025
5025
5236
4979
5725
10k

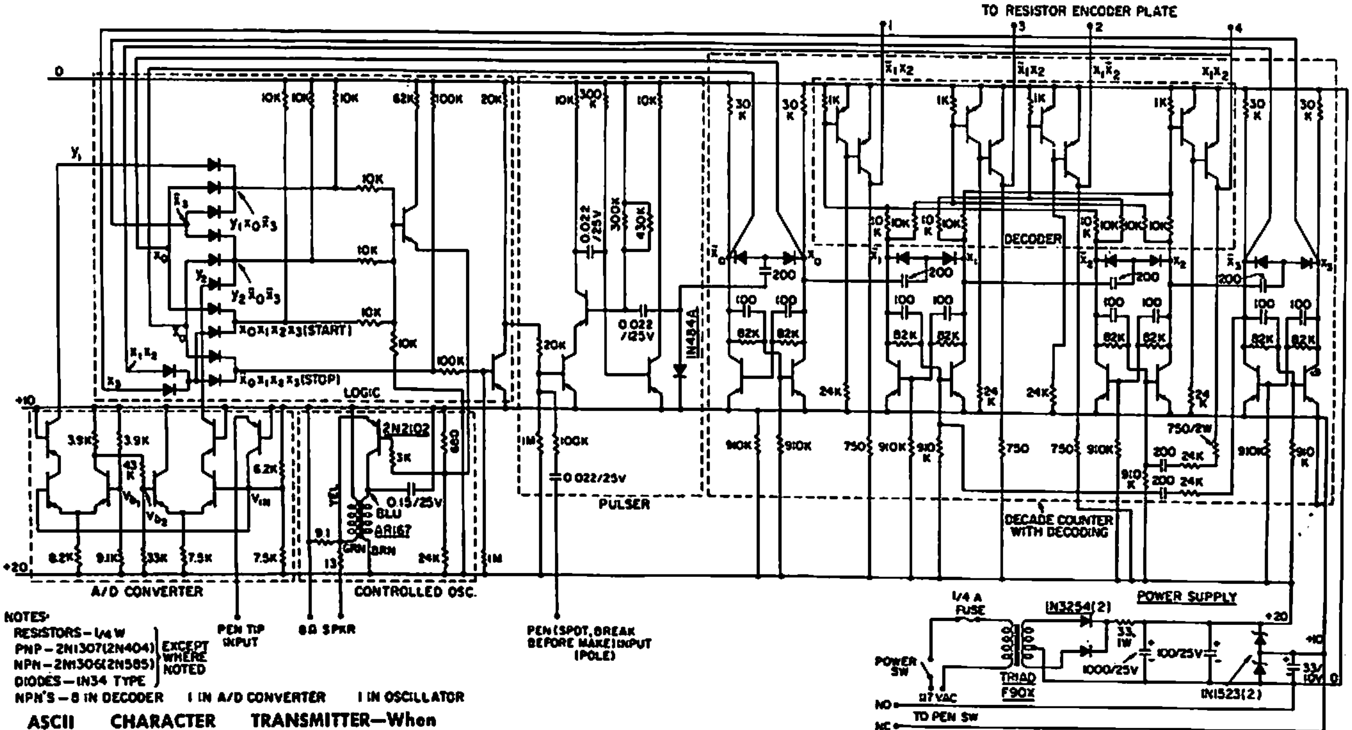
16–20 KHZ CHANNEL BANDPASS FILTER—Designed with coupled resonator units. Inductances are in mH and capacitances in pF. Maximum reflection coefficient is 0.15 over equal-ripple passband of 16.2 to 19.5 kHz. Gyration resistances are 4K.—H. J. Orchard and D. F. Sheahan, Inductorless Bandpass Filters, *IEEE Journal of Solid-State Circuits*, June 1970, p 108–118.


-21v
3pf
e_IN
0.2μf
600
μA716
15μf/30wv
1:1
R_L=600
10μf/15wv
10μf/15wv
3

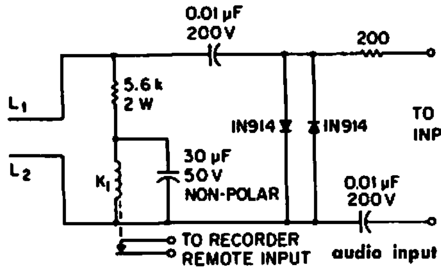
TELEPHONE-CHANNEL AMPLIFIER—Fairchild μA716 low-distortion IC opamp matches 600-ohm line impedance and provides flat frequency response over channel bandwidth of 0.1 to 3.2 kHz. Output is 13 dBm. Article contains 13 other IC opamp application circuits.—J. F. Gifford and M. Markkula, Linear IC's: Part 5, Ins and Outs of Op Amps, *Electronics*, Nov. 27, 1967, p 84–93.


3pF
0.2 μF
V_IN
600Ω
FAIRCHILD μA716
15μF
10μF
10 μF
21V
3Ω
1:1
R_L=600Ω

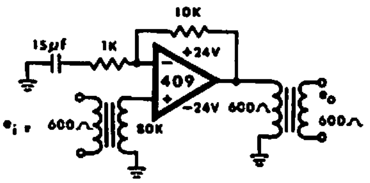
TELEPHONE-CHANNEL IC AMPLIFIER—Provides 40 dB gain with less than 0.1% distortion. Output noise level is minus 75 dBm over any 4,000-Hz bandwidth.—D. E. Lancaster, Audio Integrated Circuits—What's Available?, *Electronics World*, Oct. 1967, p 34–36.


TO RESISTOR ENCODER PLATE
LOGIC
PULSER
DECODER
DECADE COUNTER WITH DECODING
A/D CONVERTER
CONTROLLED OSC.
POWER SUPPLY
2N2102
IN484A
1N3254(2)
1N1523(2)
TRIAD F90X
117 VAC
POWER SW
1/4 A FUSE
TO PEN SW
PEN TIP INPUT
8Ω SPKR
PEN (SPOT, BREAK BEFORE MAKE) INPUT (POLE)
NOTES:
RESISTORS—1/4 W
PNP—2N1307(2N404)
NPN—2N1306(2N585)
DIODES—1N34 TYPE
EXCEPT WHERE NOTED
NPN'S—8 IN DECODER
1 IN A/D CONVERTER
1 IN OSCILLATOR

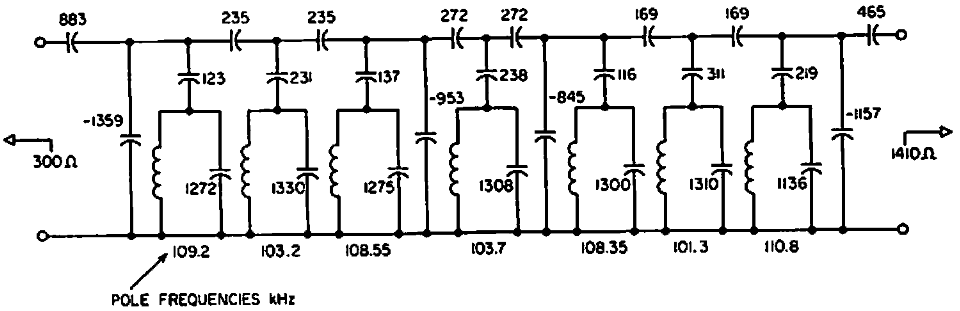
ASCII CHARACTER TRANSMITTER—When acoustically coupled to conventional handset, generates coded tone sequences for 128 alphanumeric characters when user dials remote machine and inputs message by pointing at symbols on keyboard with hand-held selection pen in hunt-and-peck fashion. Tone sequences correspond to those generated by most Teletype-Dataphone terminals in typical time-sharing systems. Pen closes conductive path and at same time has pressure-actuated switch that advances counter.—M. H. Lewin, Portable Electronic Keyboard for Computer Input by Telephone, *IEEE Transactions on Electronic Computers*, June 1967, p 332–334.


0.01 µF
200 V
200
L1
L2
5.6 k
2 W
K1
30 µF
50 V
NON-POLAR
IN914
IN914
TO AUDIO (AUX)
INPUT
0.01 µF
200 V
TO RECORDER
REMOTE INPUT

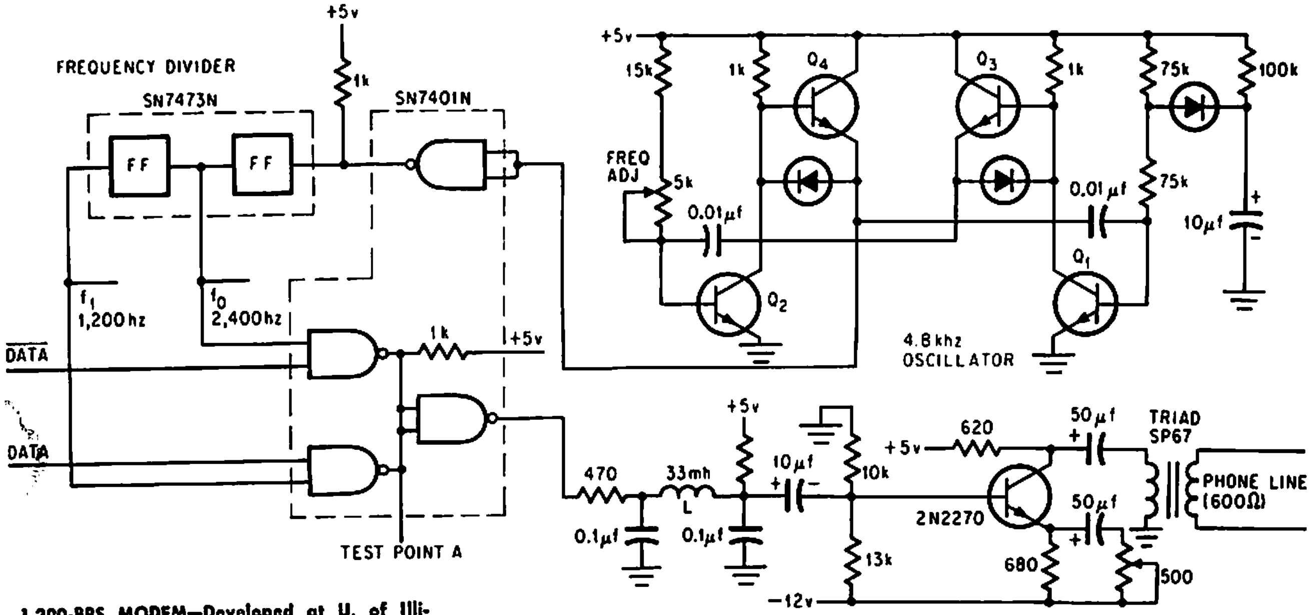
AUTOMATIC RECORDER—Requires connection to telephone input wires L1-L2, which are normally 48 V d-c. When phone is on hook, this voltage energizes relay K1 and keeps recorder switch contacts open. Combination of relay and series resistor must be well above 2K to prevent off-hook indication. Ringing voltage of 90 V at 20 Hz is blocked out of audio input to recorder by IN914 diode pair and kept out of relay coil by 30-µF capacitor. When receiver is lifted, varistor in phone drops L1-L2 voltage to about 6 V d-c, and relay drops out for starting recorder and recording both sides of conversation. Relay can be Sigma 65F1A or equivalent 24 V d-c unit.—H. Metz, Automatic Telephone Recorder, *EEE*, July 1970, p 85.


10K
15µf
1K
+24V
409
−24V
600Ω
e_i
600Ω
80K
e_o
600Ω

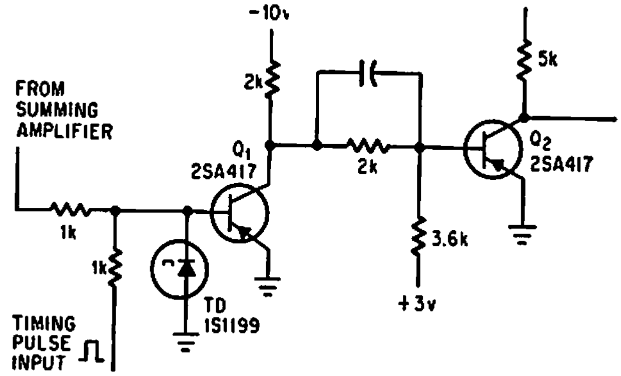
LINE AMPLIFIER—Provides gain of 100 (40 dB) when inserted in 600-ohm telephone line. Output across secondary of line transformer is 22 dBm. Uses model 409 IC opamp. With 150-ohm primary in output transformer, output level goes up to 30 dBm.—B. J. Losmandy, Operational Amplifier Application for Audio Systems, Opamp Labs, Los Angeles, Cal., 1968.


883
235
235
272
272
169
169
465
123
231
137
-953
238
-845
116
311
219
-1359
-1157
300Ω
1410Ω
1272
1330
1275
1308
1300
1310
1136
109.2
103.2
108.55
103.7
108.35
101.3
110.8
POLE FREQUENCIES kHz

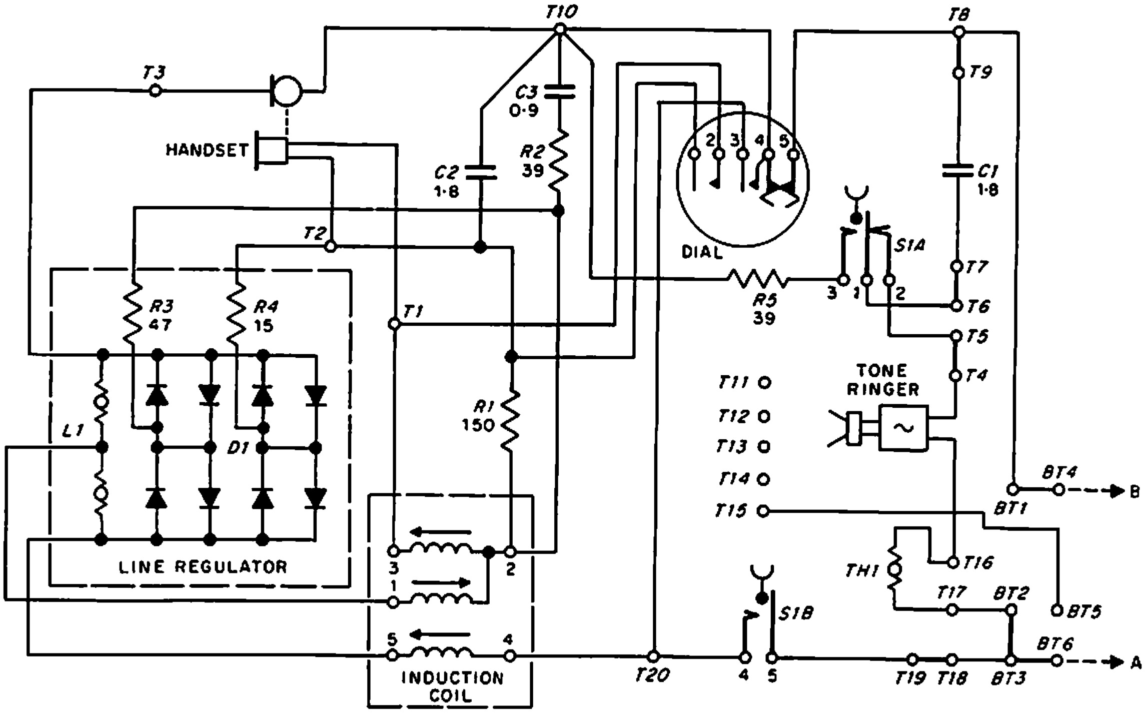
104–108 KHZ CHANNEL BANDPASS FILTER—Used in multiplex telephony. Designed with grounded inductors that are all 1.523 mH, and negative capacitors whose values are given in pF. Gives maximum reflection coefficient of 0.1 over equal-ripple passband from 104.5 to 107.85 kHz. All gyration resistances are 1.8K (Riordan gyrator). Supply voltages of 10 V positive and negative were used for opamps in both gyrators and negative-capacitance circuits that simulate components shown.—H. J. Orchard and D. F. Sheahan, Inductorless Bandpass Filters, *IEEE Journal of Solid-State Circuits*, June 1970, p 108–118.


+5v
1k
FREQUENCY DIVIDER
SN7473N
FF
FF
SN7401N
f_1
1,200hz
f_0
2,400hz
$\overline{\text{DATA}}$
DATA
1k
+5v
TEST POINT A
+5v
15k
1k
Q_4
Q_3
1k
75k
100k
FREQ
ADJ
5k
0.01µf
Q_2
0.01µf
75k
10µf
Q_1
4.8 khz
OSCILLATOR
+5v
470
33mh
L
0.1µf
0.1µf
10µf
10k
+5v
620
50µf
TRIAD
SP67
PHONE LINE
(600Ω)
2N2270
50µf
680
13k
500
−12v

1,200-BPS MODEM—Developed at U. of Illinois for Plato (Programmed Logic for Automatic Teaching Operations) system. Input signal from phone line, consisting of two cycles of 2.4-kHz sine wave for binary 0 and one cycle of 1.2 kHz for binary 1, is converted back to digital form by limiting amplifier and integrator-comparator whose threshold is set so that only the 1 pulses, twice as wide as 0 pulses, rise above threshold. Resulting 1 pulse turns on data flip-flop, while 0 pulse turns it off, to restore digital equivalent of transmitted data.—J. Stifle and M. Johnson, Design Pruning Trims Costs of Data Modem, *Electronics*, July 20, 1970, p 99–101.


-10v
2k
FROM SUMMING AMPLIFIER
Q1
2SA417
2k
5k
Q2
2SA417
1k
1k
3.6k
TD
1S1199
+3v
TIMING PULSE INPUT

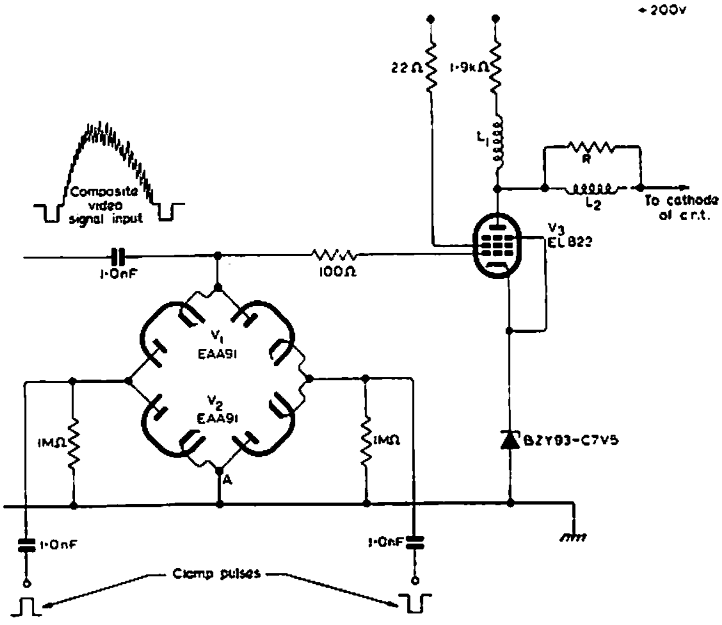
COMPARATOR WITH AND GATE—Used in feedback encoder for Japanese PCM-24 telephone system, for comparing amplitudes of pulses created by sampling speech signals 8,000 times per second. Input must be above specified level and timing pulse present to get pulsed output.—H. Inose and H. Fujisaki, Japanese Stay with PCM to Meet Mushrooming Growth in Telephony, *Electronics*, Dec. 12, 1966, p 134–147.


T10
T8
T3
T9
HANDSET
C3
0·9
R2
39
C2
1·8
C1
1·8
T2
2
3
4
5
DIAL
S1A
T7
R3
47
R4
15
T1
R5
39
3
1
2
T6
T5
TONE RINGER
T4
T11
T12
T13
T14
T15
L1
D1
R1
150
BT4
B
BT1
TH1
T16
T17
BT2
BT5
S1B
BT6
A
3
2
1
5
4
LINE REGULATOR
INDUCTION COIL
T20
4
5
T19
T18
BT3

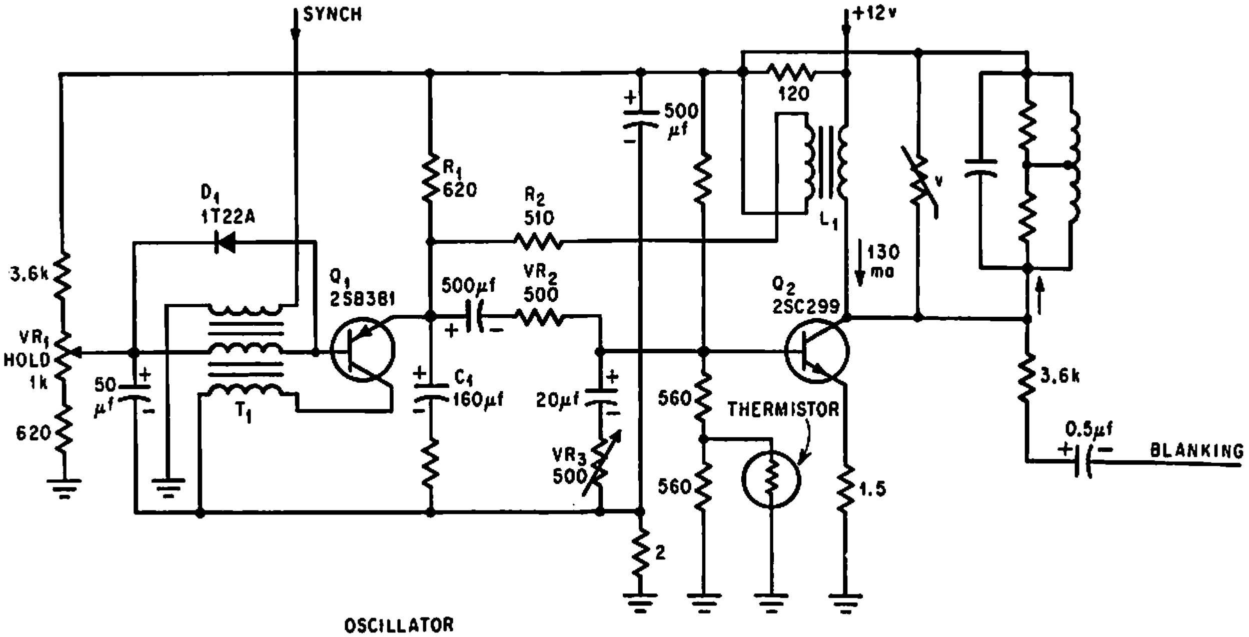
TELEPHONE TRANSMISSION CIRCUIT—Used in new handset developed for British Post Office telephone system. Includes highly effective automatic line regulator. Tone ringer is single-transistor oscillator, giving more pleasant tone than harsh magneto bell. C2 and R5 serve as dial spark-quench circuit, eliminating unwetted cradle switch contacts from speech circuit.—J. S. P. Roberton and A. C. Beadle, Deltaphone, *Electrical Communication*, 42:2, 1967, p 212–218.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

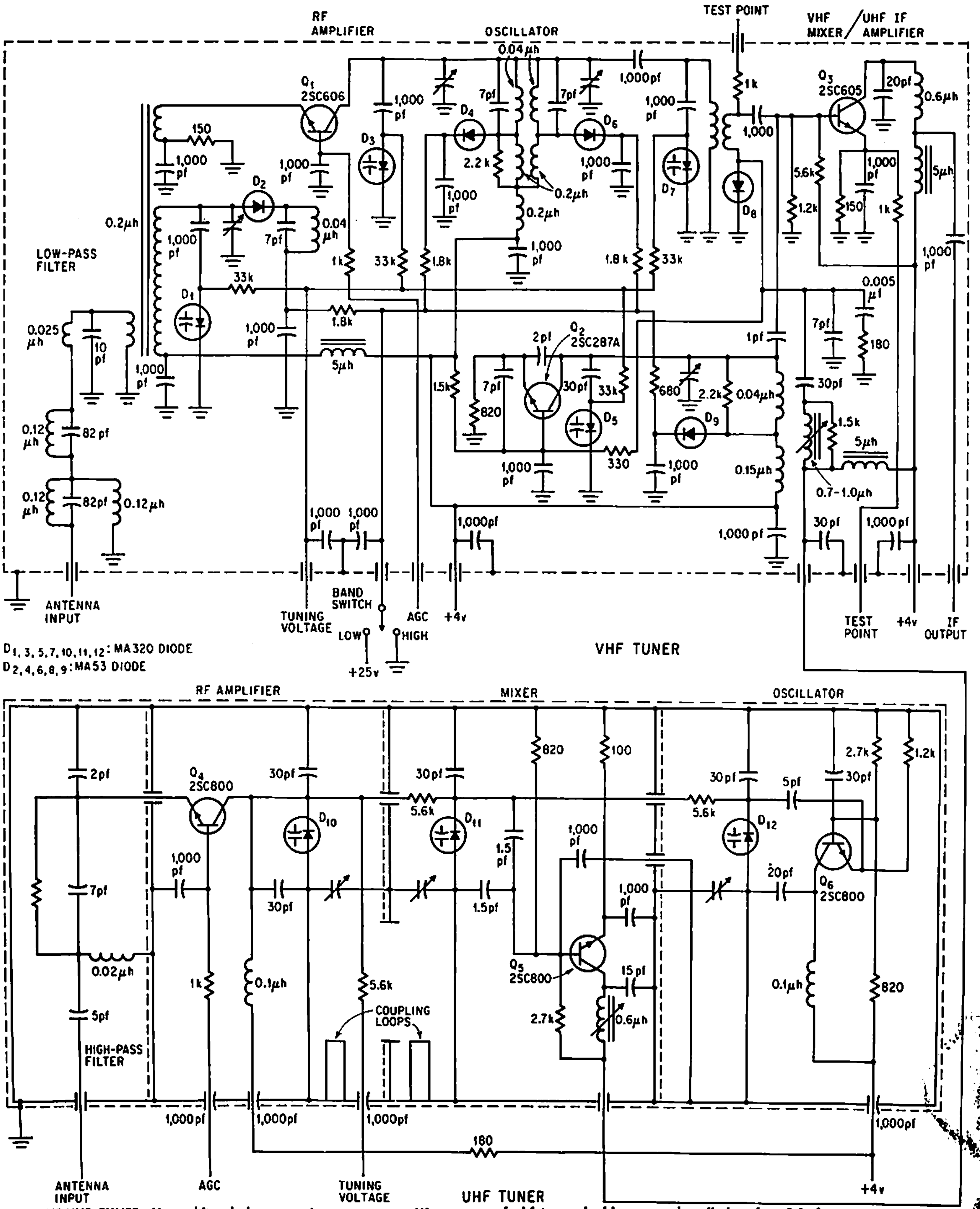
CHAPTER 85
Television Circuits—Black-and-White


+200v
22Ω
1·9kΩ
L1
R
L2
To cathode of c.r.t.
Composite video signal input
1·0nF
100Ω
V3 EL822
V1 EAA91
V2 EAA91
1MΩ
1MΩ
A
BZY93-C7V5
1·0nF
1·0nF
Clamp pulses

VIDEO AMPLIFIER WITH ZENER BIAS—Voltage regulator diode in cathode circuit of pentode makes constant black level more readily obtainable and gives higher gain because it introduces no degeneration. Without cathode degeneration, however, there is no selfcompensation for tube aging.—Voltage Regulator (Zener) Diodes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Application Book, p 59.

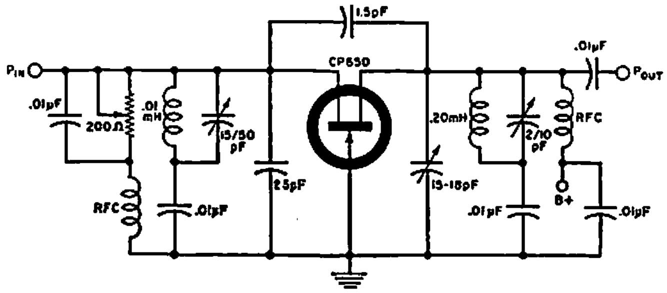

SYNCH
+12v
120
500 μf
R1 620
R2 510
D1 1T22A
3.6k
VR1 HOLD 1k
620
50 μf
T1
Q1 2SB381
500μf
VR2 500
C1 160μf
20μf
VR3 500
2
560
560
THERMISTOR
Q2 2SC299
L1
v
130 ma
3.6k
1.5
0.5μf
BLANKING
OSCILLATOR

TWO-TRANSISTOR VERTICAL DEFLECTION—Number of components is minimized with circuit version used in Sony model 700U 7-inch portable tv. Blocking oscillator Q1 periodically discharges C1, which is charged through R1 to generate vertical sawtooth sweep voltage.—Careful Sweep Design Cuts Power Drain and Cost, *Electronics*, Nov. 14, 1966, p 167–169.

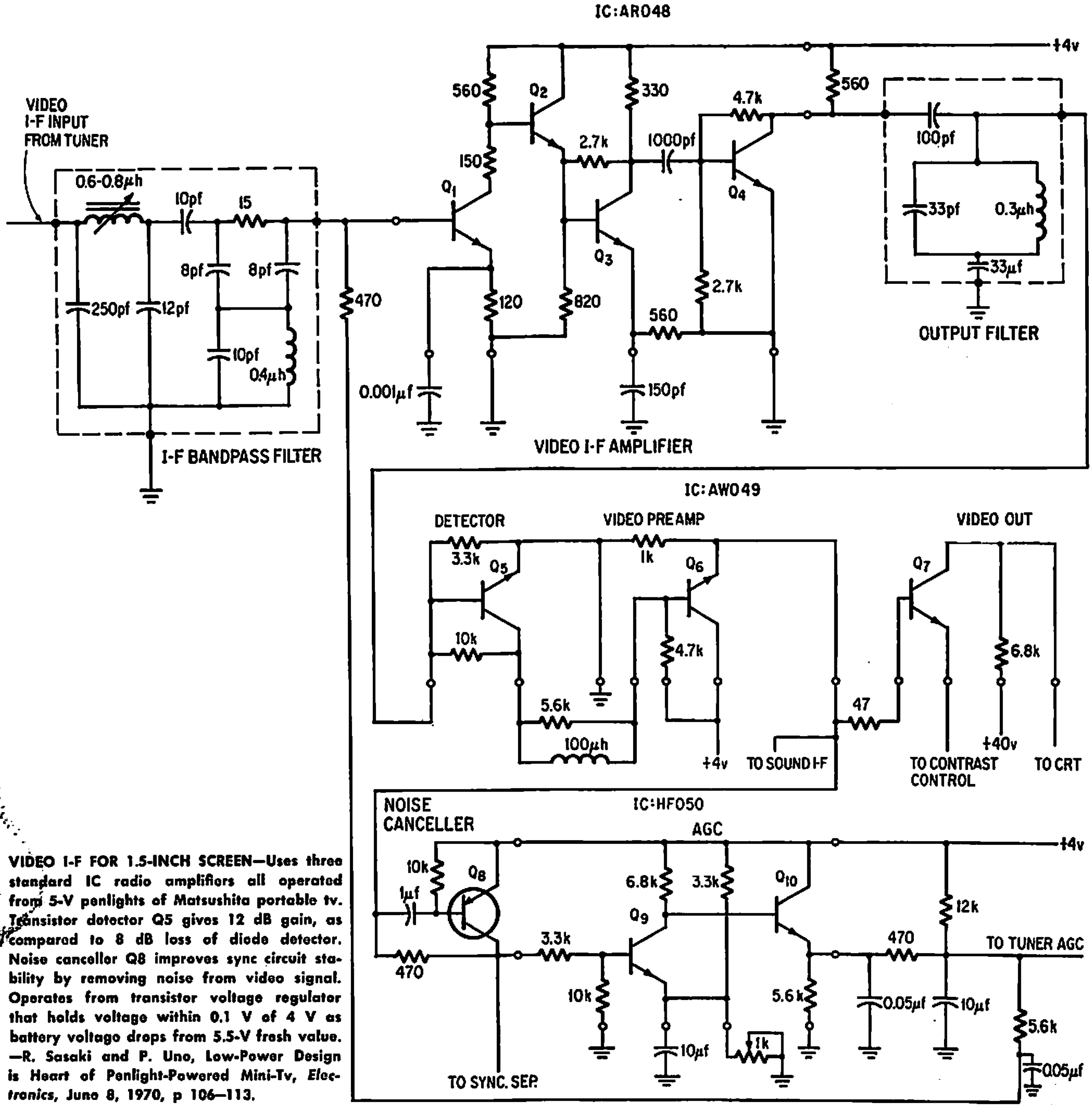

RF AMPLIFIER
OSCILLATOR
TEST POINT
VHF MIXER / UHF IF AMPLIFIER
Q1 2SC606
Q2 2SC287A
Q3 2SC605
D1
D2
D3
D4
D5
D6
D7
D8
D9
LOW-PASS FILTER
0.2μh
0.04μh
0.2μh
0.6μh
5μh
0.7-1.0μh
0.15μh
0.025 μh
0.12 μh
82 pf
1,000 pf
1,000pf
0.005 μf
150
33k
1.8k
2.2k
5.6k
1.2k
680
820
330
1.5k
180
ANTENNA INPUT
TUNING VOLTAGE
BAND SWITCH
LOW
HIGH
+25v
AGC
+4v
TEST POINT
IF OUTPUT
D1, 3, 5, 7, 10, 11, 12: MA320 DIODE
D2, 4, 6, 8, 9: MA53 DIODE
VHF TUNER
RF AMPLIFIER
MIXER
OSCILLATOR
Q4 2SC800
Q5 2SC800
Q6 2SC800
D10
D11
D12
2pf
7pf
5pf
30pf
1.5 pf
15 pf
20pf
0.02μh
0.1μh
0.6μh
1k
2.7k
100
HIGH-PASS FILTER
COUPLING LOOPS
1,000pf
180
ANTENNA INPUT
AGC
TUNING VOLTAGE
+4v
UHF TUNER

VHF-UHF TUNER—Matsushita design operates from 5-V battery and requires only single combination vhf/uhf antenna. Used in receiver drawing only 1.35 W from set of penlight batteries and having 1.5-inch-diagonal screen. Mixer stage of vhf tuner doubles as i-f amplifier in uhf mode. Uses electronic tuning through variable-capacitance diodes, fixed inductors, and switching diodes. Vhf 4:1 frequency ratio requires coil switching by diodes, but 2:1 frequency ratio of uhf band is handled without switching.—R. Sasaki and K. Uno, Low-Power Design is Heart of Penlight-Powered Mini-Tv, *Electronics*, June 8, 1970, p 106–113.

CATV DISTRIBUTION AMPLIFIER—Uses power fet made by Crystalonics, to give excellent stability with 2 W output up to several hundred megahertz for community antenna tv distribution systems.—J. Tamosaitis, The Power FET, *Electronics World*, June 1969, p 34–35 and 82.

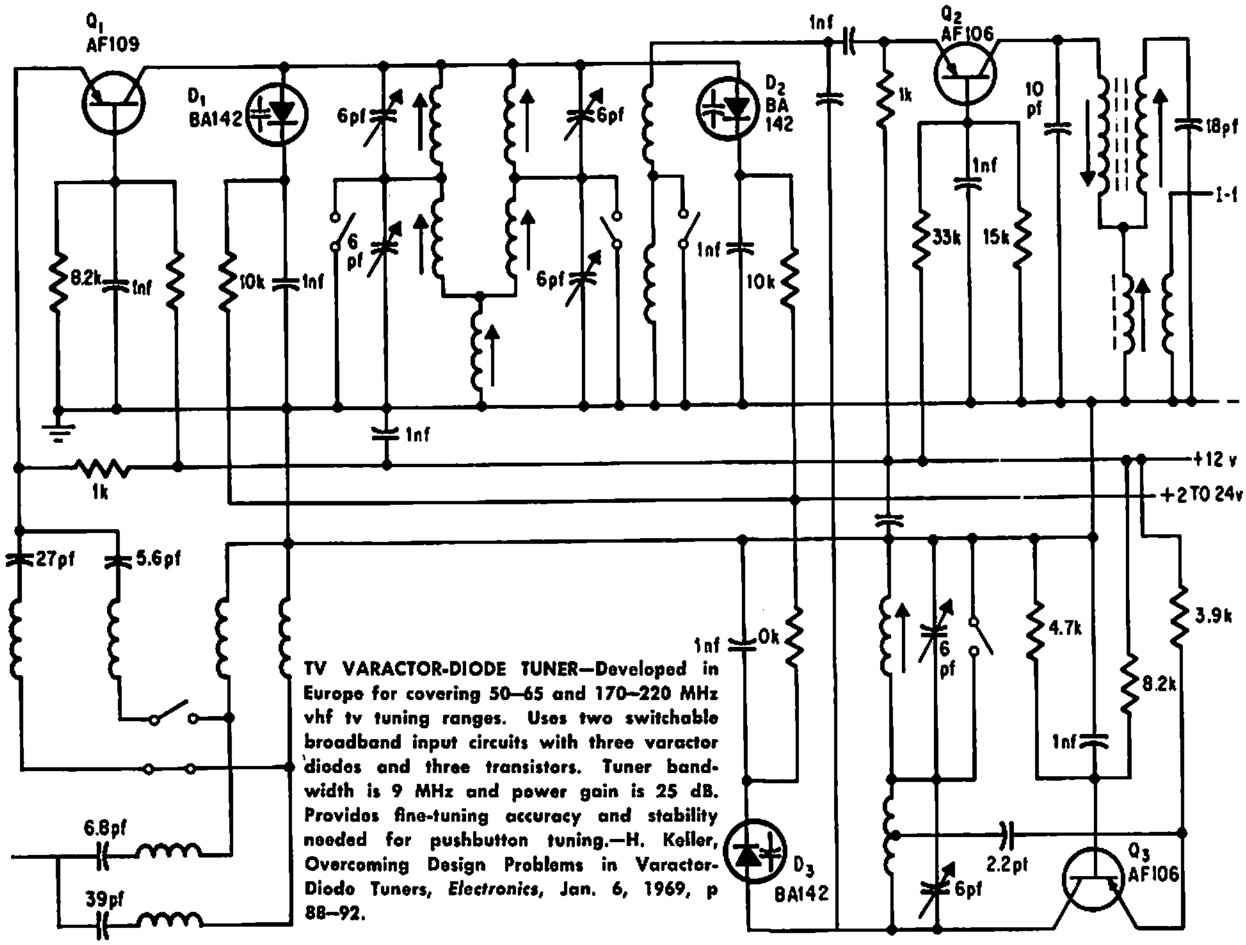


1.5pF
.01μF
P_{IN}
CP630
P_{OUT}
.01μF
200Ω
.01 mH
15/50 pF
.20mH
2/10 pF
RFC
25pF
15-18pF
RFC
.01μF
.01pF
B+
.01μF

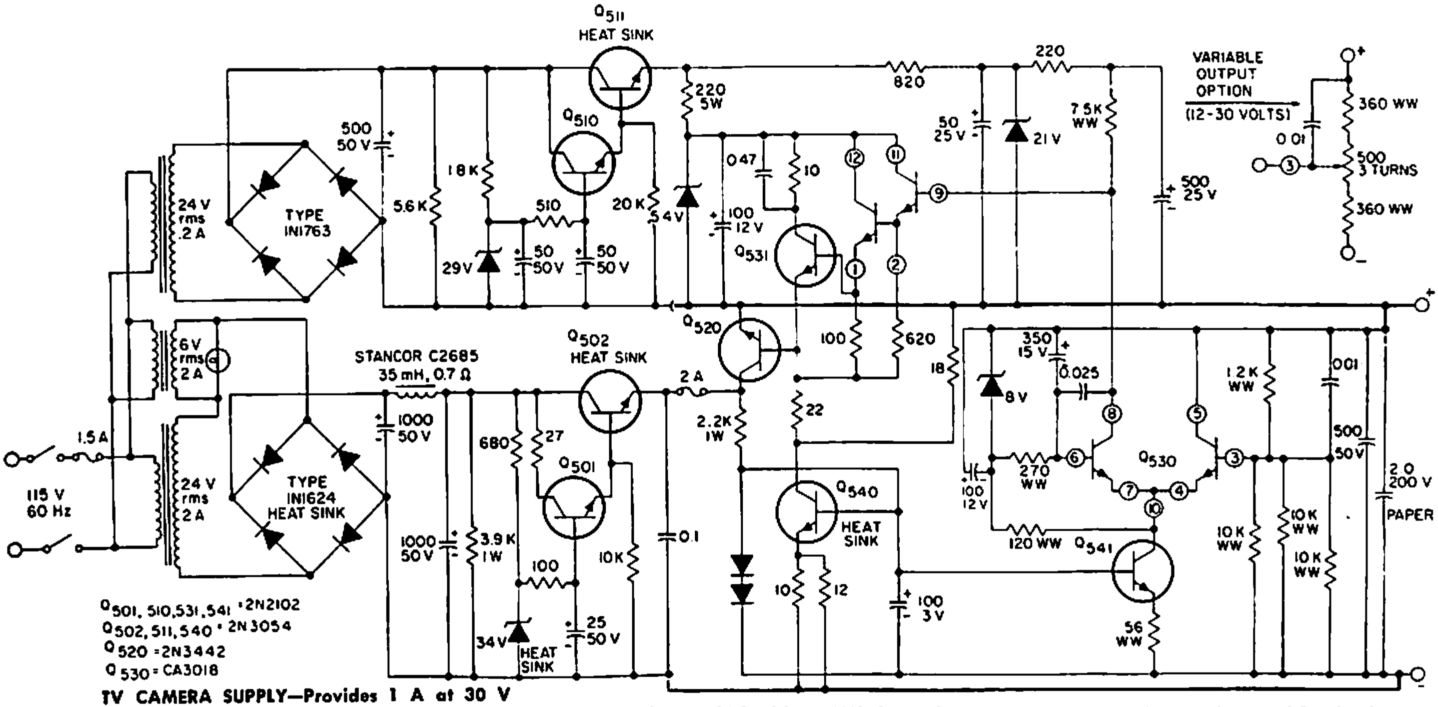


IC:AR048
+4v
VIDEO I-F INPUT FROM TUNER
560
Q2
330
4.7k
560
2.7k
1000pf
100pf
150
Q1
Q4
0.6-0.8μh
10pf
15
33pf
0.3μh
Q3
8pf
8pf
33μf
250pf
12pf
470
120
820
2.7k
560
OUTPUT FILTER
10pf
0.4μh
0.001μf
150pf
I-F BANDPASS FILTER
VIDEO I-F AMPLIFIER
IC:AW049
DETECTOR
VIDEO PREAMP
VIDEO OUT
3.3k
Q5
1k
Q6
Q7
10k
4.7k
6.8k
5.6k
47
100μh
+4v
TO SOUND I-F
+40v
TO CONTRAST CONTROL
TO CRT
NOISE CANCELLER
IC:HF050
AGC
+4v
10k
Q8
6.8k
3.3k
Q10
1μf
Q9
12k
3.3k
470
TO TUNER AGC
470
10k
5.6k
0.05μf
10μf
5.6k
10μf
1k
0.05μf
TO SYNC. SEP.

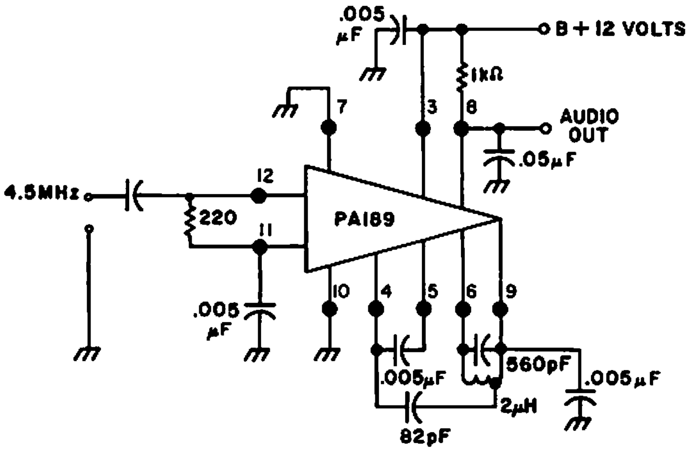
VIDEO I-F FOR 1.5-INCH SCREEN—Uses three standard IC radio amplifiers all operated from 5-V penlights of Matsushita portable tv. Transistor detector Q5 gives 12 dB gain, as compared to 8 dB loss of diode detector. Noise canceller Q8 improves sync circuit stability by removing noise from video signal. Operates from transistor voltage regulator that holds voltage within 0.1 V of 4 V as battery voltage drops from 5.5-V fresh value.—R. Sasaki and P. Uno, Low-Power Design is Heart of Penlight-Powered Mini-Tv, *Electronics*, June 8, 1970, p 106–113.


Q1
AF109
D1
BA142
6pf
6pf
6
pf
6pf
Inf
Q2
AF106
D2
BA
142
1k
10
pf
18pf
1nf
33k
15k
1-f
8.2k
Inf
10k
1nf
1nf
10k
1nf
1k
+12 v
+2 TO 24v
27pf
5.6pf
1nf
0k
6
pf
4.7k
3.9k
8.2k
1nf
6.8pf
39pf
D3
BA142
2.2pf
6pf
Q3
AF106

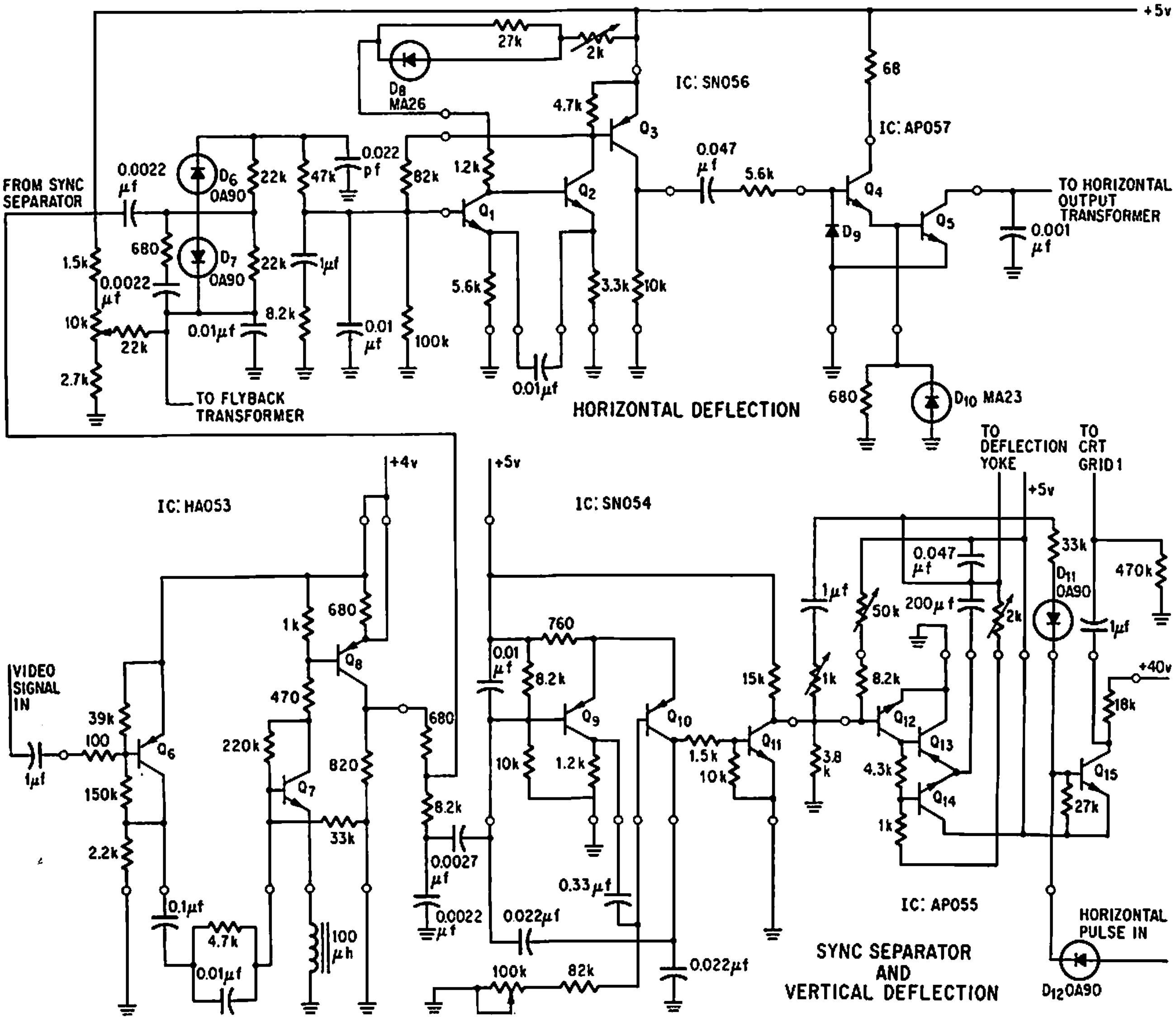
TV VARACTOR-DIODE TUNER—Developed in Europe for covering 50–65 and 170–220 MHz vhf tv tuning ranges. Uses two switchable broadband input circuits with three varactor diodes and three transistors. Tuner bandwidth is 9 MHz and power gain is 25 dB. Provides fine-tuning accuracy and stability needed for pushbutton tuning.—H. Keller, Overcoming Design Problems in Varactor-Diode Tuners, *Electronics*, Jan. 6, 1969, p 88–92.


Q511
HEAT SINK
Q510
500
50 V
24 V
rms
2 A
TYPE
IN1763
18K
5.6K
510
20K
29V
50
50V
50
50 V
220
5W
54V
820
220
50
25 V
21 V
7.5K
WW
VARIABLE
OUTPUT
OPTION
(12-30 VOLTS)
360 WW
0.01
500
3 TURNS
360 WW
.047
10
100
12 V
Q531
500
25 V
6V
rms
2A
STANCOR C2685
35 mH, 0.7 Ω
Q502
HEAT SINK
Q520
2 A
1000
50 V
680
27
Q501
2.2K
1W
100
620
18
22
350
15 V
0.025
8V
1.2K
WW
.001
500
50V
2.0
200 V
PAPER
1.5 A
115 V
60 Hz
24 V
rms
2 A
TYPE
IN1624
HEAT SINK
1000
50 V
3.9 K
1W
100
10K
0.1
Q540
HEAT
SINK
270
WW
Q530
100
12 V
120 WW
Q541
10K
WW
10K
WW
10K
WW
10
12
100
3 V
56
WW
34V
HEAT
SINK
25
50 V
Q501, 510, 531, 541 = 2N2102
Q502, 511, 540 = 2N3054
Q520 = 2N3442
Q530 = CA3018

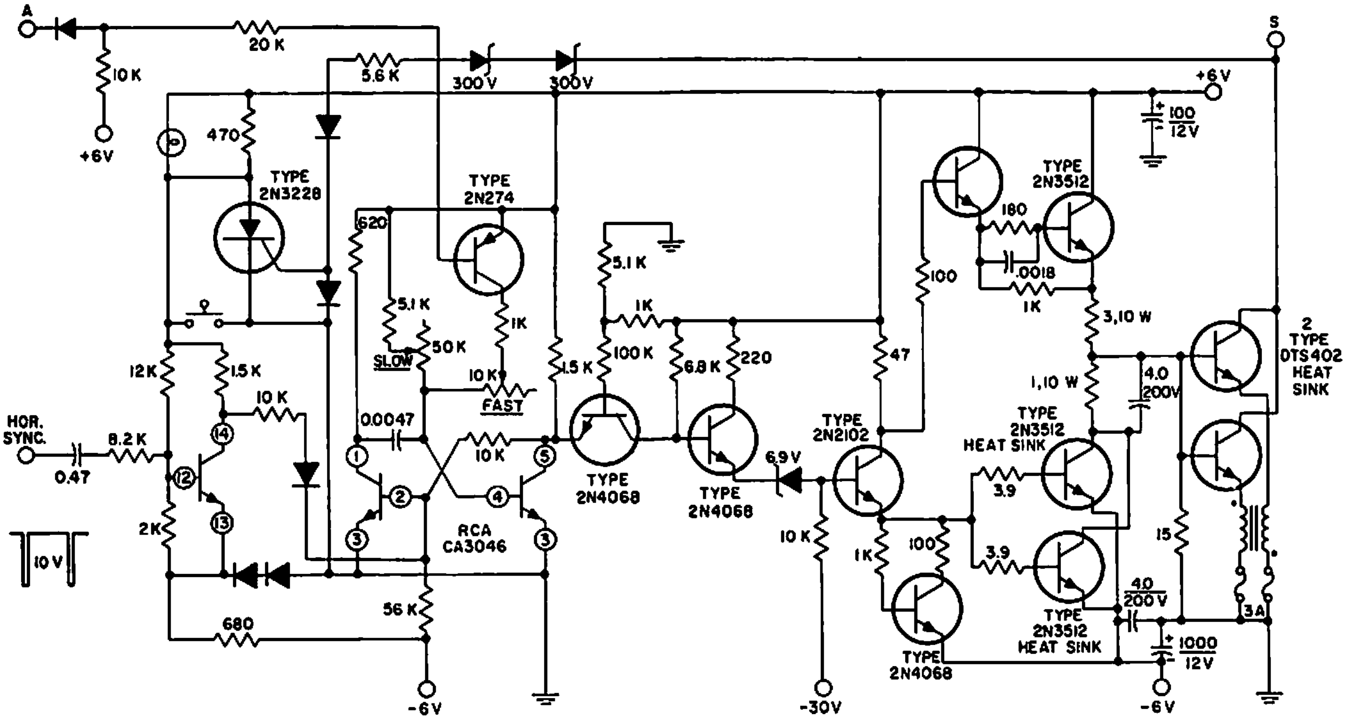
TV CAMERA SUPPLY—Provides 1 A at 30 V with 0.005% load regulation, for vertical deflection service. Noise and ripple are more than 100 dB down p-p, and line regulation is better than 0.01% for 10% change in a-c line voltage. Q530 is CA3018 IC differential amplifier which drives 2N3422 series regulator Q520. Transistors Q510 and Q511 form additional regulator stage needed for good line isolation while providing power for matching and driving network, and serving as decoupled reference for amplifier load resistor.—O. H. Shade, Jr., Stable Solid-State Vertical Deflection for High-Definition Television Systems, *RCA Review*, March 1970, p 120–147.


.005 µF
B + 12 VOLTS
1kΩ
7
3
8
AUDIO OUT
.05µF
4.5MHz
12
220
11
PA189
.005 µF
10
4
5
6
9
.005µF
560pF
.005µF
2µH
82pF

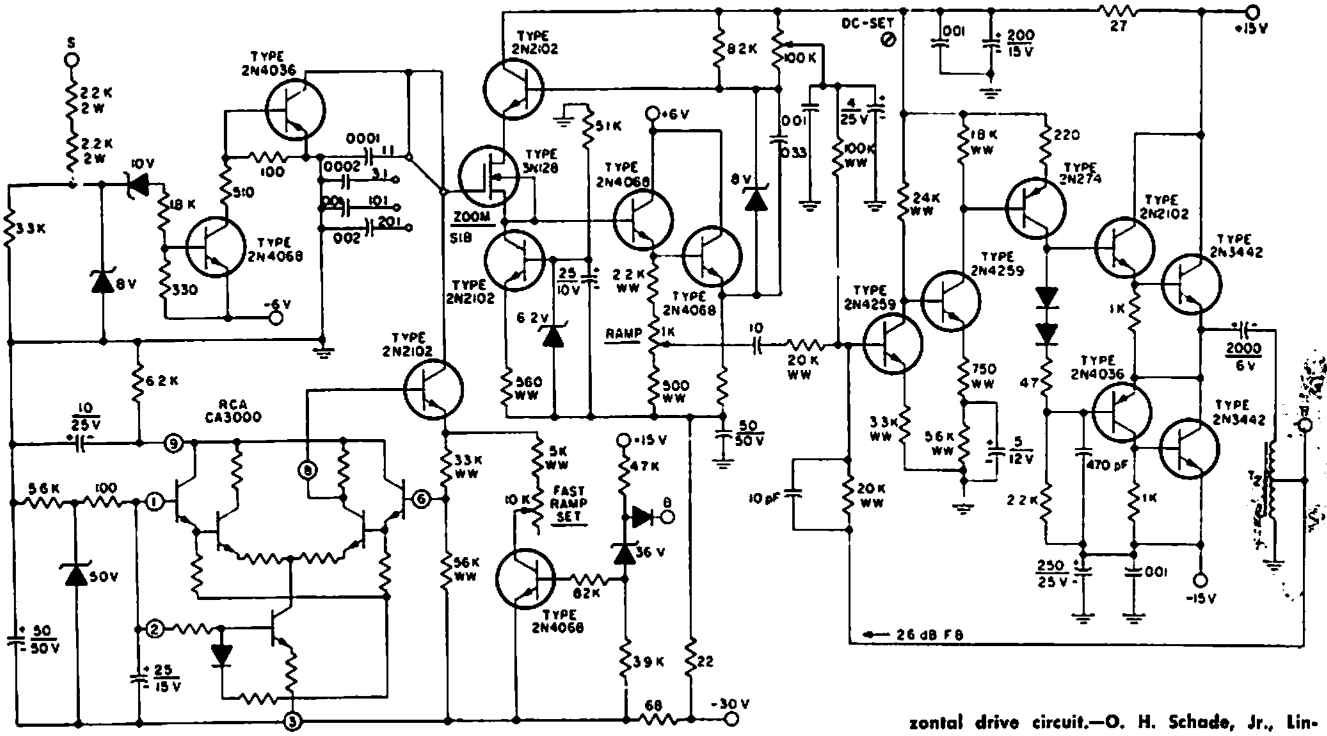
IC QUADRATURE DETECTOR—PA189 linear IC i-f amplifier is used here as quadrature-detector type of f-m discriminator for b-w tv. Arrangement is more economical than ratio detector but has about 10 dB less a-m rejection.—E. L. Haas and D. J. Hubbard, Linear Integrated Circuits in a TV Sound System, General Electric, Syracuse, N.Y., No. 90.74, 1968.


+5v
27k
2k
D8 MA26
IC: SN056
4.7k
Q3
68
IC: AP057
0.0022 µf
D6 0A90
22k
47k
0.022 pf
82k
12k
Q2
0.047 µf
5.6k
Q4
TO HORIZONTAL OUTPUT TRANSFORMER
FROM SYNC SEPARATOR
Q1
D9
Q5
0.001 µf
1.5k
680
D7 0A90
22k
1µf
0.0022 µf
5.6k
3.3k
10k
10k
22k
0.01µf
8.2k
0.01 µf
100k
2.7k
0.01µf
TO FLYBACK TRANSFORMER
HORIZONTAL DEFLECTION
680
D10 MA23
TO DEFLECTION YOKE
TO CRT GRID 1
+4v
+5v
IC: HA053
IC: SN054
+5v
33k
0.047 µf
470k
1µf
200µf
D11 0A90
50k
2k
1µf
680
1k
760
VIDEO SIGNAL IN
Q8
0.01 µf
8.2k
15k
1k
8.2k
+40v
39k
470
Q9
Q10
Q12
18k
100
Q6
220k
680
Q11
Q13
1µf
Q7
820
10k
1.2k
1.5k
3.8 k
4.3k
Q15
150k
10k
Q14
8.2k
33k
27k
2.2k
0.0027 µf
1k
0.33µf
0.1µf
0.0022 µf
0.022µf
IC: AP055
HORIZONTAL PULSE IN
4.7k
100 µh
0.022µf
0.01µf
100k
82k
SYNC SEPARATOR AND VERTICAL DEFLECTION
D12 0A90

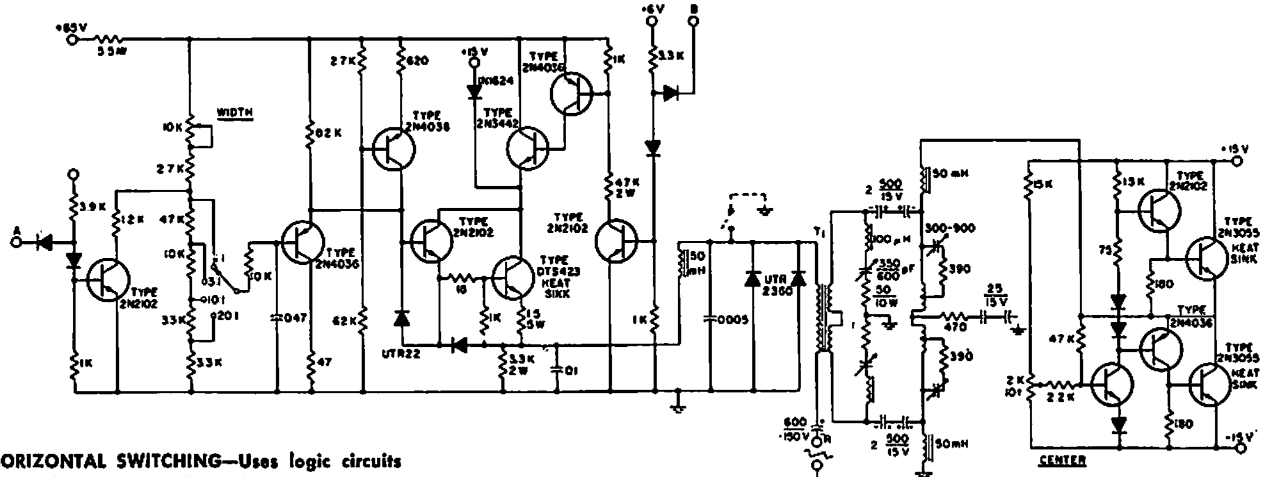
DEFLECTION WITH 5-V SUPPLY—Used in Matsushita 1.5-inch-diagonal tv operating from 5-V penlight batteries. Both IC oscillators use emitter-coupled multivibrators, with afc required only for horizontal oscillator voltage. As battery voltage drops with age, deflection amplitude and high voltage fall proportionally; since required deflection amplitude is inversely proportional to high voltage, raster width still fills screen but brightness decreases.—R. Sasaki and K. Uno, Low-Power Design is Heart of Penlight-Powered Mini-Tv, *Electronics*, June 8, 1970, p 106–113.


A
20 K
10 K
+6V
5.6 K
300 V
300 V
S
+6V
100
12V
470
TYPE
2N3228
TYPE
2N274
620
5.1 K
1K
5.1 K
50 K
SLOW
10 K
FAST
1.5 K
1K
100 K
6.8 K
220
47
100
TYPE
2N3512
180
.0018
1K
3,10 W
1,10 W
4.0
200V
2
TYPE
OTS402
HEAT
SINK
12K
1.5 K
10 K
HOR.
SYNC.
8.2 K
0.47
14
12
13
2K
10V
0.0047
10 K
1
2
3
4
5
3
RCA
CA3046
TYPE
2N4068
TYPE
2N4068
6.9V
TYPE
2N2102
TYPE
2N3512
HEAT SINK
3.9
3.9
10 K
1K
100
15
4.0
200 V
3A
TYPE
2N3512
HEAT SINK
TYPE
2N4068
1000
12V
680
56 K
-6V
-30V
-6V

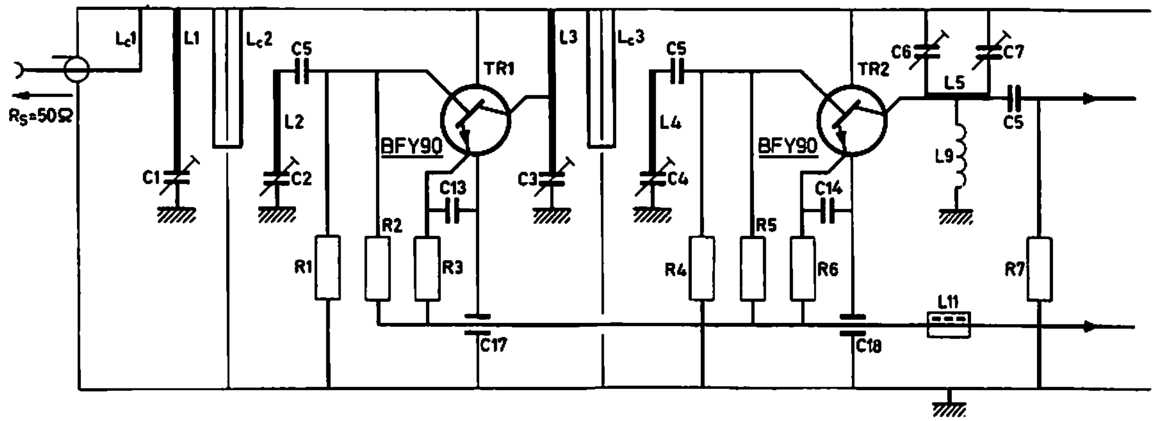
HORIZONTAL DRIVE—Circuit includes drive-waveform controls, switch circuits, and horizontal drive approaching ideal in stability and linearity, for use in high-definition 4,000-line tv system. Developed for use with 4.5-inch return-beam vidicon camera. Terminal S goes to horizontal ramp generator, and terminal A goes to horizontal switching circuit.—O. H. Schade, Jr., Linear Solid-State Horizontal-Deflection Circuit For High-Definition Television Systems, *RCA Review*, March 1970, p 148–170.

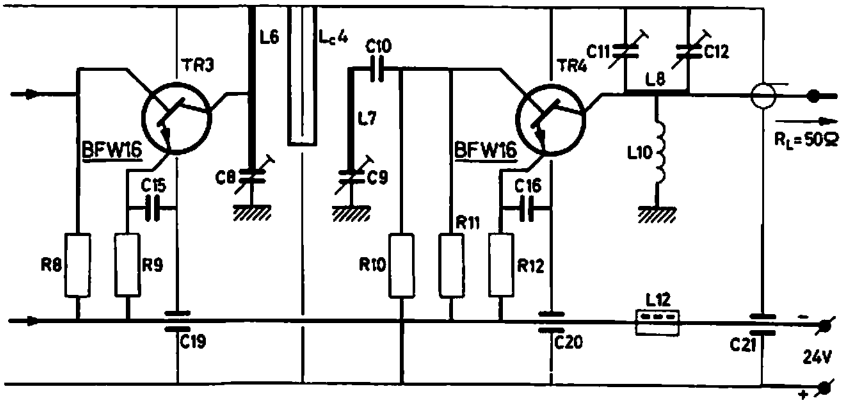

S
22 K
2 W
2.2 K
2 W
TYPE
2N4036
10V
100
18 K
510
TYPE
2N4068
330
-6V
33K
8V
.0001
.0002
.001
.002
1
10
20
ZOOM
S1B
TYPE
2N2102
TYPE
3N128
51K
+6V
TYPE
2N4068
TYPE
2N2102
25
10V
6.2V
560
WW
2.2 K
WW
TYPE
2N4068
RAMP
1K
500
WW
8V
82K
100K
DC-SET
.001
.033
4
25V
100K
WW
.001
200
15V
27
+15V
10
20 K
WW
50
50V
62 K
RCA
CA3000
10
25V
9
8
6
TYPE
2N2102
33 K
WW
56 K
WW
56 K
100
1
50V
50
50V
2
25
15V
3
5K
WW
10 K
FAST
RAMP
SET
+15 V
47 K
R
36 V
82 K
TYPE
2N4068
39 K
22
68
-30 V
18 K
WW
220
TYPE
2N274
24K
WW
TYPE
2N4259
TYPE
2N4259
750
WW
47
33 K
WW
56 K
WW
5
12V
10 pF
20 K
WW
TYPE
2N2102
1K
TYPE
2N3442
TYPE
2N4036
470 pF
2.2 K
1K
2000
6V
TYPE
2N3442
250
25V
.001
-15V
T2
26 dB FB

HORIZONTAL RAMP GENERATOR—Provides superior stability and linearity for 4.5-inch return-beam vidicon camera of 4,000-line television system. Operates at 1 MHz. Ramp output at R goes to horizontal switching circuit. Terminal S at upper left goes to horizontal drive circuit.—O. H. Schade, Jr., Linear Solid-State Horizontal-Deflection Circuit For High-Definition Television Systems, *RCA Review*, March 1970, p 148–170.


+65V
55M
WIDTH
10K
27K
47K
10K
33K
33K
3.9K
12K
1K
A
TYPE 2N2102
.051
.101
.201
10K
.047
TYPE 2N4036
82K
62K
47
27K
620
TYPE 2N4036
+15V
1N624
TYPE 2N3442
TYPE 2N4036
TYPE 2N2102
16
1K
15 5W
TYPE DTS423 HEAT SINK
UTR22
3.3K 2W
.01
1K
47K 2W
TYPE 2N2102
+6V
B
3.3K
1K
150 μH
.0005
UTR 2360
T1
2 500/15V
100 μH
350/600 pF
50/10W
300-900
390
470
25/15V
390
50 mH
50 mH
2 500/15V
500/150V
R
15K
13K
TYPE 2N2102
TYPE 2N3055 HEAT SINK
75
180
TYPE 2N4036
47K
2K 10T
2.2K
TYPE 2N3055 HEAT SINK
180
+15V
-15V
CENTER

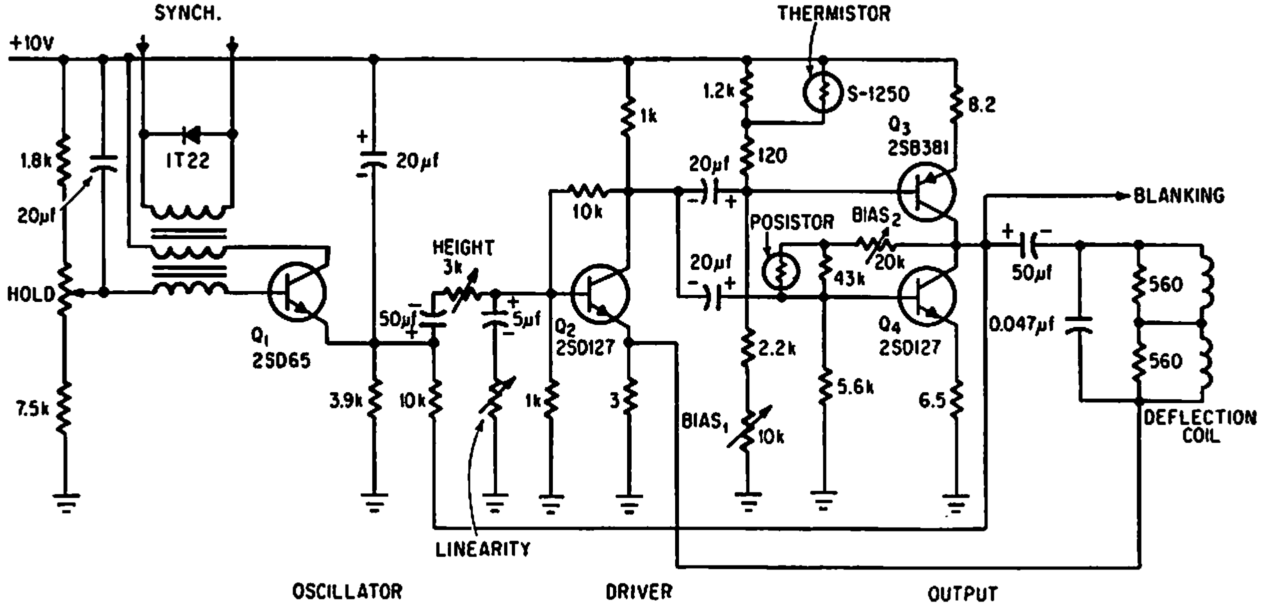
HORIZONTAL SWITCHING—Uses logic circuits to regulate control voltage levels and power supplies, as required for fast and slow scans in 4.5-inch return-beam vidicon camera of high-definition 4,000-line tv system. Terminal A goes to horizontal drive circuit, and terminal B goes to horizontal ramp generator.—O. H. Schade, Jr., Linear Solid-State Horizontal-Deflection Circuit For High-Definition Television Systems, *RCA Review*, March 1970, p 148–170.


Lc1
L1
Lc2
C5
L2
TR1
BFY90
C1
C2
C13
R2
R1
R3
C17
Rs=50Ω
L3
Lc3
C5
L4
C3
C4
TR2
BFY90
C14
R5
R4
R6
C18
C6
C7
L5
C5
L9
R7
L11

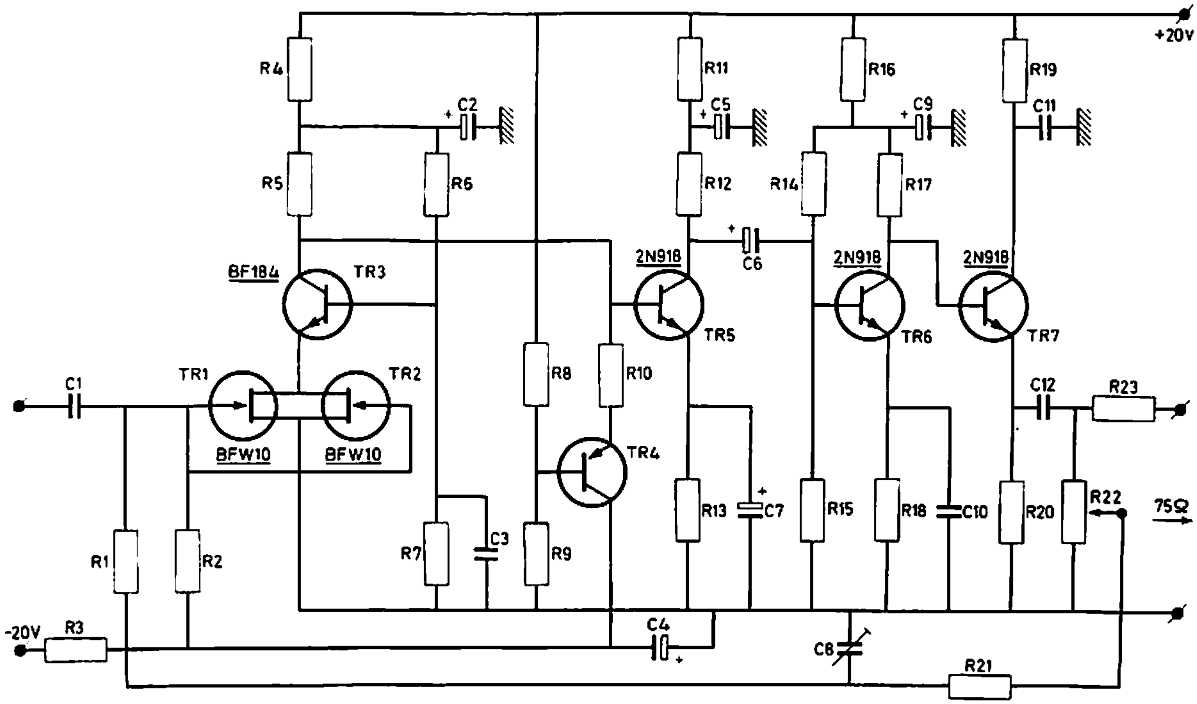

TR3
BFW16
C15
R8
R9
C19
L6
Lc4
C8
C10
L7
C9
TR4
BFW16
C16
R10
R11
R12
C20
C11
C12
L8
L10
L12
C21
RL=50Ω
-
24V
+

R_1	15 kΩ, ⅛ W
R_2	18 kΩ, ⅛ W
R_3	2.4 kΩ, ⅛ W
R_4	4.7 kΩ, ⅛ W
R_5	6.8 kΩ, ⅛ W
R_6	1 kΩ, ¼ W
R_7	2.7 kΩ, ⅛ W
R_8	1.2 kΩ, ⅛ W
R_9	180 Ω, ¼ W
R_{10}	1.5 kΩ, ¼ W
R_{11}	680 Ω, ⅛ W
R_{12}	120 Ω, ½ W
All resistors, ±5%	
C_1, C_2-C_4 C_7-C_9 C_{11}, C_{12}	12 pF
C_5	220 pF disk, −20/+50%
C_6	6 pF
C_{10}	5 pF disk, ±10%
C_{13}-C_{16}	560 pF disk, −20/+50%
C_{17}-C_{21}	1.5 nF feedthrough, −20/+50%
L_1, L_3, L_6	24 mm Ag plated Cu strip 4 mm × 0.5 mm
L_2, L_4, L_7	15 mm Ag plated Cu strip 4 mm × 0.5 mm
L_5	24 mm Ag plated Cu strip 4 mm × 0.5 mm
L_8	10 mm Ag plated Cu strip 5 mm × 0.5 mm
L_9, L_{10}	40 nH, 4 turns 0.7 mm enamelled Cu on 3 mm dia., 1.5 mm pitch
L_{11}, L_{12}	4 beads ferroxcube 3D3
L_{c1}	single loop 1.0 mm Ag plated Cu, length 28 mm, width 12 mm
L_{c2}-L_{c4}	single loop 1.0 mm Ag plated Cu, length 23 mm, width 12 mm

742–750 MHZ ANTENNA AMPLIFIER—Provides gain of 30 dB for European channel 55, with 7-dB noise factor and 80-mW output signal.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.

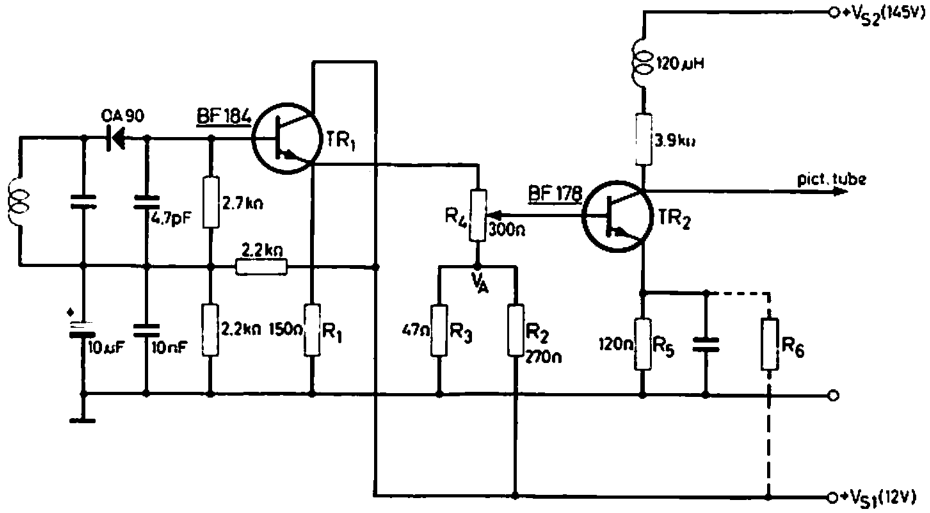

SYNCH.
+10V
THERMISTOR
S-1250
1.8k
20μf
1T22
20μf
1k
1.2k
120
8.2
Q3
2SB381
BLANKING
HOLD
Q1
2SD65
HEIGHT
3k
50μf
5μf
10k
Q2
2SD127
POSISTOR
BIAS2
20k
43k
20μf
50μf
0.047μf
560
560
Q4
2SD127
7.5k
3.9k
10k
1k
3
2.2k
5.6k
6.5
BIAS1
10k
DEFLECTION COIL
LINEARITY
OSCILLATOR
DRIVER
OUTPUT

LOW-DRAIN VERTICAL SWEEP—Design goal for 4-inch Sony 4-20UW battery-operated portable tv was reduction of battery drain. Combination of four transistors used as shown gives deflection current of 134 mA p-p with only 20 mA d-c. Power drain is thus less than half that of more conventional class A circuit.—Careful Sweep Design Cuts Power Drain and Cost, *Electronics*, Nov. 14, 1966, p 167–169.

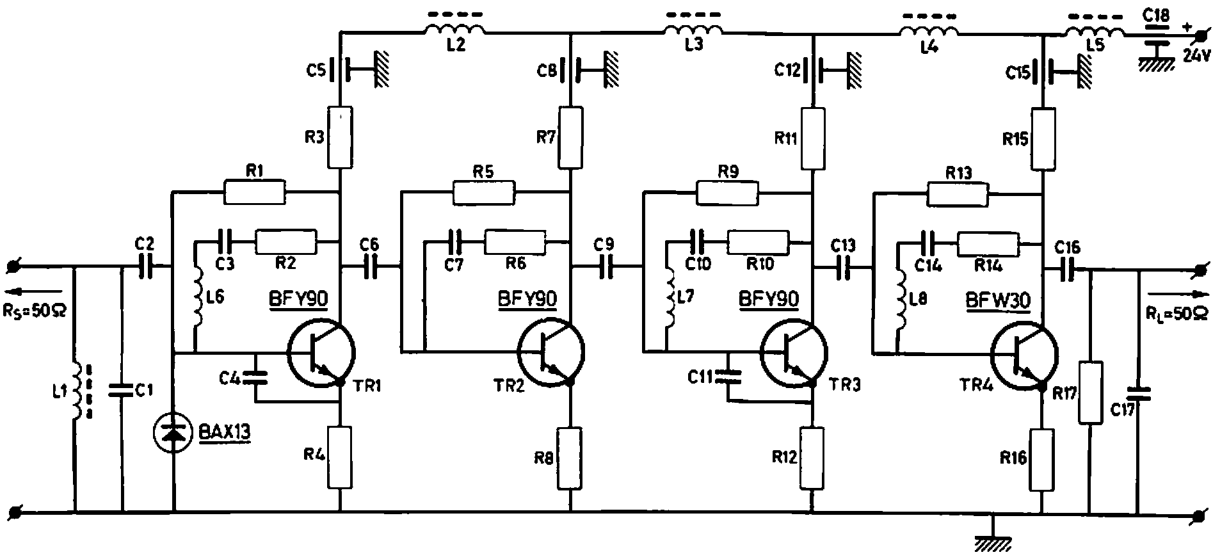

+20V
R4
C2
R11
C5
R16
C9
R19
C11
R5
R6
R12
R14
R17
C6
BF184
TR3
2N918
TR5
2N918
TR6
2N918
TR7
C1
TR1
TR2
BFW10
BFW10
R8
R10
C12
R23
TR4
R13
C7
R15
R18
C10
R20
R22
75Ω
R1
R2
R7
C3
R9
-20V
R3
C4
C8
R21

R_1	560 kΩ	R_8	12 kΩ	R_{15}	3.3 kΩ	R_{22}	10 kΩ	C_6	50 μF
R_2	0.9 MΩ	R_9	6.8 kΩ	R_{16}	100 Ω	R_{23}	68 Ω	C_7	250 μF
R_3	680 kΩ	R_{10}	24 kΩ	R_{17}	1 kΩ	C_1	0.1 μF	C_8	25 pF
R_4	270 Ω	R_{11}	180 Ω	R_{18}	270 Ω	C_2	80 μF	C_9	80 μF
R_5	1.2 kΩ	R_{12}	420 Ω	R_{19}	10 Ω	C_3	0.1 μF	C_{10}	0.6 nF
R_6	8.2 kΩ	R_{13}	1 kΩ	R_{20}	680 Ω	C_4	100 μF	C_{11}	15 nF
R_7	3.3 kΩ	R_{14}	27 kΩ	R_{21}	12 kΩ	C_5	80 μF	C_{12}	125 μF

PLUMBICON PREAMP—Circuit shows complete preamp for b-w tv camera tube such as Plumbicon. Frequency response is substantially flat to 5.5 MHz. Two fet stages in parallel in input stage give required low noise figure. Circuit makes use of frequency-dependent feedback. Miller effect in input stage is avoided by using TR3 in cascode with parallel fet's.—B. Overgoor, A Camera Tube Amplifier with FET Input, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 4, 1968, p 155–159.


OA90
BF184
TR1
4.7pF
2.7kΩ
2.2kΩ
10µF
10nF
2.2kΩ
150Ω
R1
BF178
R4
300Ω
VA
47Ω
R3
R2
270Ω
TR2
120µH
3.9kΩ
+VS2(145V)
pict. tube
120Ω
R5
R6
+VS1(12V)

BASE-CIRCUIT CONTRAST CONTROL—R2 and R3 keep black level constant while contrast is controlled with R4. Video signal is distorted at maximum setting of contrast pot, but distortion can be cleared up by turning back the control.—A. Cense, The N-P-N Silicon Planar Transistor BF178 in a Video Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 251, 1966.


L2
L3
L4
L5
C18
24V
C5
C8
C12
C15
R3
R7
R11
R15
R1
R5
R9
R13
C2
C3
R2
C6
C7
R6
C9
C10
R10
C13
C14
R14
C16
L6
L7
L8
BFY90
BFY90
BFY90
BFW30
RS=50Ω
RL=50Ω
L1
C1
C4
TR1
TR2
C11
TR3
TR4
R17
C17
BAX13
R4
R8
R12
R16

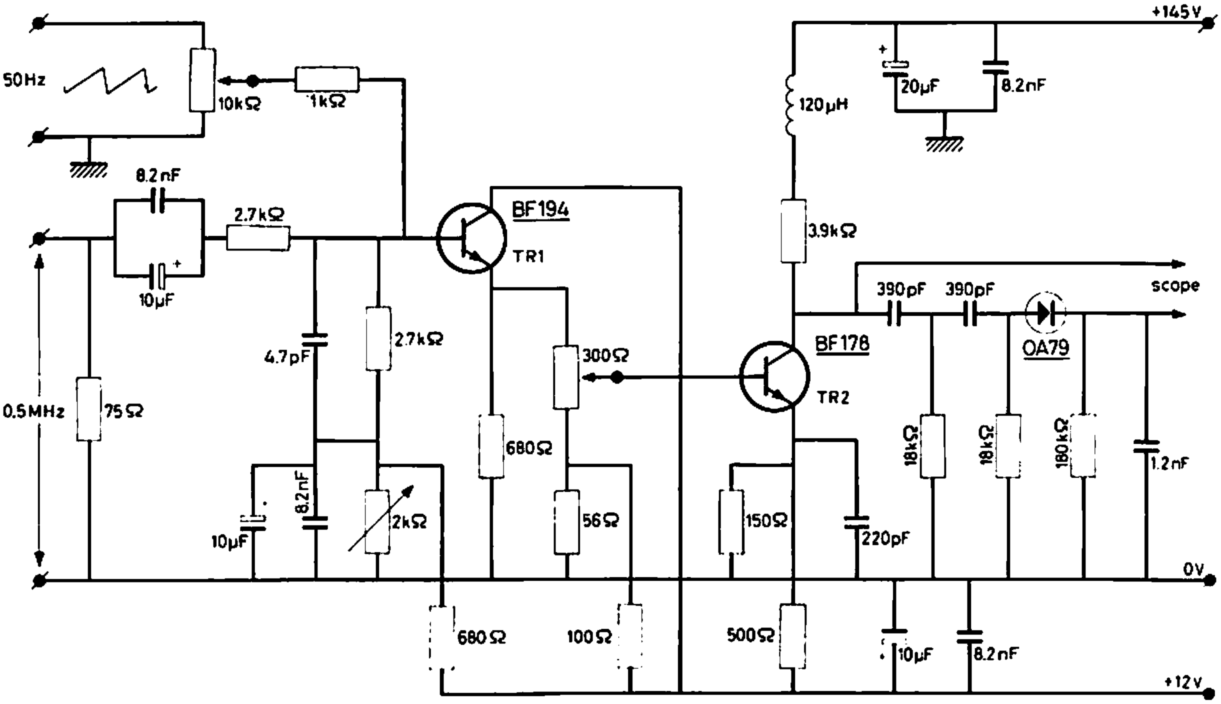
R_1, R_5	39 kΩ, $\frac{1}{8}$ W	R_9	33 kΩ, $\frac{1}{8}$ W
R_2, R_6 R_{10}, R_{14}	220 Ω , $\frac{1}{8}$ W	R_{11}	1.3 kΩ, $\frac{1}{4}$ W
		R_{13}	12 kΩ, $\frac{1}{8}$ W
R_3	3.9 kΩ, $\frac{1}{4}$ W	R_{15}	560 Ω , $\frac{1}{4}$ W
R_4, R_8, R_{12}	13 Ω , $\frac{1}{8}$ W	R_{16}	15 Ω , $\frac{1}{8}$ W
R_7	2.4 kΩ, $\frac{1}{4}$ W	R_{17}	91 Ω , $\frac{1}{8}$ W

All resistors, ±5%

C_1, C_4	2.7 pF ceramic, ±0.5%
C_2, C_6	82 pF ceramic, ±5%
C_3, C_7, C_9, C_{10} C_{13}, C_{14}, C_{16}	680 pF disk, −20/+50%
C_5, C_8, C_{12} C_{15}, C_{18}	2.2 nF feedthrough, −20/+50%
C_{11}, C_{17}	1.5 pF ceramic, ±0.5%

L_1-L_5	choke Type 3122 108 20150
L_6, L_7	40 nH, 4 turns 0.5 mm enamelled Cu on 3 mm dia., 0.5 mm pitch
L_8	30 nH, 3 turns 0.5 mm enamelled Cu on 3 mm dia., 0.5 mm pitch

FOUR-STAGE 40–860 MHZ ANTENNA AMPLIFIER—Provides gain of 26 dB and 70-mV output per signal over entire European television band, with noise factor of 6.9 to 10 dB. Inductor shunting input terminals dissipates static charges accumulated on antenna, to protect transistors from damage by sudden discharge. Further protection is provided by BAX13 diode connecting base of input transistor to ground.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.


50Hz
10kΩ
1kΩ
8.2nF
10μF
2.7kΩ
0.5MHz
75Ω
4.7pF
2.7kΩ
10μF
8.2nF
2kΩ
680Ω
BF194
TR1
300Ω
680Ω
56Ω
100Ω
+145V
120μH
20μF
8.2nF
3.9kΩ
BF178
TR2
390pF
390pF
OA79
scope
18kΩ
18kΩ
180kΩ
1.2nF
150Ω
220pF
500Ω
10μF
8.2nF
0V
+12V

MEASURING VIDEO AMPLIFIER LINEARITY—Connections are shown for showing gain and collector voltage simultaneously on screen of dual-trace cro. One input is 50-Hz sawtooth with sufficient amplitude to drive output stage from cutoff to knee. Other input is 0.5-MHz sine wave with 10 mV p-p amplitude.—A. Cense, Recent Developments in Circuits and Transistors for Television Receivers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966—1967, p 41—52.

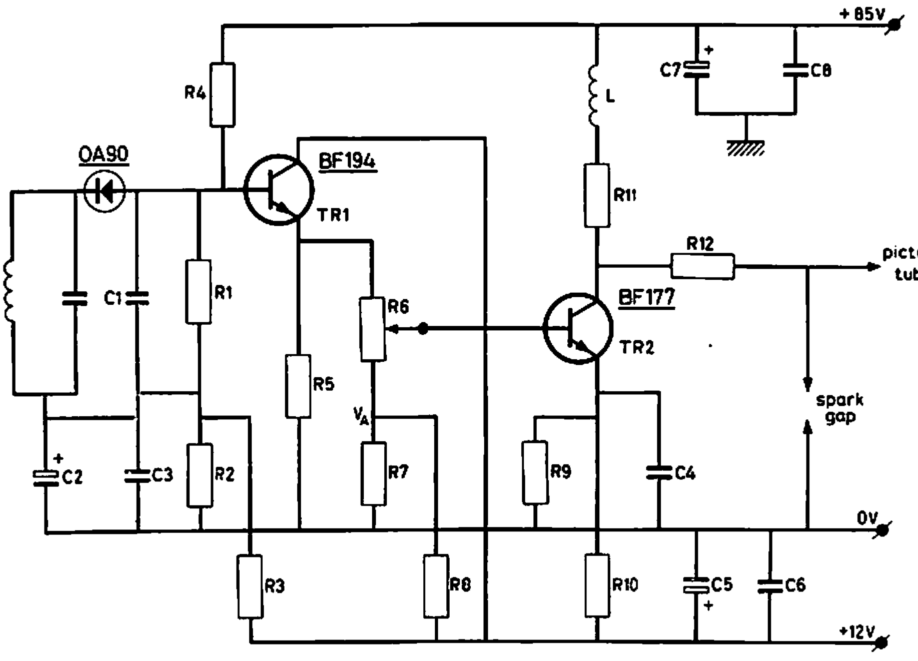
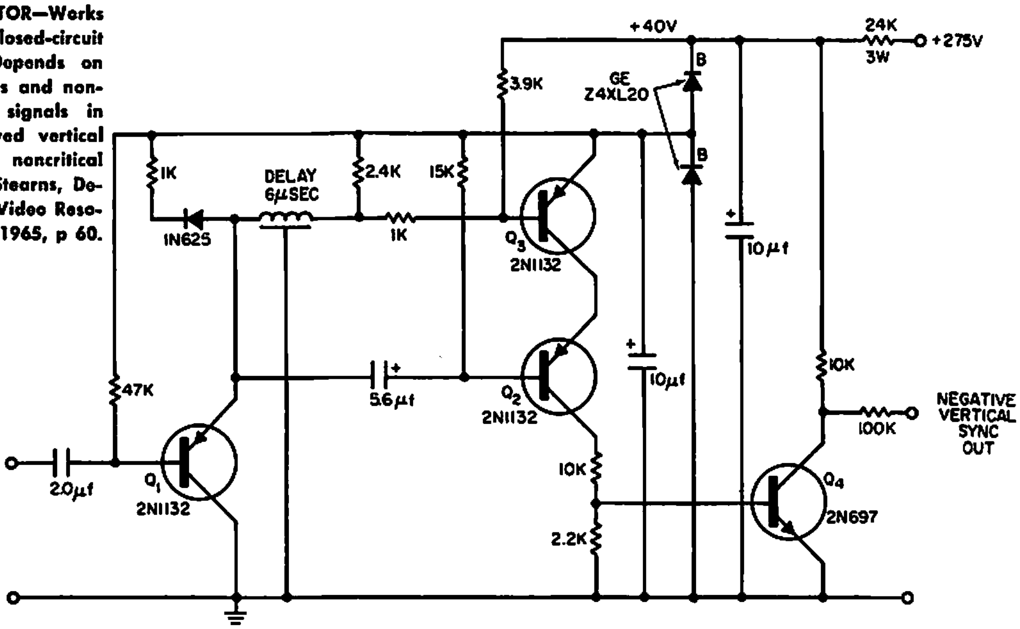

+85V
R4
OA90
BF194
TR1
C1
R1
R6
R5
V_A
C2
C3
R2
R7
R3
R8
L
C7
C8
R11
R12
picture tube
BF177
TR2
spark gap
R9
C4
0V
R10
C5
C6
+12V

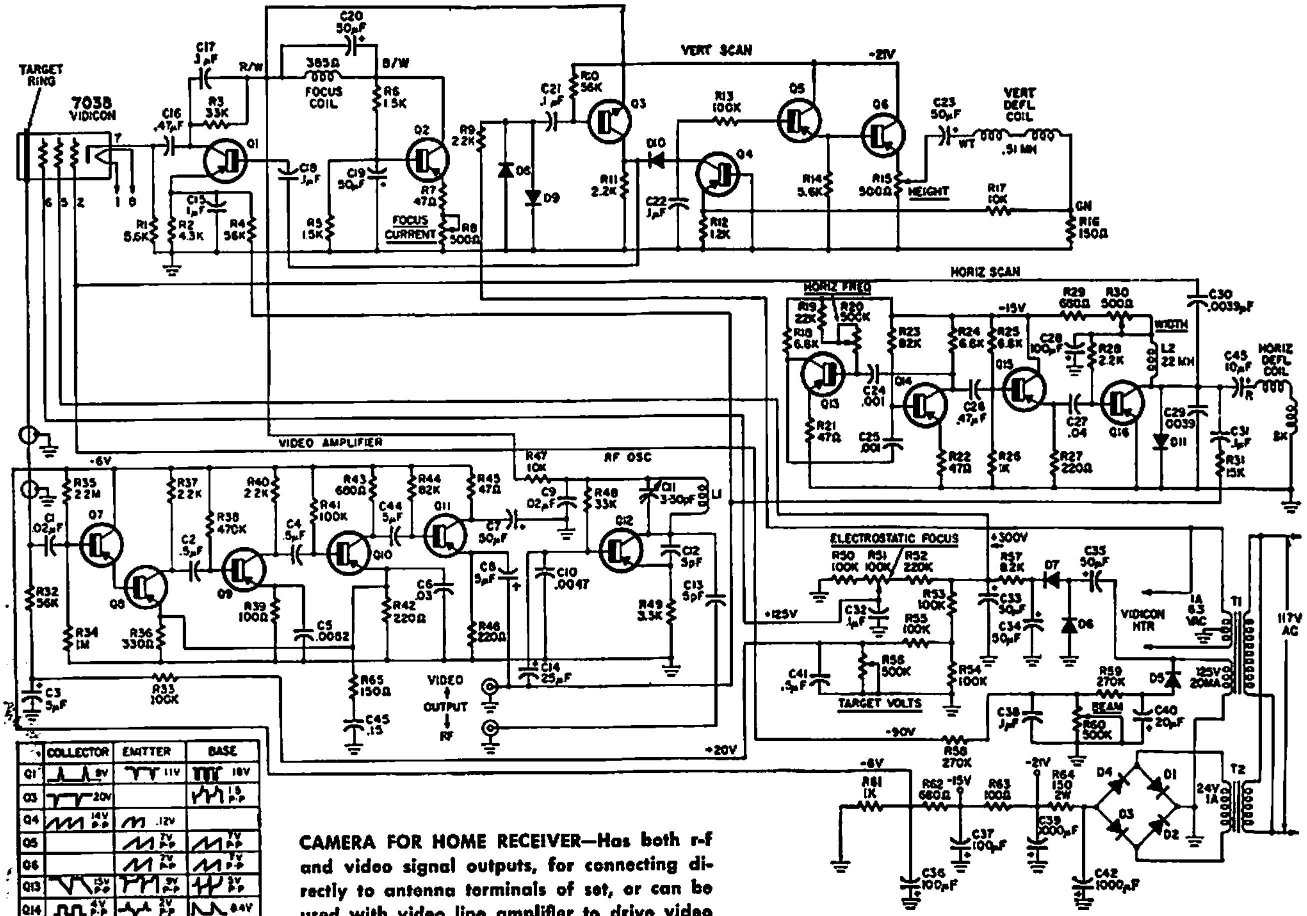
Fig. 3. Circuit diagram of the video output amplifier.

R_1	2.7 kΩ,	¼ W	R_5	470 Ω,	¼ W	R_9	180 Ω,	¼ W	C_1	4.7 pF,	500 V	C_5	10 μF,	16 V
R_2	1.2 kΩ,	¼ W	R_6	300 Ω,	pot.	R_{10}	820 Ω,	¼ W	C_2	10 μF,	16 V	C_6	6.8 nF,	500 V
R_3	1 kΩ,	¼ W	R_7	47 Ω,	¼ W	R_{11}	4.7 kΩ,	5.5 W	C_3	6.8 nF,	500 V	C_7	20 μF	250 V
R_4	390 kΩ,	¼ W	R_8	120 Ω,	1 W	R_{12}	1.5 kΩ,	1 W	C_4	180 pF,	500 V	C_8	6.8 nF,	500 V

625-LINE VIDEO AMPLIFIER—Uses two direct-coupled stages to drive 11-inch picture tube. Bandwidth is at least 4 MHz for 3-dB down at all settings of contrast control. Output voltage (black-to-white) is 50 V and gain is 30. Black level is independent of contrast control or picture content.—A. Cense, Recent Developments in Circuits and Transistors for Television Receivers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 3, 1966—1967, p 85—91.

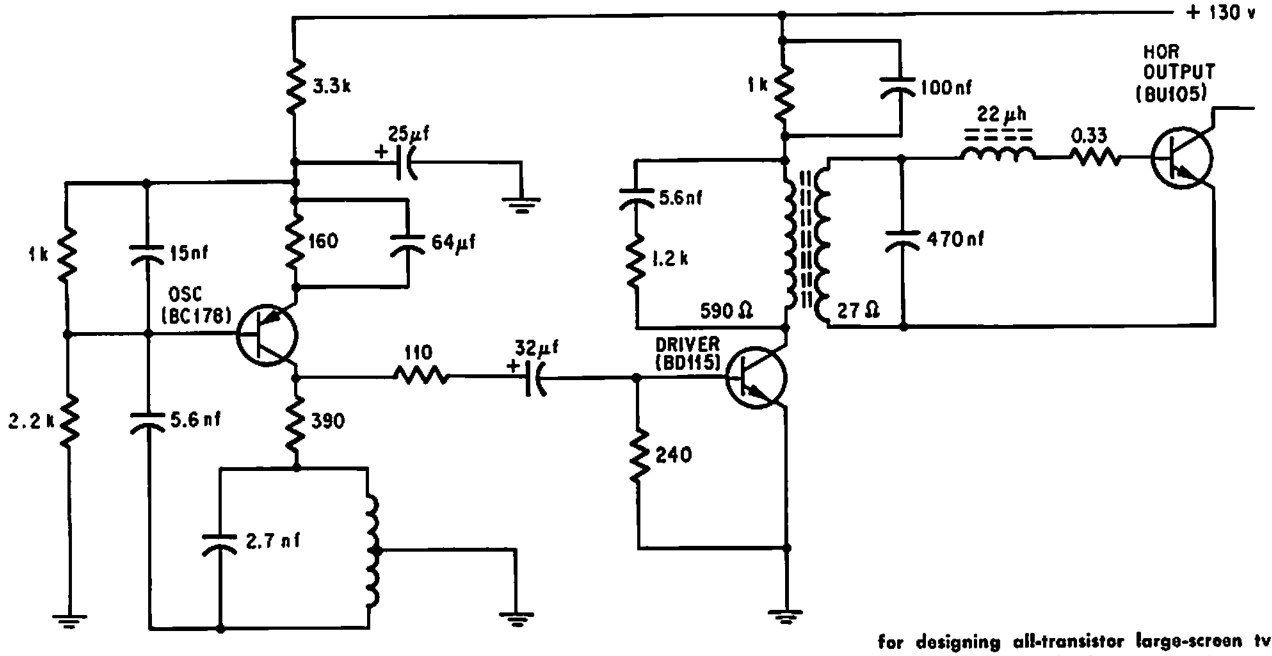
SYNC SEPARATOR FOR MONITOR—Works equally well on standard or closed-circuit signals in television monitor. Depends on coincidence of vertical sync signals and noncoincidence of horizontal sync signals in coincidence circuit. Gives improved vertical resolution, accurate interlace, and noncritical vertical hold adjustments.—H. F. Stearns, Delay-Line Sync Separator Improves Video Resolution, *Electronic Design*, Nov. 22, 1965, p 60.


+40V
24K
3W
+275V
3.9K
GE
Z4XL20
B
B
1K
DELAY
6μSEC
2.4K
15K
1N625
1K
Q3
2N1132
10μf
+
47K
5.6μf
Q2
2N1132
10μf
10K
NEGATIVE VERTICAL SYNC OUT
100K
NEGATIVE COMPOSITE SYNC IN
2.0μf
Q1
2N1132
10K
2.2K
Q4
2N697

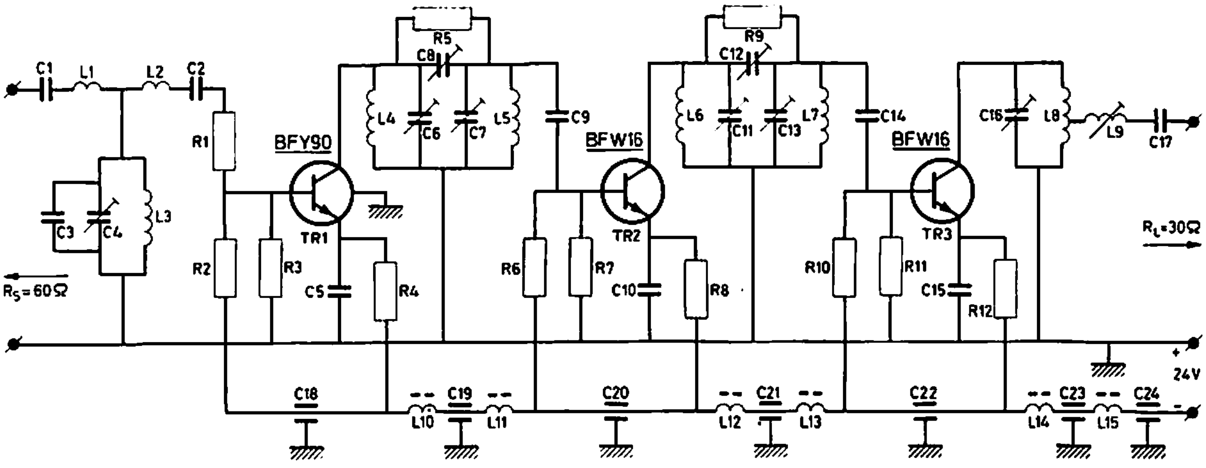

TARGET RING
7038 VIDICON
C17 5μF
R/W
C20 50μF
385Ω
FOCUS COIL
B/W
R6 1.5K
R3 33K
C16 .47μF
Q1
Q2
C18 1μF
C19 50μF
C15 1μF
R1 5.6K
R2 4.3K
R4 56K
R5 15K
R7 47Ω
FOCUS CURRENT
R8 500Ω
C21 .1μF
R10 56K
Q3
R9 22K
D8
D9
R11 2.2K
VERT SCAN
-21V
R13 100K
Q5
Q6
C23 50μF
VERT DEFL COIL
.51 MH
D10
Q4
C22 1μF
R12 1.2K
R14 5.6K
R15 500Ω
HEIGHT
R17 10K
R16 150Ω
HORIZ SCAN
HORIZ FREQ
R19 22K
R20 500K
R18 6.8K
Q13
R21 47Ω
C24 .001
C25 .001
R23 82K
Q14
R22 47Ω
R24 6.8K
R25 6.8K
-15V
C26 .47μF
Q15
R26 1K
C28 100μF
R29 680Ω
R30 500Ω
R28 2.2K
C27 .04
R27 220Ω
Q16
WIDTH
L2 22 MH
C29 .0039
D11
C30 .0039μF
C45 10μF
HORIZ DEFL COIL
C31 1μF
R31 15K
VIDEO AMPLIFIER
-6V
RF OSC
R35 22M
C1 .02μF
Q7
Q8
R32 56K
R34 1M
R37 2.2K
C2 .5μF
R38 470K
Q9
R36 330Ω
R39 100Ω
R40 2.2K
C4 .5μF
R41 100K
Q10
C5 .0082
R43 680Ω
C44 5μF
C6 .03
R42 220Ω
R44 82K
Q11
R45 47Ω
C7 50μF
C8 5μF
R46 220Ω
R47 10K
C9 .02μF
C10 .0047
R48 33K
Q12
C11 3-30pF
L1
C12 5pF
C13 5pF
R49 3.3K
C14 25μF
R65 150Ω
C45 .15
VIDEO OUTPUT
RF
R33 100K
C3 5μF
+20V
ELECTROSTATIC FOCUS
R50 100K
R51 100K
R52 220K
+300V
R57 8.2K
D7
C35 50μF
+125V
C32 1μF
R53 100K
R55 100K
C33 50μF
C34 50μF
D6
VIDICON HTR
1A 6.3 VAC
T1
117V AC
C41 .5μF
R56 500K
TARGET VOLTS
R54 100K
R59 270K
D5
125V 20MA
C38 1μF
BEAM
R60 500K
C40 20μF
-90V
R58 270K
-6V
R61 1K
R62 680Ω
-15V
R63 100Ω
-21V
R64 150 2W
D4
D1
D3
D2
24V 1A
T2
C37 100μF
C39 1000μF
C36 100μF
C42 1000μF

	COLLECTOR	EMITTER	BASE
Q1	8V	11V	18V
Q3	20V		1.5 P-P
Q4	14V P-P	.12V	
Q5		7V P-P	7V P-P
Q6		7V P-P	7V P-P
Q13	15V P-P	8V P-P	3V P-P
Q14	4V P-P	2V P-P	6.4V
Q15		3.8V P-P	4V P-P
Q16	40V P-P		2.4V P-P

CAMERA FOR HOME RECEIVER—Has both r-f and video signal outputs, for connecting directly to antenna terminals of set, or can be used with video line amplifier to drive video tape recorder or ham tv transmitter. Article gives construction details and sources for yoke and focus coils. Alternative vidicon having higher sensitivity is 7735A. Diodes D1-D7 are GE-504; D8-D11 1N60; Q1-Q2, Q6-Q13 2N3638; Q3 2N2926; Q4-Q5, Q14-Q16 SA599. With short whip antenna connected to output of oscillator, camera will transmit picture to tv set about 50 ft away.—G. Davis, Jr., Build All-Transistor TV Camera for $100, *Radio-Electronics*, July 1969, p 23–26 and 92.


+ 130 v
3.3k
25µf
1k
15nf
160
64µf
OSC
(BC178)
110
32µf
2.2k
5.6nf
390
2.7nf
1k
100nf
22µh
0.33
HOR
OUTPUT
(BU105)
5.6nf
1.2k
470nf
590Ω
27Ω
DRIVER
(BD115)
240

ALL-TRANSISTOR HORIZONTAL SYSTEM—Developed for 23-inch Philips tv sets. Oscillator should have frequency adjustment. Output stage is designed so it cannot be damaged by sudden failure of oscillator or driver. Article gives step-by-step procedure for designing all-transistor large-screen tv.—W. Hetterscheid, All-Solid State Design Overtakes Large-Screen Monochrome TV Sets, *Electronics*, June 24, 1968, p 104–111.


C1
L1
L2
C2
R1
BFY90
R5
C8
L4
C6
C7
L5
C9
BFW16
R9
C12
L6
C11
C13
L7
C14
BFW16
C16
L8
L9
C17
C3
C4
L3
TR1
R2
R3
C5
R4
R6
R7
TR2
C10
R8
R10
R11
TR3
C15
R12
R_S=60Ω
R_L=30Ω
+
24V
-
C18
C19
C20
C21
C22
C23
C24
L10
L11
L12
L13
L14
L15

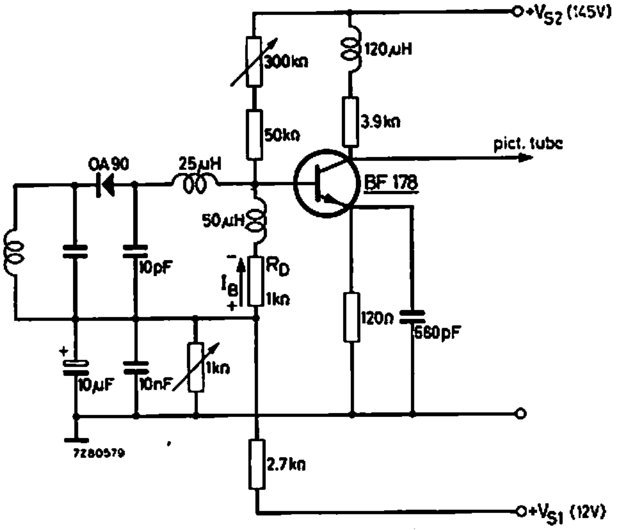
R_1	30 Ω , $\frac{1}{8}$ W
R_2	2.4 kΩ, $\frac{1}{8}$ W
R_3	3.3 kΩ, $\frac{1}{8}$ W
R_4, R_5	750 Ω , $\frac{1}{8}$ W
R_6, R_9	750 Ω , $\frac{1}{4}$ W
R_7	1.8 kΩ, $\frac{1}{4}$ W
R_8	150 Ω , $\frac{1}{4}$ W
R_{10}	470 Ω , $\frac{1}{4}$ W
R_{11}	1.2 kΩ, $\frac{1}{4}$ W
R_{12}	82 Ω , $\frac{1}{2}$ W

All resistors, ±5%

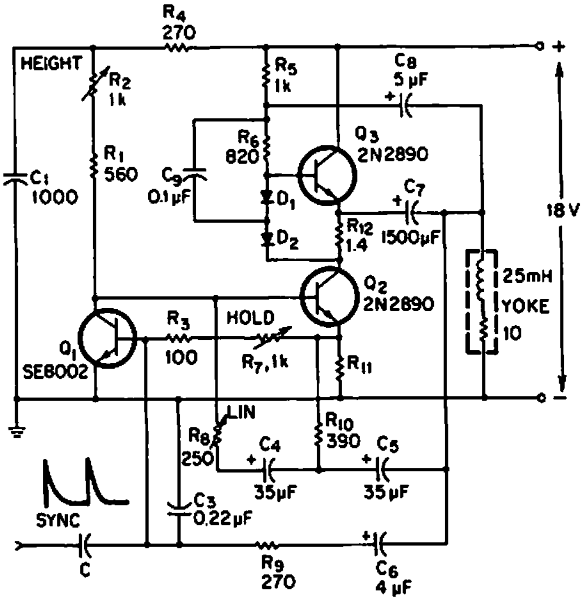
C_1, C_2	3.3 pF ceramic, ±0.5%
C_3	39 pF ceramic, ±5%
C_4, C_6, C_7, C_8 C_{11}, C_{12}, C_{13}, C_{16}	12 pF
C_5, C_{10}, C_{15}	1 nF disk, −20/+50%
C_9	100 pF ceramic, ±5%
C_{14}	15 pF ceramic, ±5%
C_{17}	8.2 pF ceramic, ±0.5%
C_{18}-C_{24}	4.7 nF feedthrough, −20/+50%

L_1, L_2	190 nH,	9 turns 0.5 mm enamelled Cu on 4 mm dia., 1.0 mm pitch
L_3	14 nH,	20 mm loop 0.6 mm Cu
L_4, L_6	35 nH,	2 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch
L_5, L_7	20 nH,	1 turn 1.3 mm Ag plated Cu on 8 mm dia.
L_8	60 nH,	3 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.5 mm pitch, tapped at $1\frac{3}{4}$ turns from earthed end
L_9	50 nH,	$2\frac{1}{2}$ turns 1.3 mm Ag plated Cu on 8 mm dia., 2.5 mm pitch
L_{10}-L_{15}	choke Type 4312 020 36701	

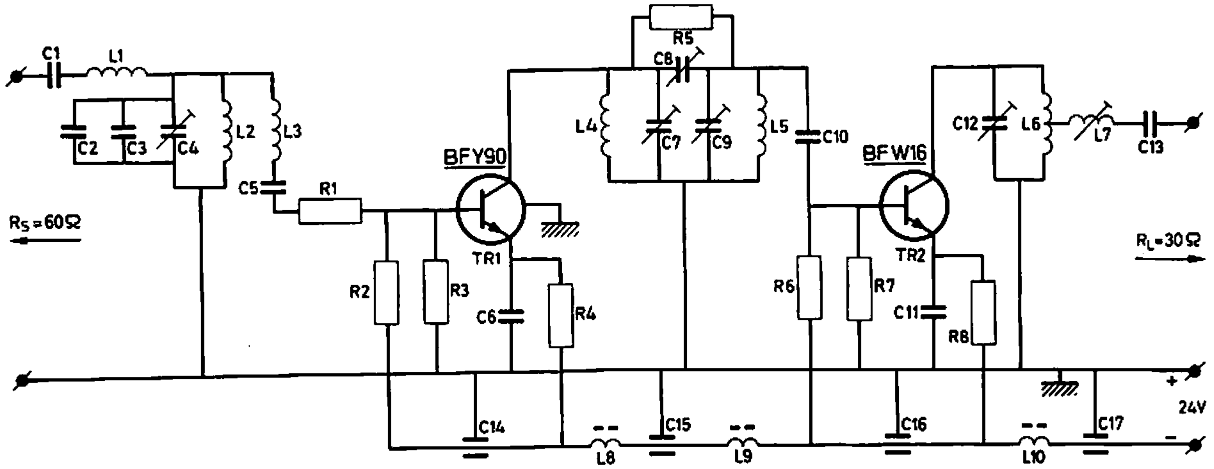
174–230 MHZ ANTENNA AMPLIFIER—Provides gain of 39 dB for European band III, with noise factor of 6.2 to 6.7 dB and 10-mW output per signal. Article gives alignment instructions.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–73.


+V_{S2} (145V)
300kΩ
120μH
50kΩ
3.9kΩ
pict. tube
OA90
25μH
BF 178
50μH
R_D
1kΩ
I_B
10pF
120Ω
680pF
1kΩ
10μF
10nF
2.7kΩ
7Z80579
+V_{S1} (12V)

SINGLE-STAGE VIDEO AMPLIFIER—Silicon planar transistor supplies sufficient drive for all large-screen picture tubes. Circuit values are for European 625-line system. One drawback is inability of video detector to operate at low input levels because high base current flows through detector load resistor RD and causes reverse voltage for detector diode, with resulting distortion in peak white signal. Another problem is insufficient bandwidth.—A. Conse, The N-P-N Silicon Planar Transistor BF178 in a Video Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 251, 1966.


R4 270
HEIGHT
R2 1k
R5 1k
C8 5 μF
R1 560
C1 1000
C9 0.1μF
R6 820
Q3 2N2890
D1
D2
C7
R12 1.4
1500μF
18 V
Q2 2N2890
25mH YOKE 10
Q1 SE8002
R3 100
HOLD
R7, 1k
R11
LIN
R8 250
C4 35μF
R10 390
C5 35μF
C3 0.22μF
SYNC
C
R9 270
C6 4 μF

CHOKELESS VERTICAL SWEEP—Efficiency of chokeless vertical deflection circuit for small-screen b-w tv is improved by resonating yoke with capacitor and isolating yoke for that portion of retrace pulse which exceeds B+. Generates yoke current of 0.6 A p-p in 25-mH 10-ohm yoke from 18-V supply. Retrace time is 1.35 ms.—J. M. Tucker, Higher-Efficiency Chokeless Vertical Sweep, *EEE*, July 1969, p 106.


C1
L1
C2
C3
C4
L2
L3
C5
R1
R_S=60Ω
BFY90
TR1
R2
R3
C6
R4
R5
C8
L4
C7
C9
L5
C10
BFW16
TR2
R6
R7
C11
R8
C12
L6
L7
C13
R_L=30Ω
C14
L8
C15
L9
C16
L10
C17
24V

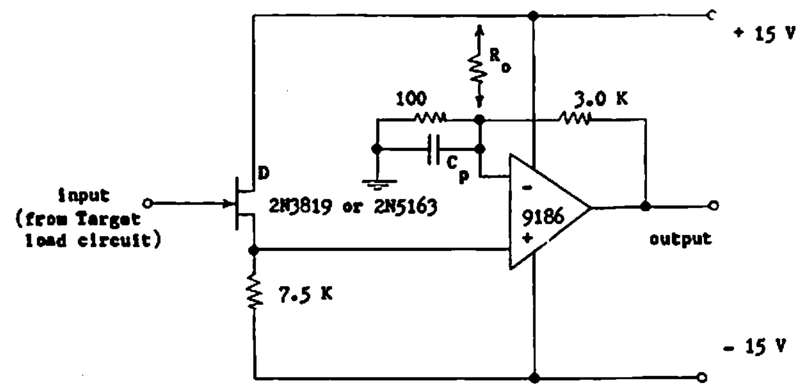
R_1	27 Ω, ⅛ W
R_2	2.2 kΩ, ⅛ W
R_3	1.5 kΩ, ⅛ W
R_4	1 kΩ, ⅛ W
R_5	7.5 kΩ, ⅛ W
R_6	470 Ω, ¼ W
R_7	1.2 kΩ, ¼ W
R_8	82 Ω, ½ W

All resistors, ±5%

C_1, C_5	6.8 pF ceramic, ±0.5%
C_2	10 pF ceramic, ±0.5%
C_3	100 pF ceramic, ±5%
C_4, C_7, C_8 C_9, C_{12}	12 pF
C_6, C_{11}	4.7 nF disk, −20/+50%
C_{10}	15 pF ceramic, ±5%
C_{13}	22 pF ceramic, ±5%
C_{14}-C_{17}	4.7 nF feedthrough, −20/+50%

L_1, L_3	380 nH,	14 turns 0.5 mm enamelled Cu on 4 mm dia., 0.5 mm pitch
L_2	28 nH,	2 turns 1.0 mm enamelled Cu on 4 mm dia., 2.5 mm pitch
L_4, L_5	135 nH,	5 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.5 mm pitch
L_6	135 nH,	5 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.5 mm pitch, tapped 2½ turns from earthed end
L_7	70 nH,	2 turns·1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch
L_8-L_{10}	choke Type 4312 020 36701	

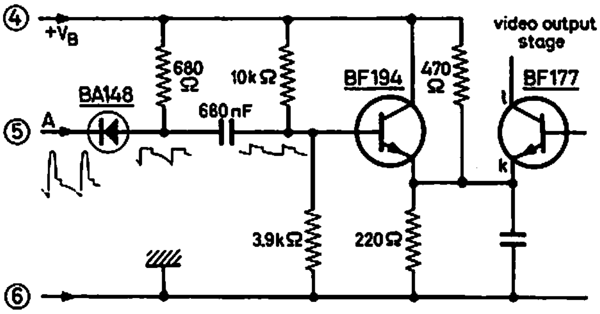
87.5–108 MHZ ANTENNA AMPLIFIER—Provides gain of 43 dB for European band II, with noise factor of 6 to 6.5 dB and 25-mW output per signal. Article gives alignment information.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.



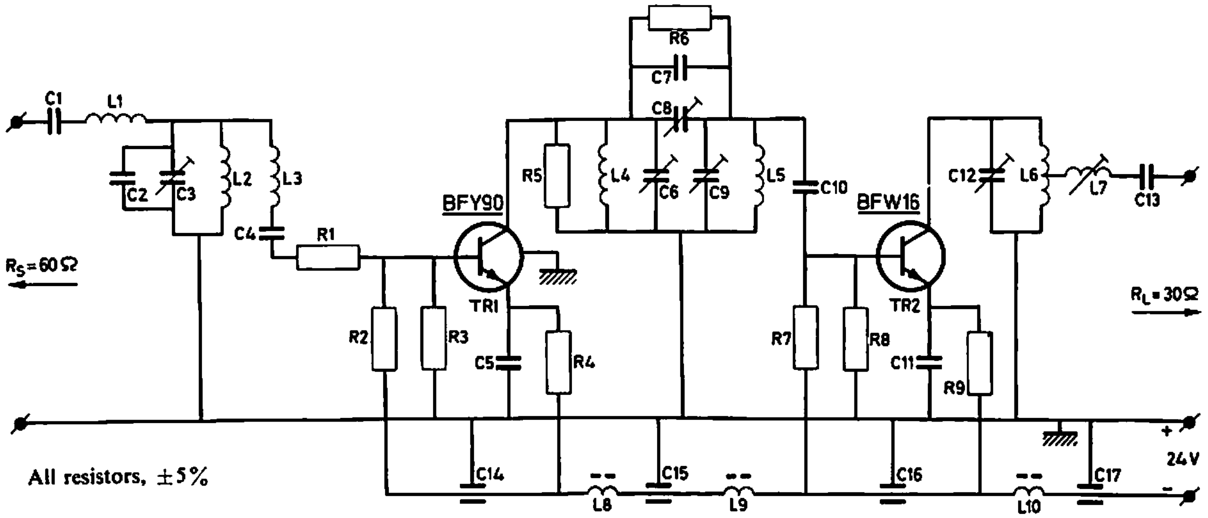
+ 15 V
R_o
100
3.0 K
C_p
D
Input
(from Target
load circuit)
2N3819 or 2N5163
9186
-
+
output
7.5 K
- 15 V

VIDICON PREAMP—Input fet is used as source follower to provide impedance buffering for wide range of vidicon target loading circuits. High open-loop gain of 1,000 for opamp and 1-MHz bandwidth make arrangement ideal for video amplifiers requiring high-frequency peaking and low noise.—A Video Pre-Amplifier for Use With a Vidicon, Optical Electronics, Tucson, Ariz., No. 10089.

VERTICAL BLANKING CIRCUIT—With terminals 4, 5, and 6 connected to field (vertical) output stage, circuit generates suitable blanking pulse for feeding directly to emitter of video output transistor in small-screen battery-operated tv receiver. Diode clips initial peak of flyback voltage.—A. H. Nillesen, Field Deflection Circuit for Tiny-Vision Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 256, 1967.



④
+V_B
⑤
A
⑥
BA148
680 Ω
10kΩ
680nF
BF194
470 Ω
video output stage
BF177
k
3.9kΩ
220Ω



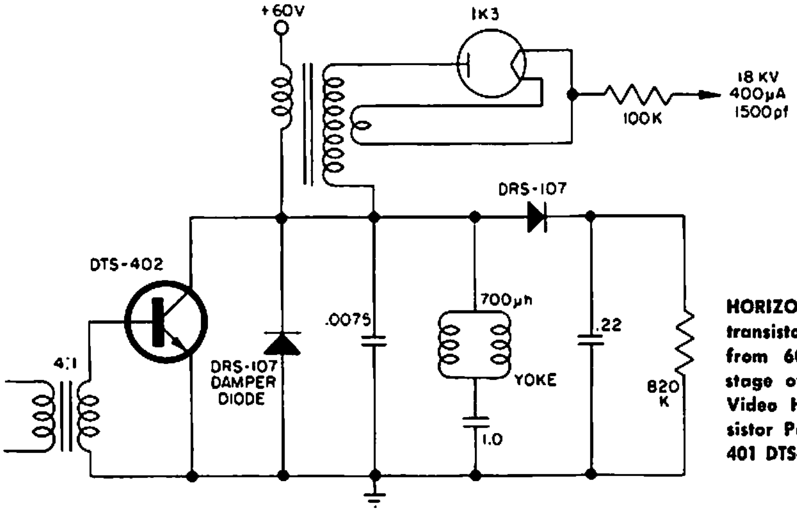
C1
L1
C2
C3
L2
L3
C4
R1
R_S=60Ω
R2
R3
BFY90
TR1
C5
R4
R5
R6
C7
C8
L4
C6
C9
L5
C10
R7
R8
BFW16
TR2
C11
R9
C12
L6
L7
C13
R_L=30Ω
C14
L8
C15
L9
C16
L10
C17
+
24V
-

All resistors, ±5%

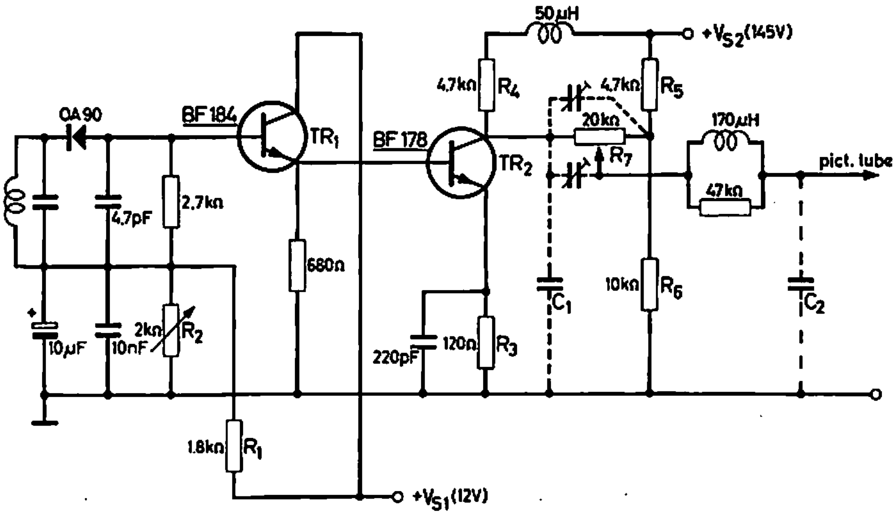
R_1	10 Ω, $\frac{1}{8}$ W	C_1, C_4, C_7	12 pF ceramic, ±5%
R_2	2.2 kΩ, $\frac{1}{8}$ W	C_2	10 pF ceramic, ±0.5%
R_3	1.5 kΩ, $\frac{1}{8}$ W	C_3, C_6, C_8	12 pF
R_4, R_5	1 kΩ, $\frac{1}{8}$ W	C_9, C_{12}	
R_6	750 Ω, $\frac{1}{8}$ W	C_5, C_{11}	4.7 nF disk, −20/+50%
R_7	470 Ω, $\frac{1}{4}$ W	C_{10}	82 pF ceramic, ±5%
R_8	1.2 kΩ, $\frac{1}{4}$ W	C_{13}	56 pF ceramic, ±5%
R_9	82 Ω, $\frac{1}{2}$ W	C_{14}-C_{17}	4.7 nF feedthrough, −20/+50%

L_1, L_3	500 nH,	21 turns 0.5 mm enamelled Cu on 4 mm dia., 0.5 mm pitch
L_2	200 nH,	13 turns 1.0 mm enamelled Cu on 4 mm dia., 1.5 mm pitch
L_4	200 nH,	8 turns 1.0 mm enamelled Cu on 8 mm dia., 1,5 mm pitch
L_5	85 nH,	4 turns 1.0 mm enamelled Cu on 8 mm dia., 2.5 mm pitch
L_6	240 nH,	11 turns 1.0 mm enamelled Cu on 8 mm dia., 2.0 mm pitch, tapped 4½ turns from earthed end
L_7	75 nH,	3 turns 1 mm enamelled Cu on 8 mm dia., 2.0 mm pitch,
L_8-L_{10}	choke Type 4312 020 36701	

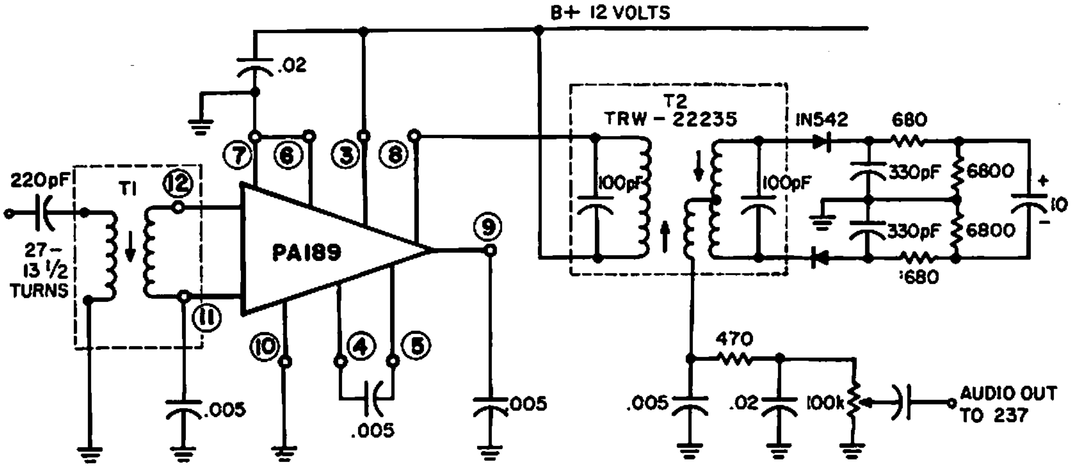
47–68 MHZ ANTENNA AMPLIFIER—Provides gain of 52 dB for European band I, with noise factor of 6 to 6.5 db and 10-mW output per signal. Article gives alignment information.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.


+60V
1K3
18 KV
400µA
1500pf
100K
DRS-107
DTS-402
4:1
DRS-107
DAMPER
DIODE
.0075
700µh
YOKE
1.0
.22
820
K

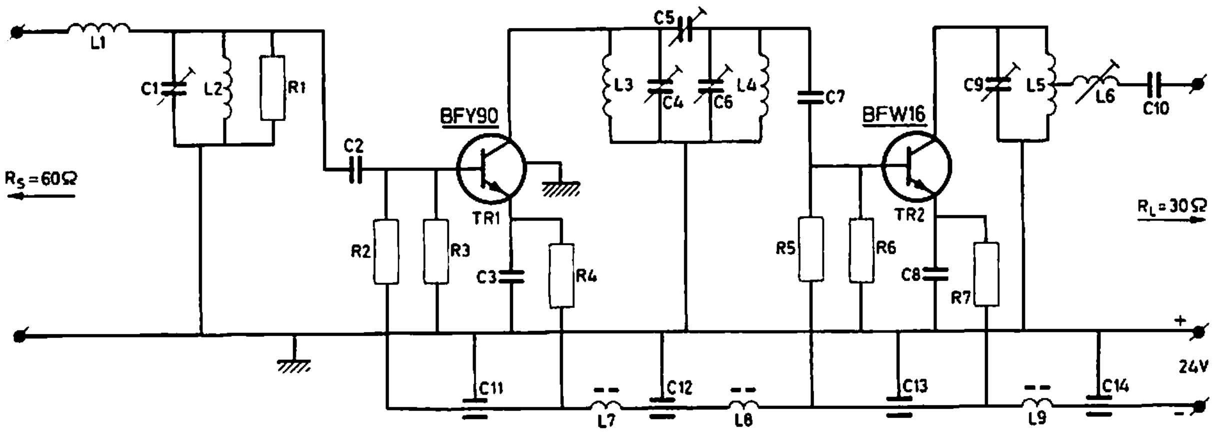
HORIZONTAL OUTPUT—Uses silicon power transistor designed especially for operation from 60-V supply in horizontal deflection stage of large-screen monochrome tv set.—Video Horizontal and Vertical Output Transistor Pair, Delco Radio, Kokomo, Ind., DTS-401 DTS-402, 1968.


50µH
+V_S2(145V)
4.7kΩ
R4
4.7kΩ
R5
20kΩ
R7
170µH
pict. tube
47kΩ
OA90
BF184
TR1
BF178
TR2
4.7pF
2.7kΩ
680Ω
10µF
10nF
2kΩ
R2
220pF
120Ω
R3
C1
10kΩ
R6
C2
1.8kΩ
R1
+V_S1(12V)

VIDEO WITH CONTRAST CONTROL—Shows method of applying contrast control in collector circuit of video output transistor. R5 and R6 provide constant black level during contrast control. Report discusses design problems, including that of capacitance introduced by long wires going from contrast pot at front of set to video amplifier. Total value of C1 and C2 is about 30 pF.—A. Cense, The N-P-N Silicon Planar Transistor BF178 in a Video Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 251, 1966.


B+ 12 VOLTS
.02
220pF
T1
12
7
6
3
8
27–
13 1/2
TURNS
PA189
9
11
10
4
5
.005
.005
.005
T2
TRW – 22235
100pF
100pF
IN542
680
330pF
6800
330pF
6800
+
10
–
680
470
.005
.02
100k
AUDIO OUT
TO 237

IC I-F AND RATIO DETECTOR—PA189 linear IC with external components shown gives good a-m rejection and very high gain along with bandwidth of at least 50 kHz. I-f value is 4.5 MHz. Sensitivity is 200 µV for 3 dB limiting.—E. L. Haas and D. J. Hubbard, Linear Integrated Circuits in a TV Sound System, General Electric Co., Syracuse, N.Y., Application Note 90.74, 6/68.

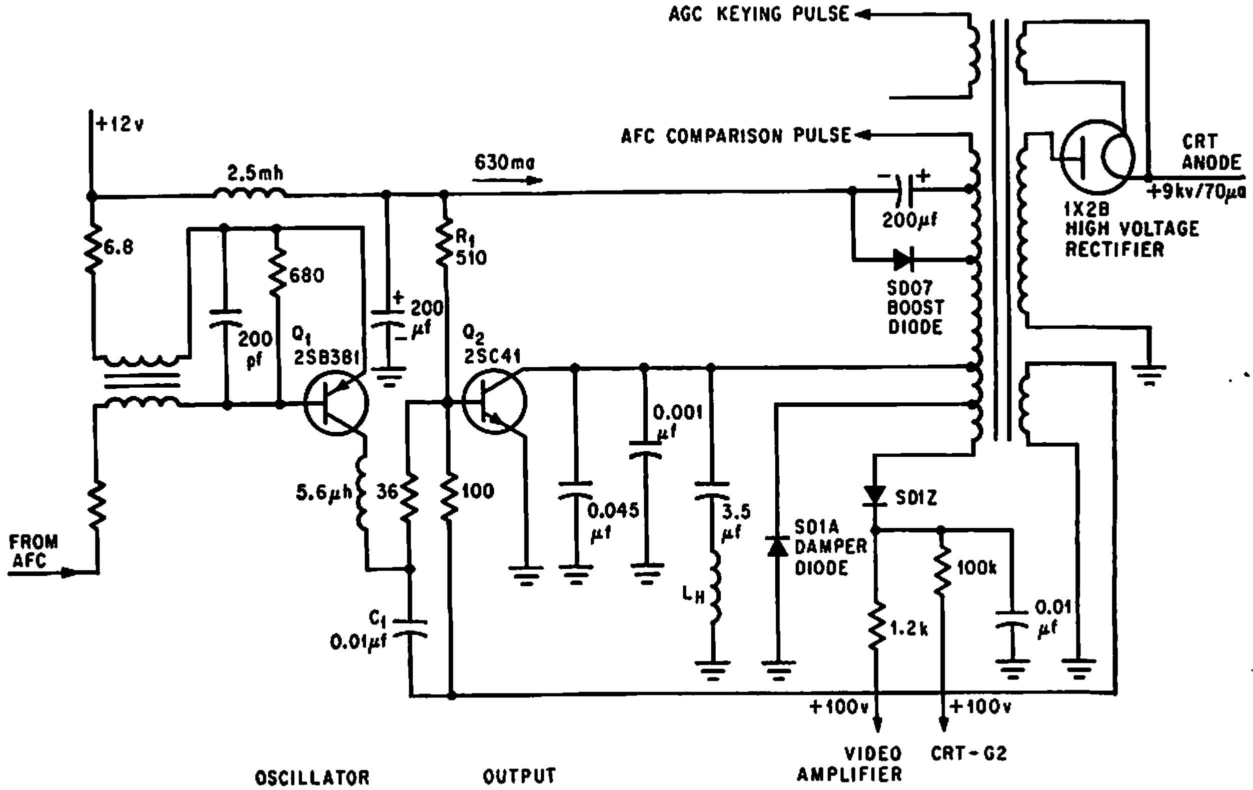

L1
C1
L2
R1
R$_S$=60Ω
C2
BFY90
TR1
R2
R3
C3
R4
C5
L3
C4
C6
L4
C7
BFW16
TR2
R5
R6
C8
R7
C9
L5
L6
C10
R$_L$=30Ω
+
24V
−
C11
L7
C12
L8
C13
L9
C14

R_1	1.2 kΩ, ¼ W	All resistors, ±5%
R_2	2.2 kΩ, ¼ W	
R_3	1.5 kΩ, ¼ W	
R_4	1 kΩ, ¼ W	
R_5	470 Ω, ¼ W	
R_6	1.2 kΩ, ¼ W	
R_7	82 Ω, ¼ W	

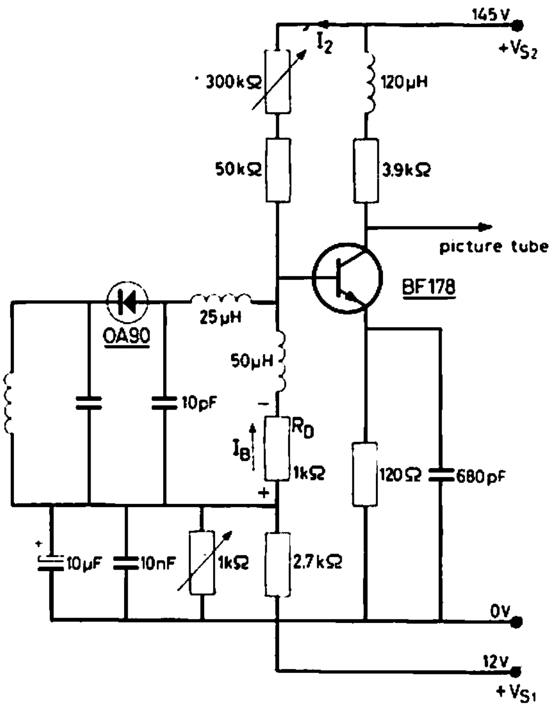
C_1, C_4-C_6, C_9	12 pF
C_2, C_{10}	15 pF ceramic, ±5%
C_3, C_8	4.7 nF disk, −20/+50%
C_7	27 pF ceramic, ±5%
C_{11}-C_{14}	4.7 nF feedthrough, −20/+50%

L_1 450 nH, 13 turns 0.5 mm enamelled Cu on 5 mm dia., 0.5 mm pitch
L_2 400 nH, 12 turns 1.0 mm enamelled Cu on 8 mm dia., 1.5 mm pitch
L_3 300 nH, 10 turns 1.0 mm enamelled Cu on 8 mm dia., 2.0 mm pitch
L_4 165 nH, 6 turns 1.0 mm enamelled Cu on 8 mm dia., 2.0 mm pitch
L_5 275 nH, 10 turns 1.0 mm enamelled Cu on 8 mm dia., 2.5 mm pitch, tapped 4½ turns from earthed end
L_6 300 nH, 7 turns 1.3 mm Ag plated Cu on 12 mm dia., 2.0 mm pitch
L_7-L_9 choke Type 4312 020 36701

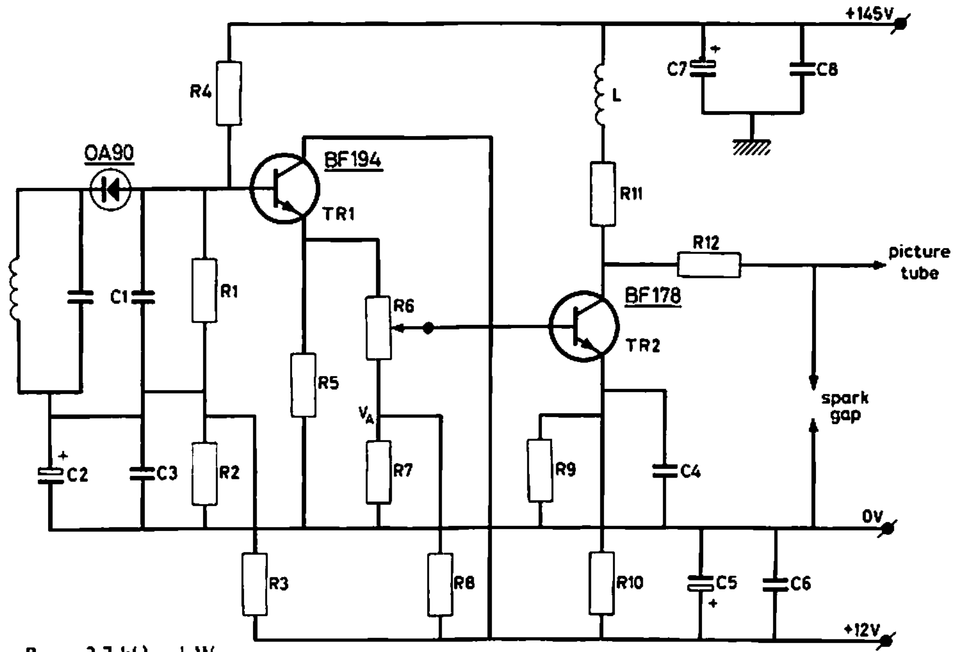
61–68 MHZ ANTENNA AMPLIFIER—Provides gain of 50 dB for European channel 4, with 7-dB noise factor and 150-mW output signal. —J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.


AGC KEYING PULSE
AFC COMPARISON PULSE
+12v
2.5mh
630ma
6.8
680
200 pf
Q1 2SB381
+ 200 µf
R1 510
Q2 2SC41
200µf
SD07 BOOST DIODE
CRT ANODE
+9kv/70µa
1X2B HIGH VOLTAGE RECTIFIER
0.001 µf
5.6µh
36
100
0.045 µf
3.5 µf
LH
SD1A DAMPER DIODE
SD1Z
100k
1.2k
0.01 µf
C1 0.01µf
FROM AFC
+100v
+100v
VIDEO AMPLIFIER
CRT-G2
OSCILLATOR
OUTPUT

TWO-TRANSISTOR HORIZONTAL SWEEP—Used in Sony 7-inch 700U portable tv. Tertiary winding on flyback transformer provides positive feedback to base of Q2 to offset gain lost through omission of driver stage. Total power consumption of horizontal output stage is only 9.5 W. Sweep Eliminates Driver Stage, *Electronics*, Nov. 14, 1966, p 169–171.


145 V
+Vs2
I2
300kΩ
120µH
50kΩ
3.9kΩ
picture tube
BF178
OA90
25µH
50µH
10pF
RD
IB
1kΩ
120Ω
680pF
10µF
10nF
1kΩ
2.7kΩ
0V
12V
+Vs1

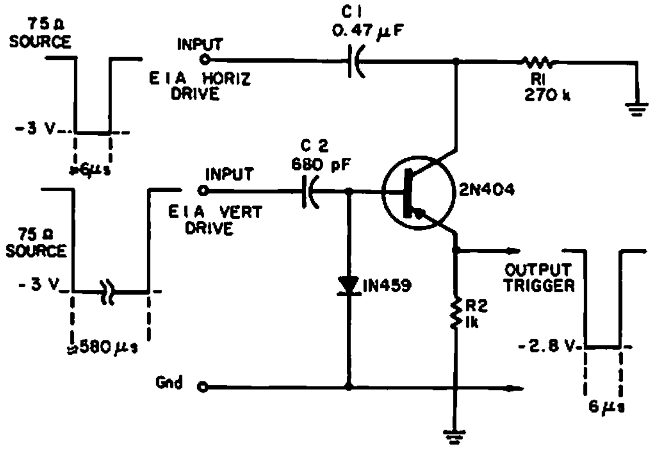
SINGLE-STAGE VIDEO AMPLIFIER—Provides bandwidth of 4.5 MHz at 3-dB-down points and 80 V black-to-white output voltage for typical large-screen picture tube such as A59-11W in European 625-line tv receiver. Transistor is direct-coupled to video detector circuit. Contrast control is in base circuit, where it places no restrictions on circuit layout or wiring, and does not affect either bandwidth or transient response.—A. Cense, Recent Developments in Circuits and Transistors for Television Receivers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966—1967, p 41—52.

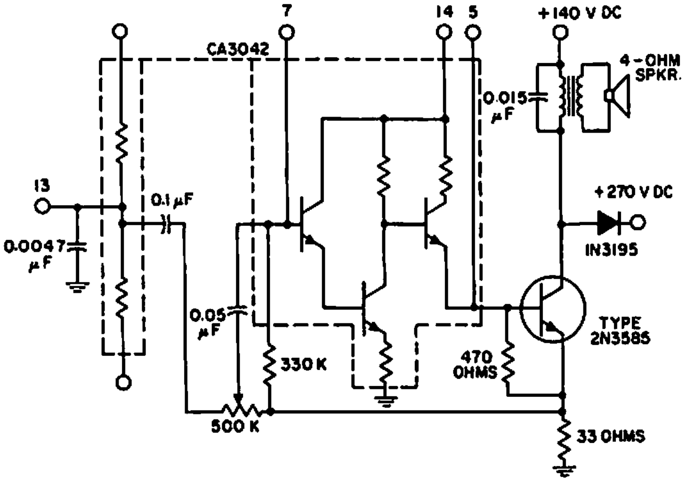

+145V
R4
C7
C8
L
OA90
BF194
TR1
R11
R12
picture tube
C1
R1
R6
BF178
TR2
R5
VA
spark gap
C2
C3
R2
R7
R9
C4
0V
R3
R8
R10
C5
C6
+12V

R_1	2.7 kΩ,	¼ W
R_2	2.2 kΩ,	¼ W
R_3	1 kΩ,	¼ W
R_4	560 kΩ,	¼ W
R_5	680 Ω,	¼ W
R_6	300 Ω,	pot.
R_7	56 Ω,	1 W
R_8	100 Ω,	1 W
R_9	150 Ω,	¼ W
R_{10}	560 Ω,	¼ W
R_{11}	3.9 kΩ,	5.5 W
R_{12}	1.5 kΩ,	1 W
C_1	4.7 pF,	500 V
C_2	10 µF,	16 V
C_3	6.8 nF,	500 V
C_4	220 pF,	500 V
C_5	10 µF,	16 V
C_6	6.8 nF,	500 V
C_7	20 µF,	250 V
C_8	6.8 nF,	500 V
L	120 µH,	air coil

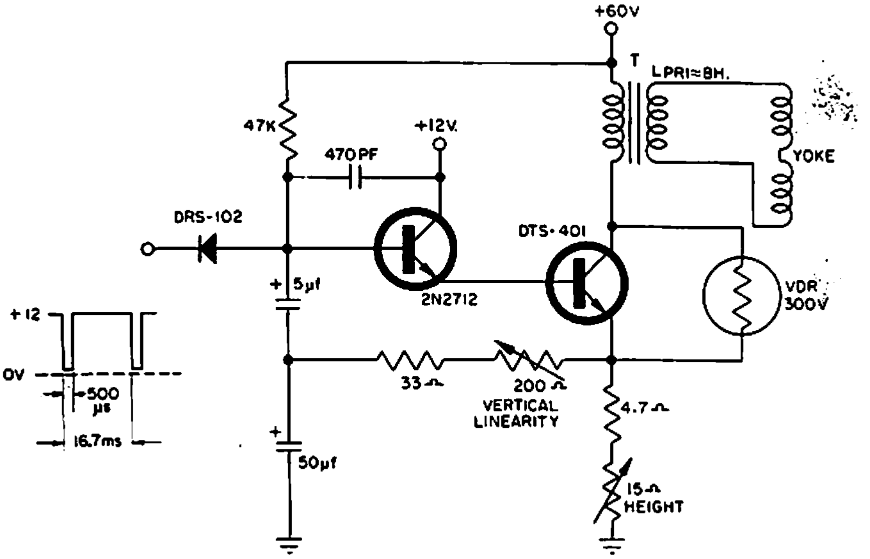
VIDEO DETECTOR AND AMPLIFIER—Direct coupling is used throughout to keep black level constant and independent of picture content in European large-screen 625-line tv receiver. Collector circuit compensation is used in first video amplifier stage to provide required bandwidth. Spark gap protects transistors from high-voltage spikes appearing at picture-tube cathode as result of flashovers. Maximum breakdown voltage of spark gap is 3,000 V.—A. Cense, Recent Developments in Circuits and Transistors for Television Receivers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 2, 1966—1967, p 41—52.

SELECTING FIRST LINE OF FRAME—Signal-powered coincidence gate delivers output trigger only when pulses are present at both inputs, for triggering cro coincident with first field of each frame in interlaced television scanning system. Overcomes problem of delayed time base in cro that may lock onto first or second field pulse at random because it cannot distinguish between them.—O. Harper, Coincidence Gate Generates First Field Reference Trigger, *Electronic Design*, Sept. 27, 1967, p 66.

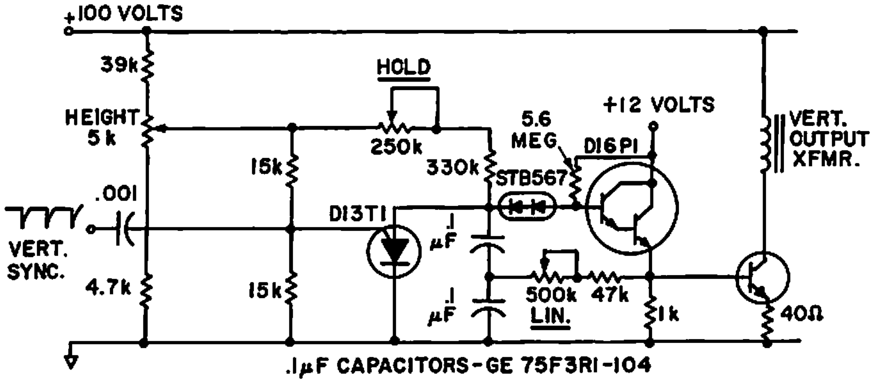

75 Ω SOURCE
-3 V
≈6 μs
75 Ω SOURCE
-3 V
≈580 μs
INPUT
EIA HORIZ DRIVE
INPUT
EIA VERT DRIVE
C1 0.47 μF
C2 680 pF
R1 270 k
2N404
1N459
R2 1k
OUTPUT TRIGGER
-2.8 V
6 μs
Gnd


7
14
5
+140 V DC
CA3042
4-OHM SPKR.
0.015 μF
13
0.0047 μF
0.1 μF
+270 V DC
1N3195
0.05 μF
330 K
470 OHMS
TYPE 2N3585
500 K
33 OHMS

FEEDBACK VOLUME CONTROL—Used with CA3042 IC to cut production costs through use of smaller coupling capacitors. Delivers 2 W audio power output at 7 kHz maximum deviation from 4.5-MHz carrier.—L. Kaplan, Feedback-Type Volume-Control Circuits for RCA-CA3041 and CA3042 Integrated Circuits, RCA, Harrison, N.J., No. ICAN-5841, 1968.

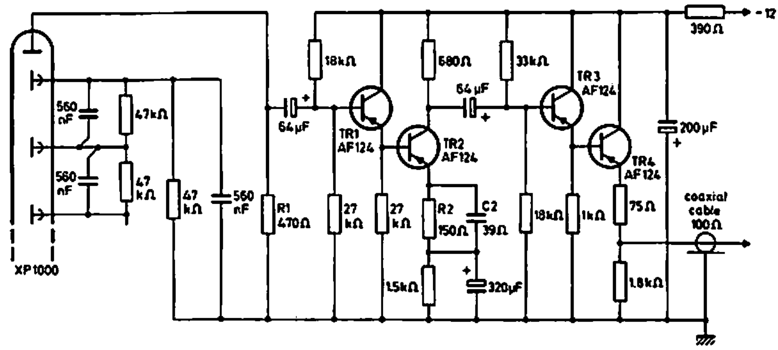

+60V
T
LPRI≈8H.
YOKE
47K
+12V.
470PF
DRS-102
DTS-401
2N2712
5μf
VDR 300V
+12
0V
500 μs
16.7ms
33Ω
200Ω
VERTICAL LINEARITY
4.7Ω
15Ω HEIGHT
50μf

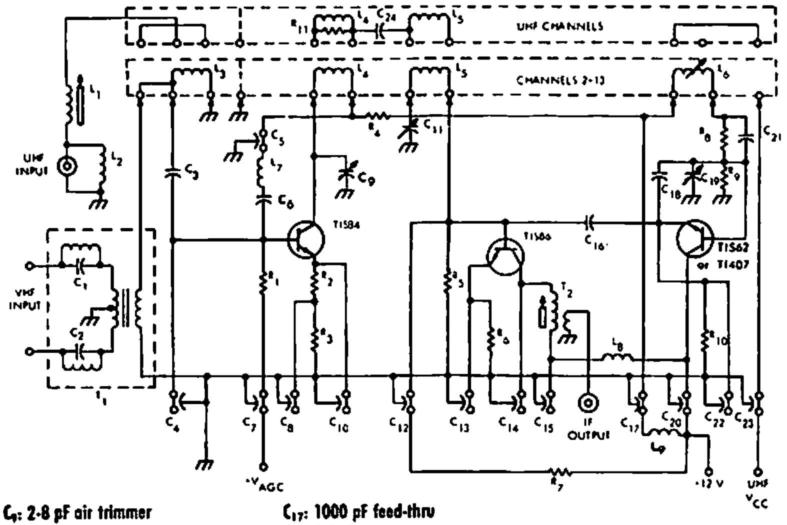
VERTICAL OUTPUT—Uses silicon power transistor designed especially for operation from 60-V supply in vertical deflection stage. Has good gain linearity.—Video Horizontal and Vertical Output Transistor Pair, Delco Radio, Kokomo, Ind., DTS-401 DTS-402, 1968.


+100 VOLTS
39k
HEIGHT 5 k
HOLD
250k
330k
5.6 MEG
+12 VOLTS
D16PI
STB567
VERT. OUTPUT XFMR.
.001
VERT. SYNC.
15k
D13TI
.1 µF
4.7k
15k
.1 µF
500k 47k
LIN.
1 k
40Ω
.1µF CAPACITORS-GE 75F3RI-104

SOLID-STATE VERTICAL DEFLECTION—Uses D13T1 programmable ujt as relaxation oscillator operating at 60-Hz sweep rate, with synchronization by 4-V negative pulses. D16P1 high-gain Darlington drives output power transistor, and multipellet diode provides d-c level shifting. Bootstrap feedback through 500K improves linearity.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 11/67, p 10.

PHOTOMULTIPLIER AMPLIFIER FOR FLYING-SPOT SCANNER—Used for detecting high-frequency modulated light from flying-spot scanners used for slide reproduction in television studios. For color slides, three identical amplifiers are required. Photomultiplier shown will handle bandwidth from d-c to 100 MHz, but XP1210 will go up to 350 MHz.—J. M. Schonkeren, "Photomultipliers," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1970, p 102.


XP1000
560 nF
47kΩ
560 nF
47 kΩ
47 kΩ
560 nF
R1 470Ω
64µF
18kΩ
TR1 AF124
27 kΩ
27 kΩ
680Ω
64µF
TR2 AF124
R2 150Ω
C2 39Ω
1.5kΩ
320µF
33kΩ
TR3 AF124
18kΩ
1kΩ
TR4 AF124
75Ω
1.8kΩ
200µF
390Ω
-12V
coaxial cable 100Ω

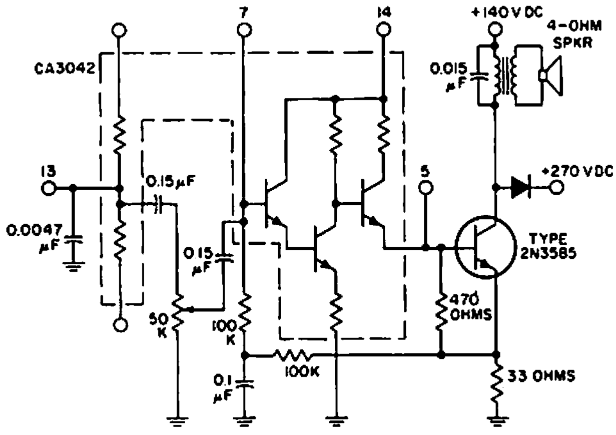

UHF CHANNELS
CHANNELS 2-13
UHF INPUT
VHF INPUT
TIS84
TIS86
TIS62 or TI407
T1
T2
IF OUTPUT
+VAGC
-12 V
UHF VCC

C_1: 47 pF
C_2: 47 pF
C_3: 8.2 pF
C_4: 18 pF feed-thru
C_5: 30 pF feed-thru
C_6: 0.68 pF
C_7: 1000 pF feed-thru
C_8: 1000 pF feed-thru
C_9: 2-8 pF air trimmer
C_{10}: 39 pF feed-thru
C_{11}: 2-8 pF air trimmer
C_{12}: 30 pF feed-thru
C_{13}: 1000 pF feed-thru
C_{14}: 10 pF feed-thru
C_{15}: 1000 pF feed-thru
C_{16}: 3.6 pF
C_{17}: 1000 pF feed-thru
C_{18}: 5.6 pF
C_{19}: 0.5-3 pF air trimmer
C_{20}: 1000 pF feed-thru
C_{21}: 5.6 pF
C_{22}: 2.5 pF feed-thru
C_{23}: 1000 pF feed-thru
C_{24}: 5.6 pF

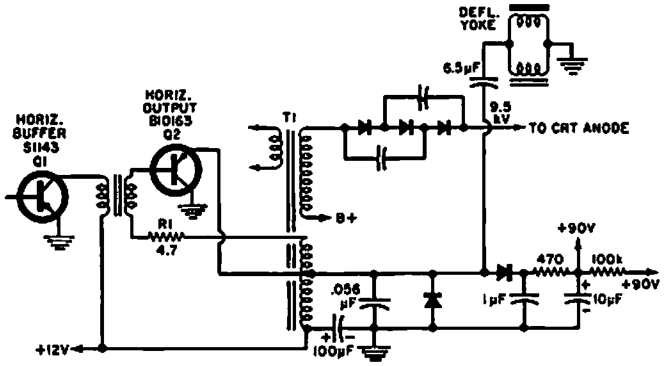
RESISTORS (½ W, ten percent)
R_1: 1 kΩ
R_2: 15 Ω
R_3: 560 Ω
R_4: 390 Ω
R_5: 1.2 kΩ
R_6: 220 Ω
R_7: 10 kΩ
R_8: 5.6 kΩ
R_9: 10 kΩ
R_{10}: 1 kΩ
R_{11}: 10 kΩ

INDUCTORS
L_1: UHF matching coil
L_2: UHF matching coil
L_3: as required per channel
L_4: as required per channel
L_5: as required per channel
L_6: as required per channel
L_7: neutralizing coil
L_8: RFC
L_9: RFC

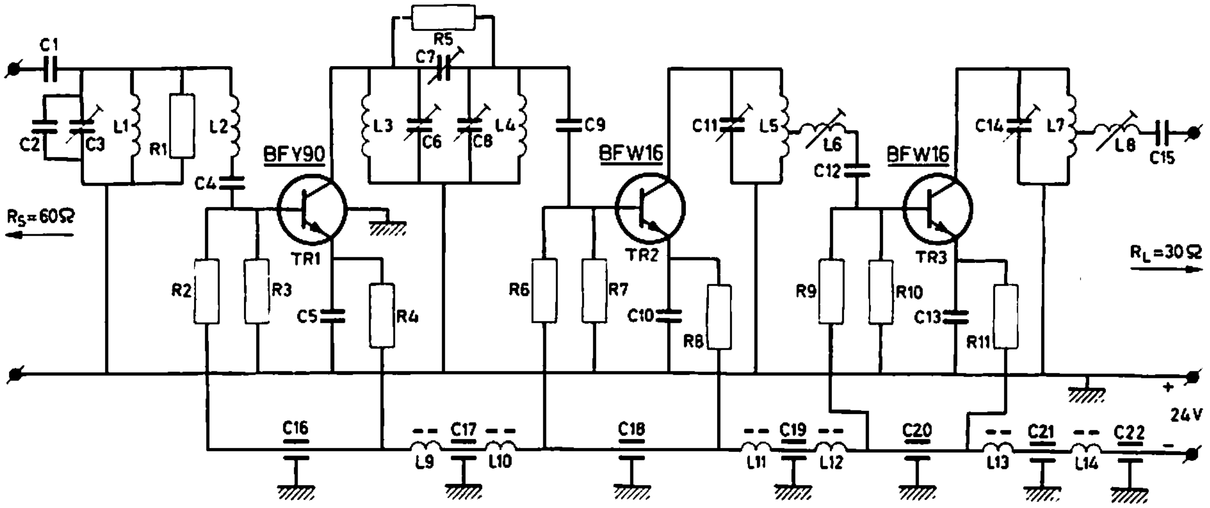
VHF TUNER—Uses npn planar silicon transistors. Power gain ranges from 39 dB for channel 2 to 35 dB for channel 13. Noise figure ranges from 5.5 to 6.2 dB, i-f rejection from 55 to 84 dB, and image rejection from 66 to 88 dB. T1 is balun assembly, including i-f traps, and T2 is i-f output transformer.—Preferred Semiconductors and Components, Texas Instruments, Dallas, Texas, Bulletin CC101, 1968, p 1039.


CA3042
7
14
+140 V DC
4-OHM SPKR
0.015 µF
13
0.15µF
5
+270 VDC
0.0047 µF
0.15 µF
TYPE 2N3585
50 K
100 K
470 OHMS
100K
0.1 µF
33 OHMS

VOLUME CONTROL WITH IC—Circuit illustrates method of using conventional volume control with IC audio amplifier for tv sound. —L. Kaplan, Feedback-Type Volume-Control Circuits for RCA-CA3041 and CA3042 Integrated Circuits, RCA, Harrison, N.J., No. ICAN-5841, 1968.


DEFL. YOKE
6.5µF
HORIZ. OUTPUT BI0163 Q2
HORIZ. BUFFER SII43 QI
T1
9.5 kV
TO CRT ANODE
R1 4.7
B+
+90V
470
100k
+90V
.056 µF
1µF
10µF
+12V
100µF

HORIZONTAL OUTPUT WITH B+ AND HV SUPPLIES—High-voltage rectifier circuit of G-E Model TA 9-inch tv uses conventional three-rectifier two-capacitor voltage-doubler with unique method of operation. With 5-kV positive pulse from T1, first and third rectifiers act in effect as peak detectors during retrace, and middle rectifier conducts during trace time. Result is maximum output of about 9.5 kV.—W. H. Buchsbaum, Line-Operated Transistor TV Sets: G-E, *Electronics World*, Oct. 1966, p 29 and 70.


C1
R5
C7
C2
C3
L1
R1
L2
L3
C6
C8
L4
C9
C11
L5
L6
C12
C14
L7
L8
C15
C4
BFY90
BFW16
BFW16
Rs=60Ω
TR1
TR2
TR3
RL=30Ω
R2
R3
C5
R4
R6
R7
C10
R8
R9
R10
C13
R11
+
24V
-
C16
C17
L9
L10
C18
C19
L11
L12
C20
C21
L13
L14
C22

R_1	1.6 kΩ, 1/8 W
R_2	2.4 kΩ, 1/8 W
R_3	3.3 kΩ, 1/8 W
R_4	1 kΩ, 1/8 W
R_5	7.5 kΩ, 1/8 W
R_6	750 Ω , 1/4 W
R_7	1.8 kΩ, 1/4 W
R_8	180 Ω , 1/4 W
R_9	470 Ω , 1/4 W
R_{10}	1.2 kΩ, 1/4 W
R_{11}	82 Ω , 1/2 W

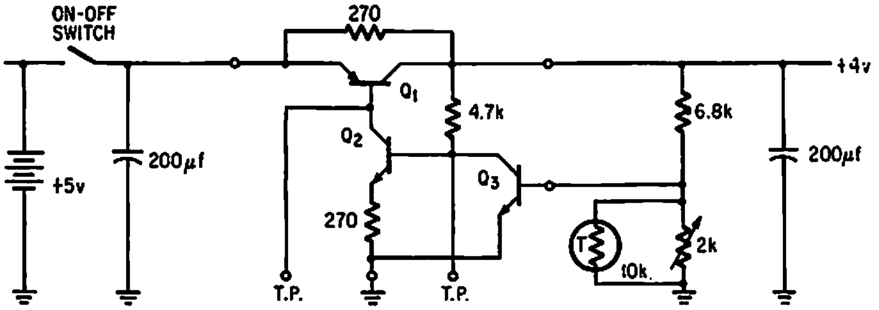
All resistors, ±5%

C_1, C_9, C_{12}	3.9 pF ceramic, ±0.5%
C_2	10 pF ceramic, ±0.5%
C_3, C_6, C_8, C_{11}, C_{14}	12 pF
C_4, C_5, C_{10}, C_{13}	1 nF disk, −20/+50%
C_7	3 pF
C_{15}	2.2 pF ceramic, ±0.5%
C_{16}-C_{22}	4.7 nF feedthrough, −20/+50%

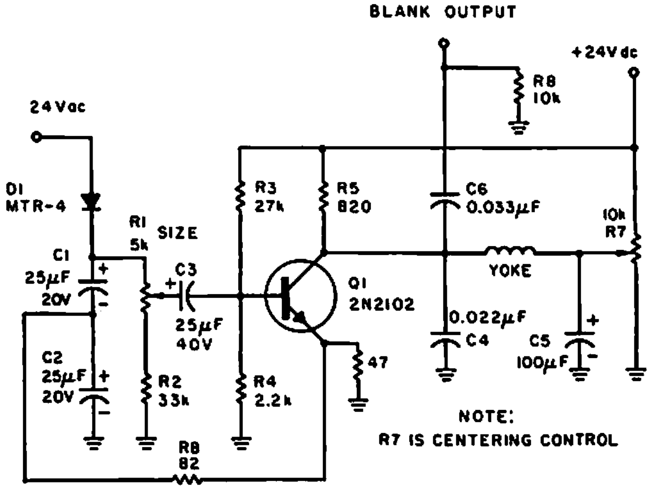
L_1, L_3, L_4	35 nH,	2 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch
L_2	120 nH,	5½ turns 1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch
L_5	35 nH,	2 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch, tapped 3/4 turn from earthed end
L_6	100 nH,	4½ turns 1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch
L_7	60 nH,	3 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.5 mm pitch, tapped 3/4 turn from earthed end
L_8	165 nH,	5½ turns 1.3 mm Ag plated Cu on 11 mm dia., 2.0 mm pitch
L_9-L_{14}	choke Type 4312 020 36701	

202–209 MHZ ANTENNA AMPLIFIER—Provides gain of 44 dB for European channel 9, with 6.3-dB noise factor and 150-mW output signal.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.

PENLIGHT REGULATOR—Holds output constant within 0.1 V as 5.5-V penlight supply for 1.5-inch Matsushita portable tv ages down to 4 V.—R. Sasaki and K. Uno, Low-Power Design is Heart of Penlight-Powered Mini-Tv, *Electronics*, June 8, 1970, p 106–113.

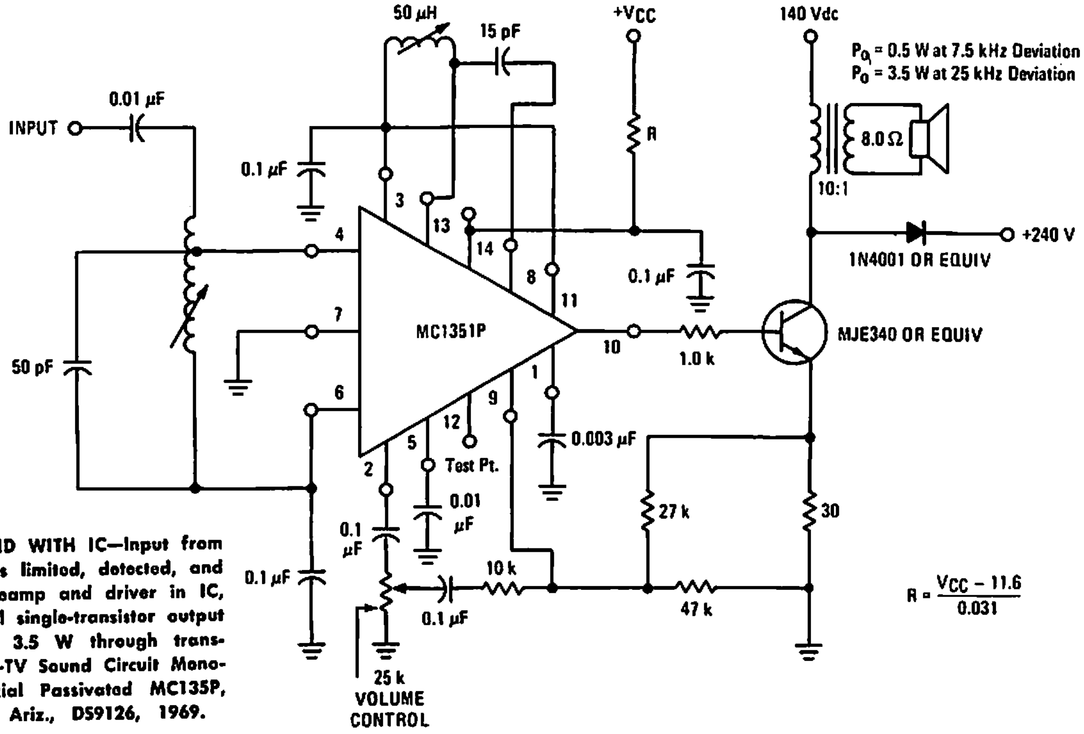


ON-OFF SWITCH
270
+4v
Q1
4.7k
6.8k
Q2
200μf
+5v
Q3
200μf
270
T
2k
10k
T.P.
T.P.



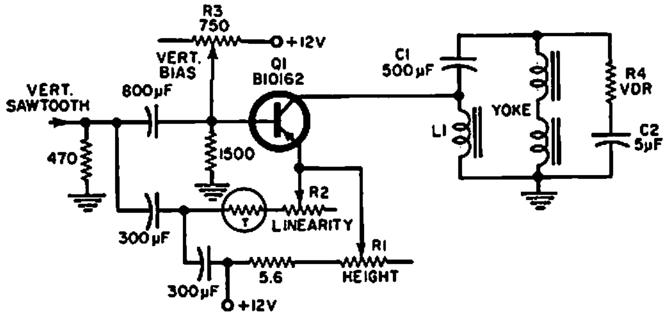
BLANK OUTPUT
+24Vdc
R8 10k
24Vac
D1 MTR-4
R3 27k
R5 820
C6 0.033μF
R1 5k
SIZE
10k R7
C1 25μF 20V
C3
YOKE
Q1 2N2102
25μF 40V
0.022μF C4
C5 100μF
C2 25μF 20V
R2 33k
R4 2.2k
47
R8 82
NOTE: R7 IS CENTERING CONTROL

LINE-LOCKED VERTICAL SWEEP—A-c input at 24 V is applied to half-wave rectifier-filter delivering nearly linear line-locked vertical sawtooth that is amplified by Q1 for driving deflection yoke. R7 and C5 set d-c reference for centering control. Blank output may be used to trigger sync and cathode-blanking functions of camera.—J. M. Meacham, TV-Camera Vertical Sweep Produced by Filter Ripple, *Electronic Design*, Feb. 1, 1969, p 72.

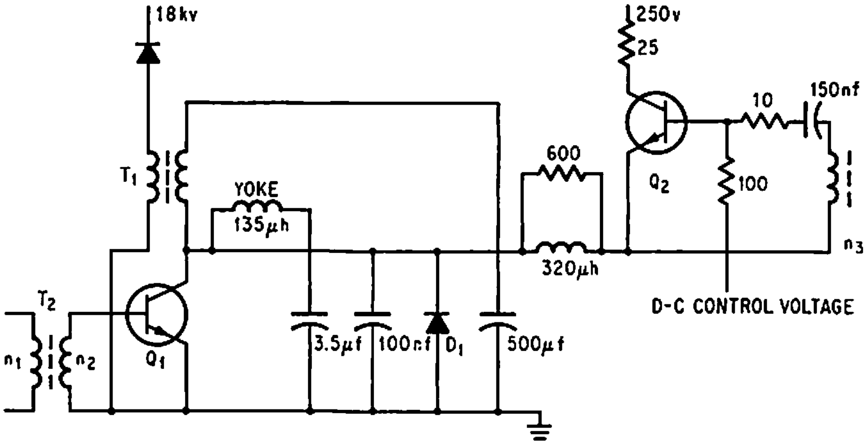


50 μH
15 pF
+VCC
140 Vdc
P_{O_1} = 0.5 W at 7.5 kHz Deviation
P_O = 3.5 W at 25 kHz Deviation
0.01 μF
INPUT
R
8.0 Ω
0.1 μF
10:1
3
13
+240 V
4
14
1N4001 OR EQUIV
8
0.1 μF
11
7
MC1351P
10
1.0 k
MJE340 OR EQUIV
50 pF
1
9
6
12
0.003 μF
5
2
Test Pt.
27 k
30
0.01 μF
0.1 μF
0.1 μF
10 k
0.1 μF
47 k
25 k VOLUME CONTROL
$R = \frac{V_{CC} - 11.6}{0.031}$

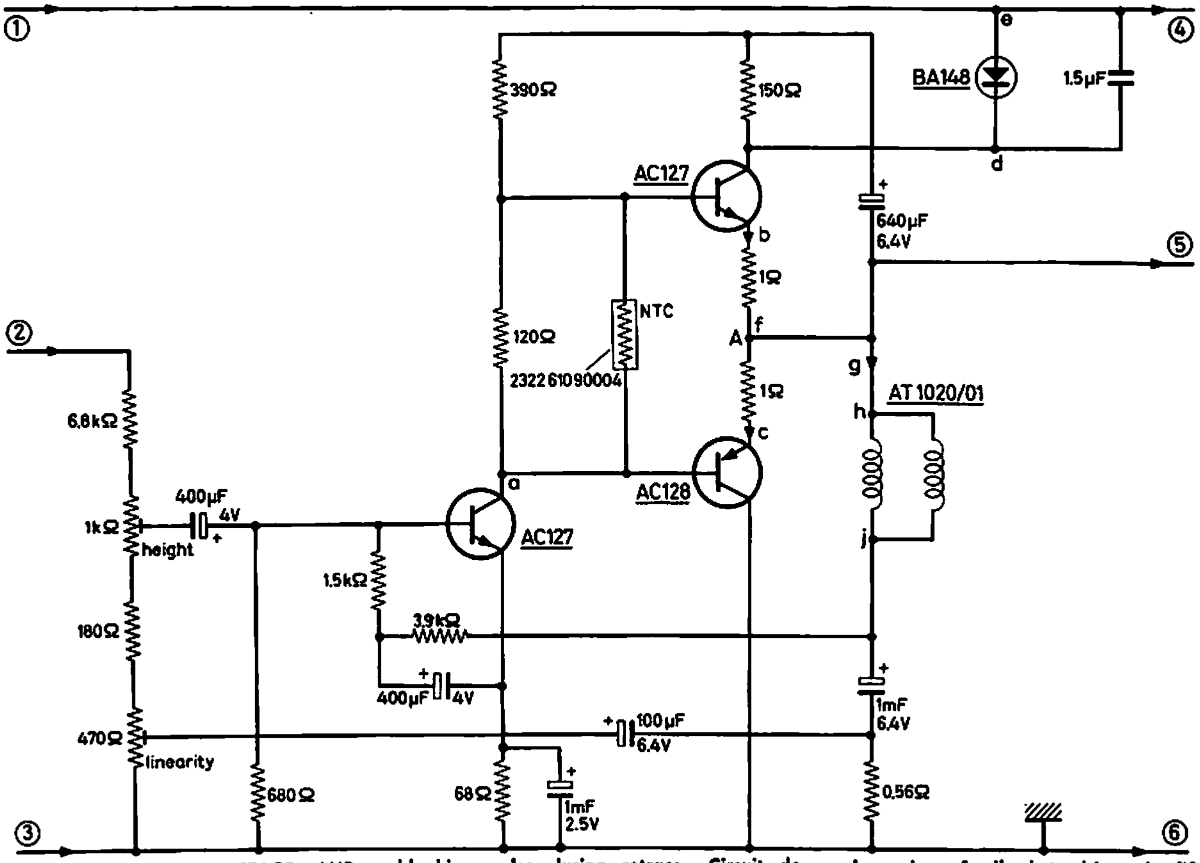
COMPLETE TV SOUND WITH IC—Input from 4.5-MHz sound i-f is limited, detected, and passed to audio preamp and driver in IC, then fed to external single-transistor output stage that delivers 3.5 W through transformer to speaker.—TV Sound Circuit Monolithic Silicon Epitaxial Passivated MC135P, Motorola, Phoenix, Ariz., DS9126, 1969.


R3
750
+12V
VERT.
BIAS
Q1
B10162
VERT.
SAWTOOTH
800µF
470
1500
R2
LINEARITY
300µF
R1
HEIGHT
5.6
300µF
+12V
C1
500µF
L1
YOKE
R4
VDR
C2
5µF

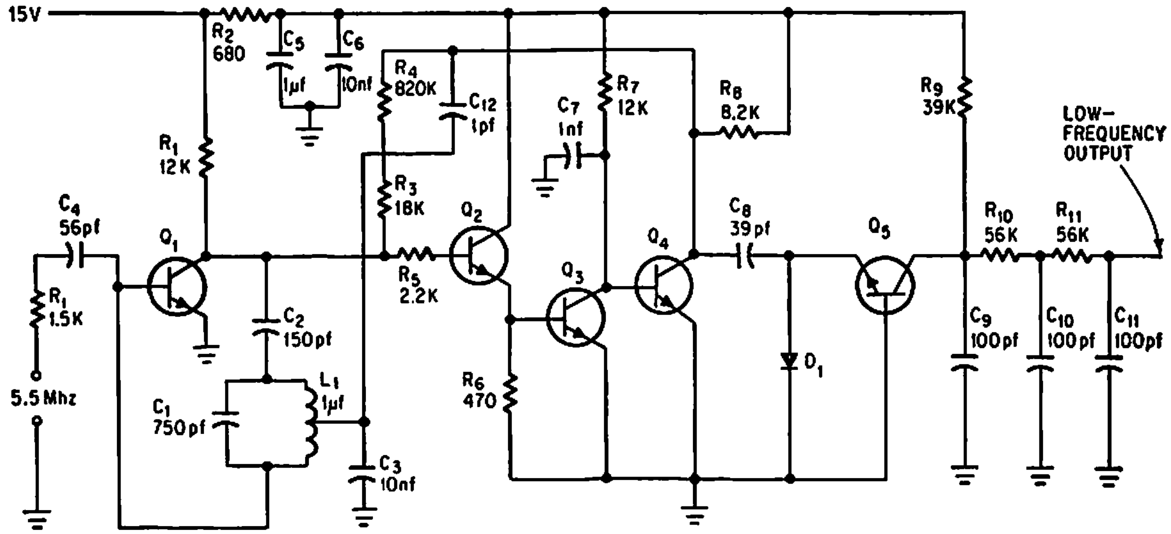
CONSTANT-HEIGHT VERTICAL OUTPUT—Voltage-dependent resistor R4 and C2 are shunted across deflection yoke to maintain constant height despite output voltage variations in G-E Model TA 9-inch portable tv.—W. H. Buchsbaum, Line-Operated Transistor TV Sets: G-E, *Electronics World*, Oct. 1966, p 29 and 70.


18kv
T1
YOKE
135µh
T2
n1
n2
Q1
3.5µf
100nf
D1
500µf
250v
25
Q2
10
150nf
600
100
320µh
n3
D-C CONTROL VOLTAGE

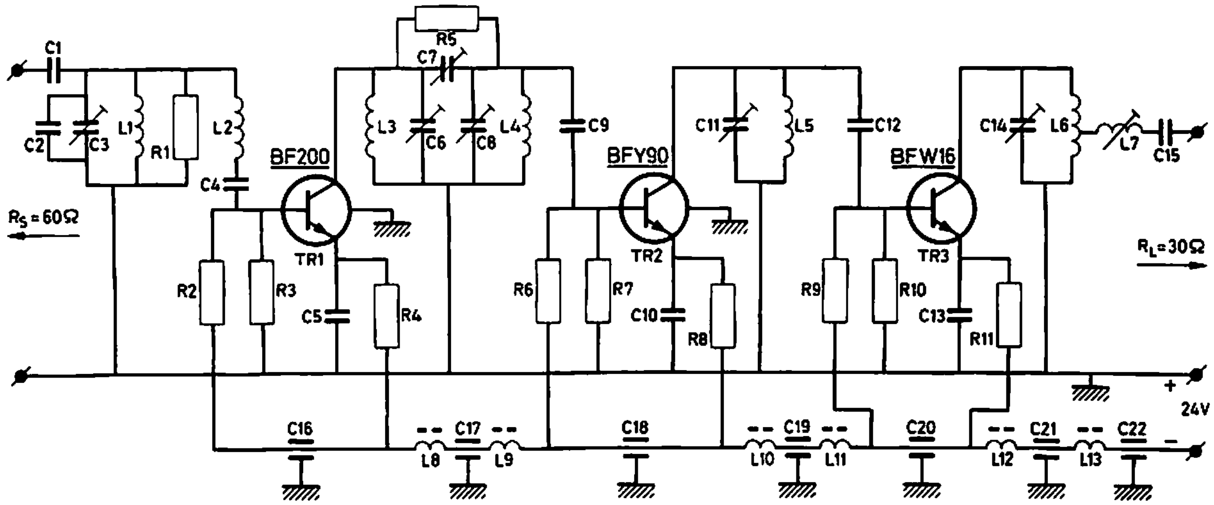
HORIZONTAL DEFLECTION—Addition of Q2 to output driver stage eliminates need for power transformer and high-voltage transistors in Siemens AG tv developed for 250-V European a-c line voltages. Q2 switches rectified 250-V supply to deflection circuit during flyback interval, when voltage across yoke is at peak. Winding n3 is on T2. Arrangement also gives low-level d-c for vertical deflection and audio stages; control voltage properly applied to Q2 keeps this source stable even for 20-W power drain. Use standard 300-V transistors.—Add One (Electronics Abroad), *Electronics*, Feb. 19, 1968, p 238.


①
②
③
④
⑤
⑥
390Ω
150Ω
e
BA148
1.5µF
d
AC127
b
640µF
6.4V
1Ω
NTC
120Ω
2322 610 90004
A
f
g
1Ω
AT1020/01
h
c
AC128
a
AC127
j
6.8kΩ
400µF
4V
1kΩ
height
1.5kΩ
3.9kΩ
180Ω
400µF
4V
1mF
6.4V
470Ω
linearity
100µF
6.4V
680Ω
68Ω
1mF
2.5V
0.56Ω

TINY-VISION FIELD OUTPUT STAGE AND DRIVER—Terminals 1, 2, and 3 come from field oscillator of small-screen battery-operated tv receiver, and terminals 4, 5, and 6 go to blanking circuit that supplies suitable blanking pulse during retrace. Circuit design minimizes current drain by using two medium-power transistors in complementary connection, without usual transformer. Output stage consumes only 1.1 W. Use of both d-c and a-c feedback to driver simplifies adjustment of circuit.—A. H. Nilleson, Field Deflection Circuit for Tiny-Vision Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 256, 1967.


15V
R2 680
C5 1µf
C6 10nf
R4 820K
C12 1pf
R7 12K
C7 1nf
R8 8.2K
R9 39K
LOW-FREQUENCY OUTPUT
R1 12K
C4 56pf
R1 1.5K
5.5 Mhz
Q1
C2 150pf
C1 750pf
L1 1µf
C3 10nf
R3 18K
R5 2.2K
Q2
Q3
Q4
R6 470
C8 39pf
D1
Q5
R10 56K
R11 56K
C9 100pf
C10 100pf
C11 100pf

NO-COIL IC FOR TV SOUND I-F—Only coil used in Standard Elektrik Lorenz IC monolithic chip is in mixer, and requires no adjustment. Designed for standard 5.5-MHz European f-m intercarrier frequency, converted to sound i-f of about 250 kHz in mixer. Hartley oscillator can deviate 150 kHz without affecting mixer performance, so fixed coil can be used. Overall gain is about 60 dB from 50 to 450 kHz, with 12 V output for about 7-mV input.—Electronics Abroad—West Germany—Uncoiled, *Electronics*, Oct. 17, 1966, p 223.


C1
R5
C7
C2
C3
L1
R1
L2
C4
L3
C6
C8
L4
C9
BF200
TR1
R2
R3
C5
R4
R_S=60Ω
C11
L5
C12
BFY90
TR2
R6
R7
C10
R8
C14
L6
L7
C15
BFW16
TR3
R9
R10
C13
R11
R_L=30Ω
+
24V
−
C16
C17
C18
C19
C20
C21
C22
L8
L9
L10
L11
L12
L13

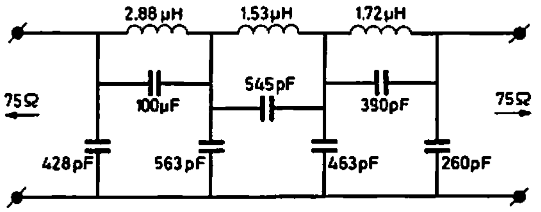
R_1	1.6 kΩ, ¼ W
R_2	2.4 kΩ, ¼ W
R_3	3.3 kΩ, ¼ W
R_4	3 kΩ, ⅛ W
R_5	3.9 kΩ, ⅛ W
R_6	1.3 kΩ, ¼ W
R_7	910 Ω , ¼ W
R_8	1.3 kΩ, ¼ W
R_9	470 Ω , ½ W
R_{10}	1.2 kΩ, ½ W
R_{11}	165 Ω , ½ W

All resistors, ±5%

C_1	4.7 pF ceramic, ±0.5%
C_2, C_{12}	5.6 pF ceramic, ±0.5%
C_3, C_6, C_8 C_{11} C_{14},	12 pF
C_4, C_5, C_{10}, C_{13}	1 nF disk, −20/+50%
C_7	3 pF
C_9	6.8 pF ceramic, ±0.5%
C_{15}	2.2 pF ceramic, ±0.5%
C_{16}-C_{22}	4.7 nF feedthrough, −20/+50%

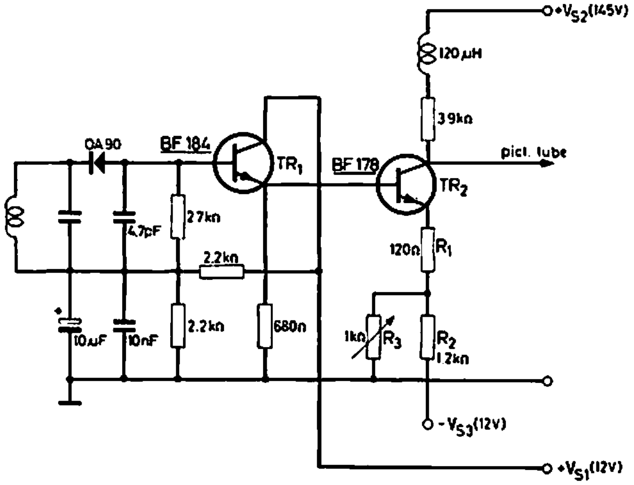
L_1, L_3-L_5	35 nH,	2 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch
L_2	120 nH,	5½ turns 1.3 mm Ag plated Cu on 8 mm dia., 2.0 mm pitch
L_6	60 nH,	3 turns 1.3 mm Ag plated Cu on 8 mm dia., 2.5 mm pitch, tapped 3/4 turn from earthed end
L_7	165 nH,	5½ turns 1.3 mm Ag plated Cu on 11 mm dia., 2.0 mm pitch
L_8-L_{13}	choke Type 4312 020 36701	

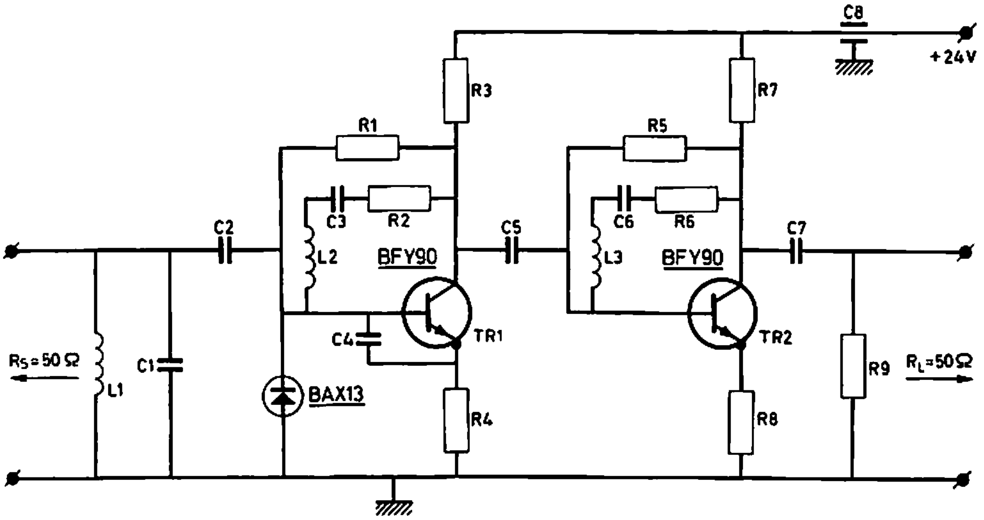
60-MW 202–209 MHZ ANTENNA AMPLIFIER—Provides gain of 48 dB for European channel 9, with 5.7-dB noise factor.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.


2.88 µH
1.53µH
1.72µH
100µF
545pF
390pF
75Ω
75Ω
428pF
563pF
463pF
260pF

LOW-PASS FOR NOISE ABOVE 5.5 MHZ—Used after preamp of television camera to suppress noise above desired bandwidth, which peaks at about 8 MHz and extends beyond 12 MHZ.—B. Overgoor, A Camera Tube Amplifier with FET Input, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 4, 1968, p 155–159.

EMITTER-CIRCUIT CONTRAST CONTROL—Control R3 is here located in emitter load of video output stage of two-stage video amplifier. One advantage is that long leads may be used between contrast pot and video amplifier without affecting performance. R2 and negative supply voltage together hold black level constant during contrast control. —A. Conse, The N-P-N Silicon Planar Transistor BF178 in a Video Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 251, 1966.


+VS2(145V)
120µH
39kΩ
pict. tube
OA90
BF 184
TR1
BF 178
TR2
4.7pF
27kΩ
2.2kΩ
120Ω
R1
10µF
10nF
2.2kΩ
680Ω
1kΩ
R3
R2
1.2kΩ
-VS3(12V)
+VS1(12V)


C8
+24V
R3
R7
R1
R5
C3
R2
C6
R6
C2
C5
C7
L2
BFY90
L3
BFY90
TR1
TR2
C4
RS=50Ω
C1
L1
BAX13
R4
R8
R9
RL=50Ω

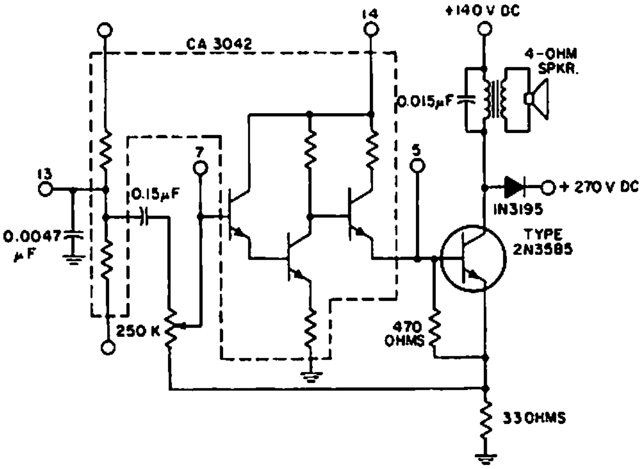
R_1	33 kΩ, ⅛ W
R_2, R_6	240 Ω , ⅛ W
R_3	3.3 kΩ, ⅛ W
R_4, R_8	13 Ω , ⅛ W
R_5	22 kΩ, ⅛ W
R_7	1.8 kΩ, ¼ W
R_9	91 Ω , ⅛ W

All resistors, ±5%

C_1	1.5 pF ceramic, ±0.5%
C_2, C_5	82 pF ceramic, ±5%
C_3, C_6, C_7	680 pF disk, −20/+50%
C_4	2.7 pF ceramic, ±0.5%
C_8	2.2 nF feedthrough, −20/+50%

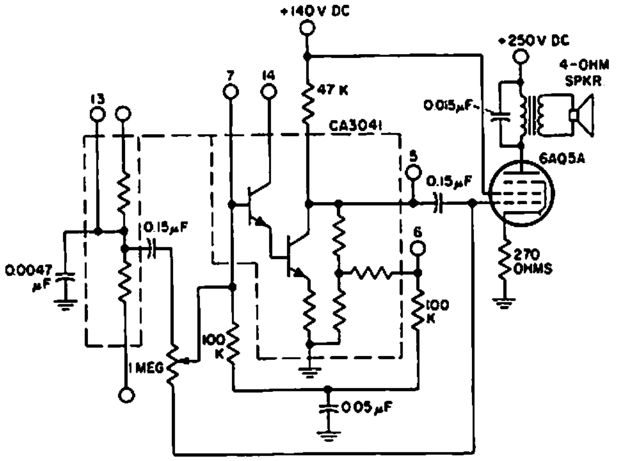
L_1	choke Type 3122 108 20150
L_2	50 nH, 5 turns 0.5 mm enamelled Cu on 3 mm dia,, 0.5 mm pitch
L_3	30 nH, 3 turns 0.5 mm enamelled Cu on 3 mm dia., 0.5 mm pitch

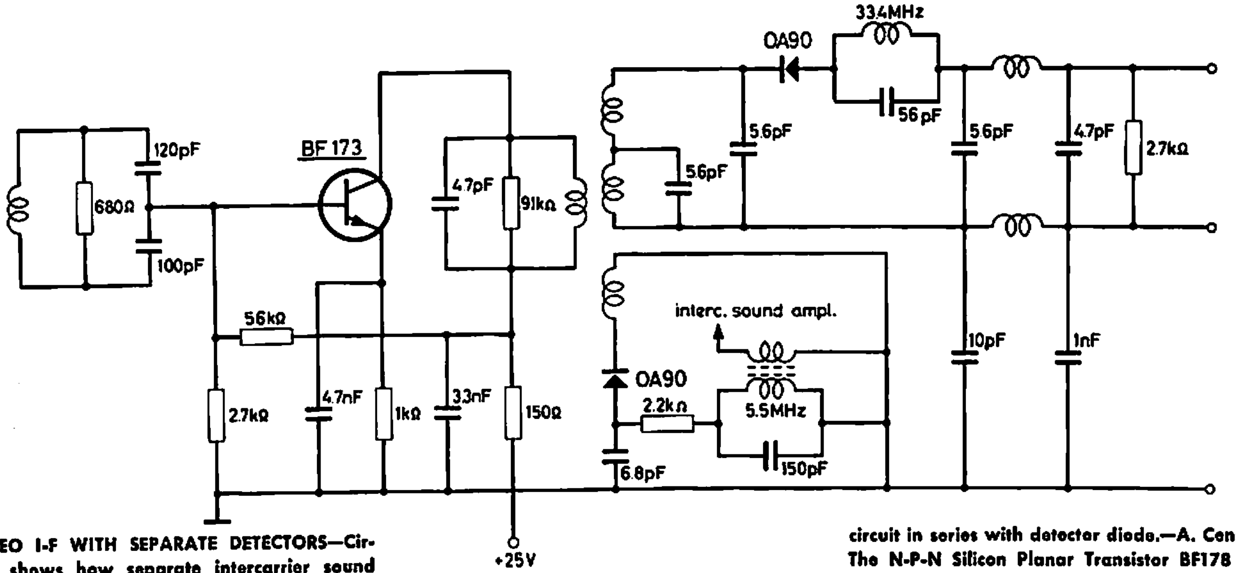
40–860 MHZ ANTENNA AMPLIFIER—Provides gain of 13.5 dB for 30-mW output per signal over entire European television band, with noise factor of 6.3 to 10 dB. Uses transistors having very high transition frequency and very low feedback capacitance, for common-emitter configuration.—J. Tuil, Transistor Equipped Aerial Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 2, 1968, p 60–78.


13
0.0047 μF
CA 3042
14
+140 V DC
4-OHM SPKR.
0.015μF
7
0.15μF
5
+ 270 V DC
IN3195
TYPE 2N3585
250 K
470 OHMS
33OHMS

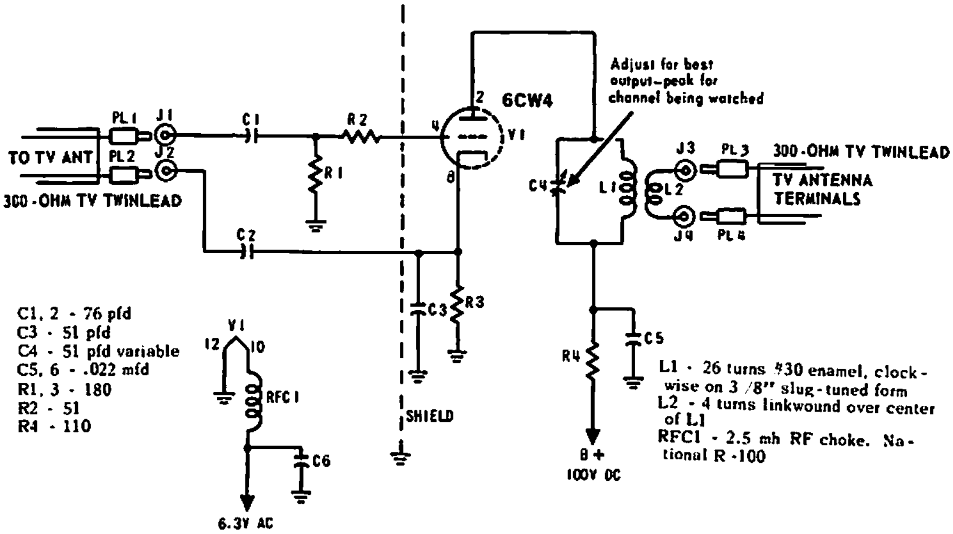
LOW-COST FEEDBACK VOLUME CONTROL—Uses minimum number of components with CA3042 IC. Although steady-state current flows through volume control, it is limited to about 1.5 μA under worst-case conditions.—L. Kaplan, Feedback-Type Volume-Control Circuits for RCA-CA3041 and CA3042 Integrated Circuits, RCA, Harrison, N.J., No. ICAN-5841, 1968.

FEEDBACK VOLUME CONTROL—Used with CA3041 IC to increase power output and gain over that obtained with conventional losser type of control. At 4.5 MHz, circuit provides 1 W power output at 8.5 kHz deviation.—L. Kaplan, Feedback-Type Volume-Control Circuits for RCA-CA3041 and CA3042 Integrated Circuits, RCA, Harrison, N.J., No. ICAN-5841, 1968.

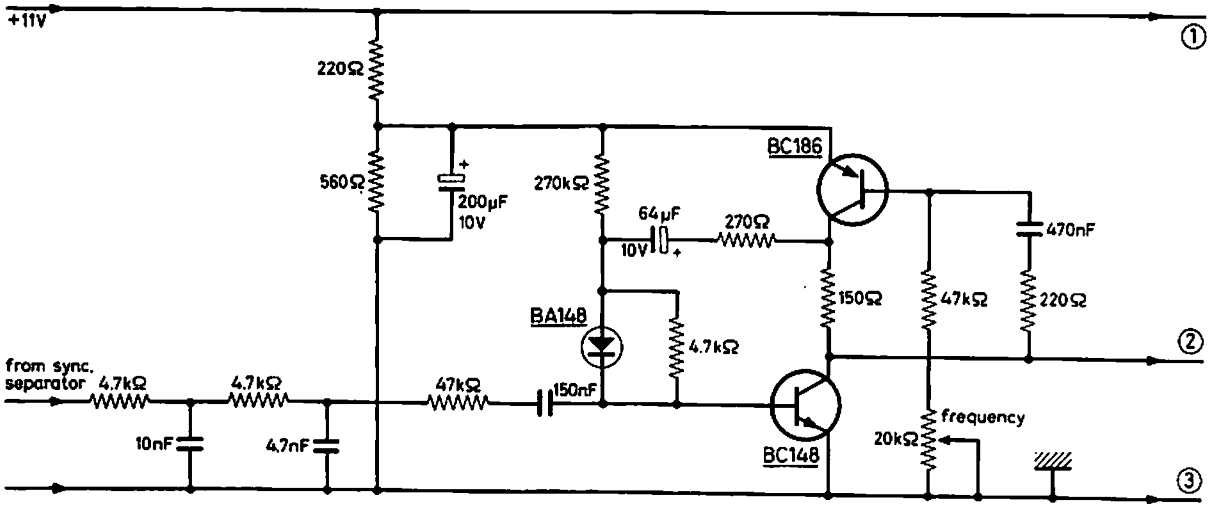

+140 V DC
+250V DC
4-OHM SPKR
13
7
14
47 K
CA3041
0.015μF
5
0.15μF
6AQ5A
0.0047 μF
0.15μF
6
270 OHMS
100 K
100 K
1 MEG
0.05μF


33.4MHz
OA90
56pF
5.6pF
5.6pF
47pF
2.7kΩ
120pF
BF 173
680Ω
100pF
47pF
91kΩ
56pF
56kΩ
interc. sound ampl.
OA90
2.7kΩ
4.7nF
1kΩ
33nF
150Ω
2.2kΩ
5.5MHz
6.8pF
150pF
10pF
1nF
+25V

VIDEO I-F WITH SEPARATE DETECTORS—Circuit shows how separate intercarrier sound detector can be used with video output stage of European 625-line tv receiver, for compatibility with color programs. Video and intercarrier signals have separate takeoffs, so sound carrier can be heavily suppressed in video detector by 33.4-MHz parallel tuned circuit in series with detector diode.—A. Cense, The N-P-N Silicon Planar Transistor BF178 in a Video Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 251, 1966.


TO TV ANT
300-OHM TV TWINLEAD
PL1
J1
PL2
J2
C1
C2
R2
R1
4
2
8
6CW4
V1
Adjust for best output—peak for channel being watched
C4
L1
L2
J3
PL3
J4
PL4
300-OHM TV TWINLEAD
TV ANTENNA TERMINALS
C3
R3
SHIELD
R4
C5
B+
100V DC
V1
12
10
RFC1
C6
6.3V AC
C1, 2 - 76 pfd
C3 - 51 pfd
C4 - 51 pfd variable
C5, 6 - .022 mfd
R1, 3 - 180
R2 - 51
R4 - 110
L1 - 26 turns #30 enamel, clockwise on 3/8" slug-tuned form
L2 - 4 turns linkwound over center of L1
RFC1 - 2.5 mh RF choke. National R-100

TV SIGNAL BOOSTER—Can be inserted in 300-ohm twinlead at back of set, to boost signal strength of weaker signals in reception area. Parts at left of broken shield line must be shielded from rest of circuit to eliminate undesirable interference and hash.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 168.

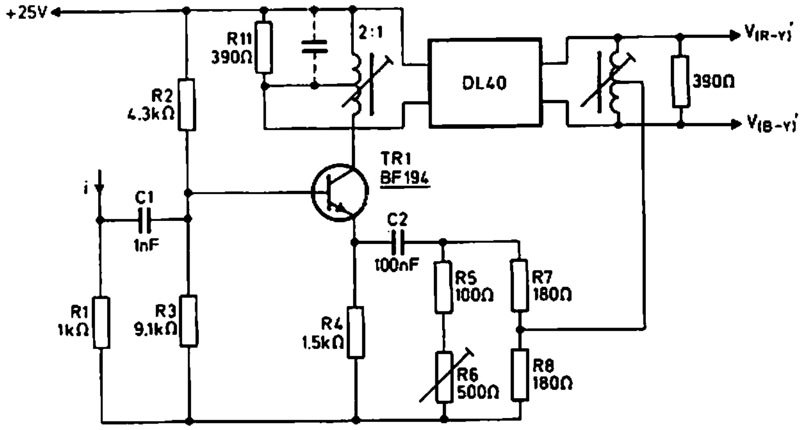

+11V
①
220Ω
560Ω
200μF
10V
270kΩ
64μF
10V
270Ω
BC186
470nF
150Ω
47kΩ
220Ω
BA148
4.7kΩ
②
from sync. separator
4.7kΩ
4.7kΩ
47kΩ
150nF
10nF
4.7nF
BC148
frequency
20kΩ
③

TINY-VISION FIELD OSCILLATOR—Makes use of Miller integrator principle to generate sawtooth voltage having sufficient amplitude to meet requirements of small-screen battery-operated tv receiver. Terminals 1, 2, and 3 go to field output stage. Report describes operation of oscillator in detail.—A. H. Nillesen, Field Deflection Circuit for Tiny-Vision Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 256, 1967.

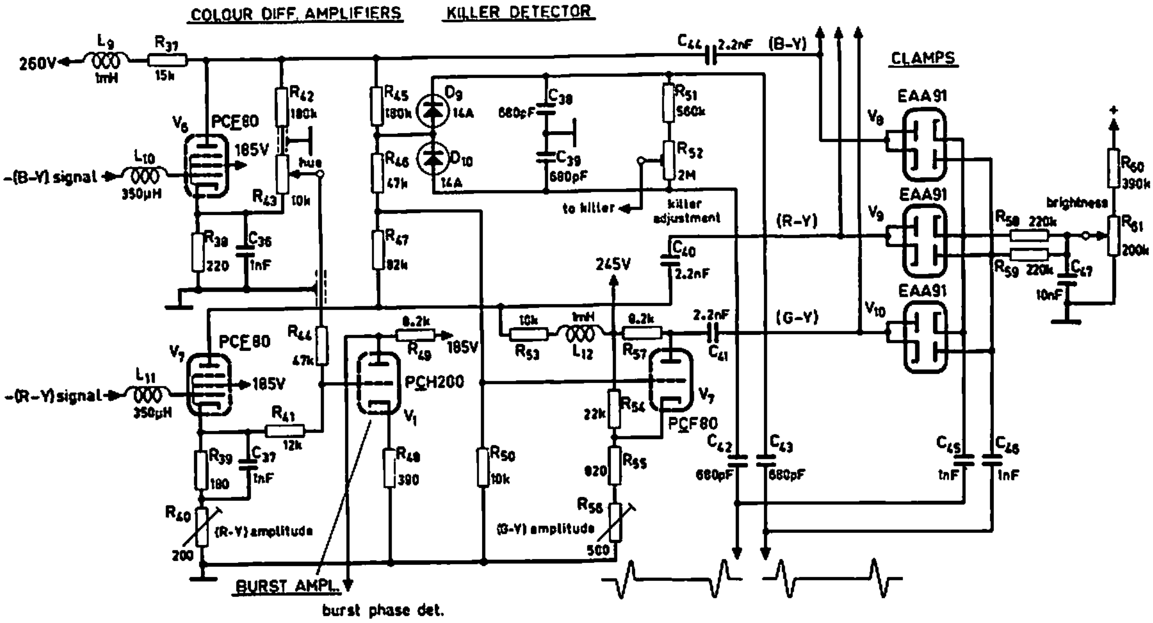
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 86

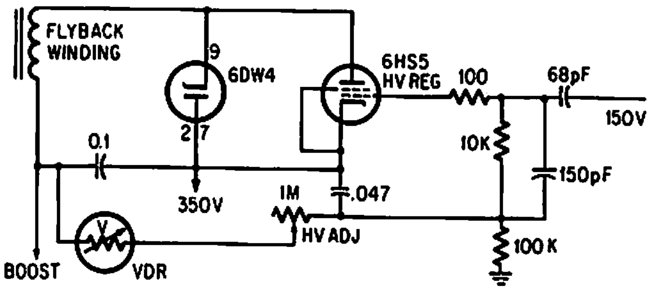
Television Circuits—Color


+25V
R11
390Ω
2:1
DL40
V(R-Y)'
390Ω
V(B-Y)'
R2
4.3kΩ
TR1
BF194
i
C1
1nF
C2
100nF
R5
100Ω
R7
180Ω
R1
1kΩ
R3
9.1kΩ
R4
1.5kΩ
R6
500Ω
R8
180Ω

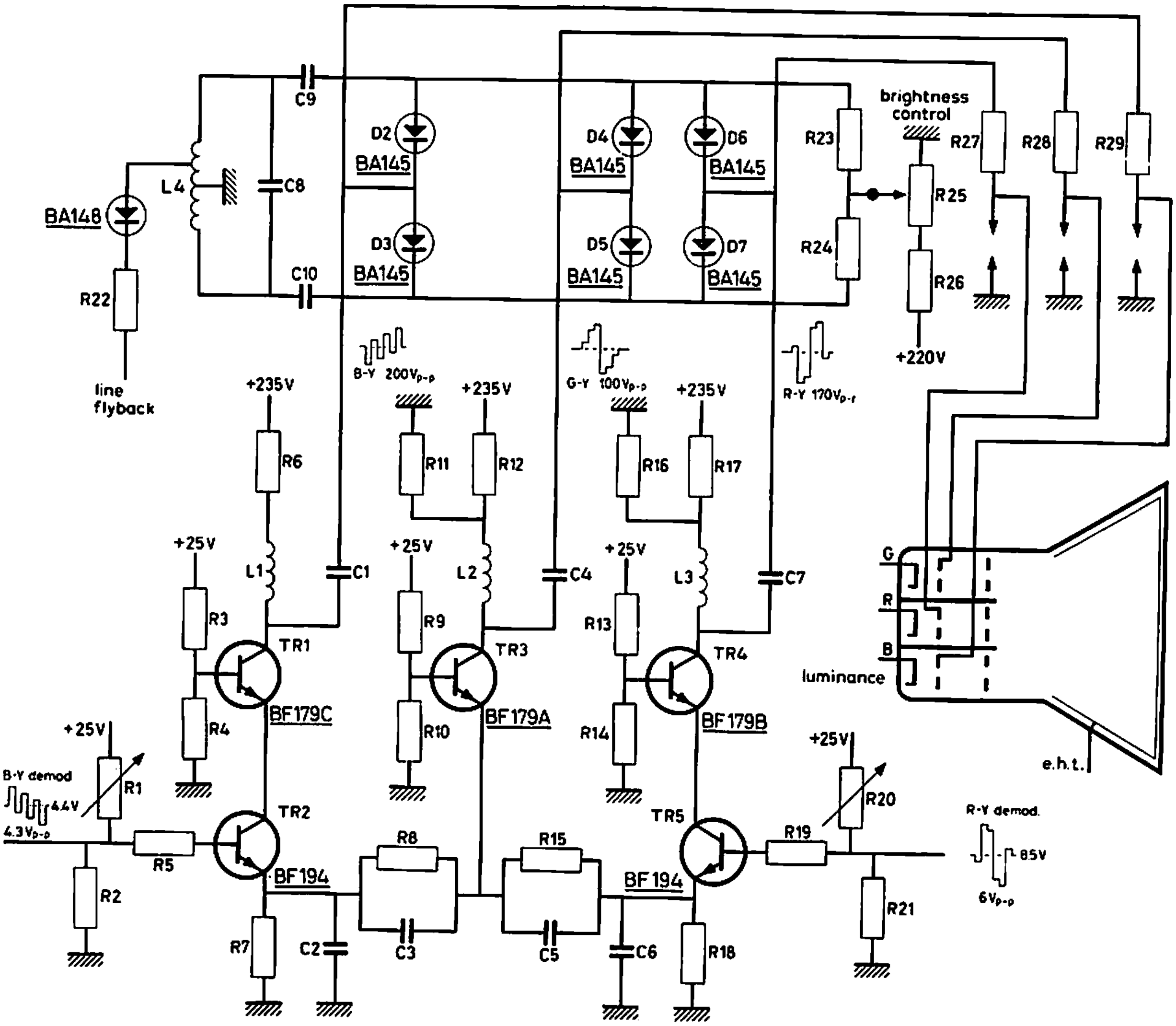
MATRIX FOR CHROMINANCE SIGNAL—Chrominance signal is fed to base of delay line driver transistor TR1. Uses Philips DL40 delay line having nominal frequency of 4.433619 MHz and phase delay of 63.943 μs. Output of delay line is balanced with 2:1 stepdown transformer to simplify addition of delayed and undelayed signals.—C. A. M. Sidler, Pal Matrix Circuits Using Delay Line DL40, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Application Note 88, 1970.


COLOUR DIFF. AMPLIFIERS
KILLER DETECTOR
260V
L9
1mH
R37
15k
R42
180k
R45
180k
D9
14A
680pF
C38
C44
2.2nF
(B-Y)
R51
560k
CLAMPS
EAA91
V8
V6
PCE80
185V
hue
-(B-Y) signal
L10
350μH
R43
10k
R46
47k
D10
14A
C39
680pF
R52
2M
to killer
killer adjustment
(R-Y)
V9
EAA91
brightness
R60
390k
R58
220k
R61
200k
R59
220k
C47
10nF
R38
220
C36
1nF
R47
82k
245V
C40
2.2nF
EAA91
V10
V7
PCE80
R44
47k
8.2k
R49
185V
10k
R53
1mH
L12
8.2k
R57
2.2nF
C41
(G-Y)
-(R-Y) signal
L11
350μH
185V
PCH200
V1
R41
12k
22k
R54
V7
PCF80
C42
680pF
C43
680pF
C45
1nF
C46
1nF
R39
180
C37
1nF
R48
390
R50
10k
820
R55
R40
(R-Y) amplitude
200
R56
(G-Y) amplitude
500
BURST AMPL.
burst phase det.

COLOR DIFFERENCE AMPLIFIER—Color difference signals are applied to control grids of pentodes for amplification and adjustment of gain in accordance with NTSC specifications. Double-diode circuit is used for killer detection, in G—Y matrix circuit branch going to anode of B—Y amplifier. This diode circuit detects negative-going burst in B—Y signal. Double-diode clamp at output of each color difference amplifier gives same clamping level for all three signals, with brightness control changing all levels simultaneously.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.


FLYBACK WINDING
9
6DW4
2
7
0.1
350V
6HS5 HV REG
100
68pF
150V
10K
150pF
.047
IM
HV ADJ
100K
BOOST
VDR

X-RAY HOLD-DOWN—Used in Zenith 1970 television receivers to provide automatic protection against excessive x-ray emission from high-voltage power supply. Circuit limits horizontal, drive voltage to about 27 kV regardless of line voltage and load. Also provides protection if voltage regulator fails or is removed from socket.—Consumer Hazards: How They Can Be Fixed, *Electronics*, Aug. 3, 1970, p 62–67.

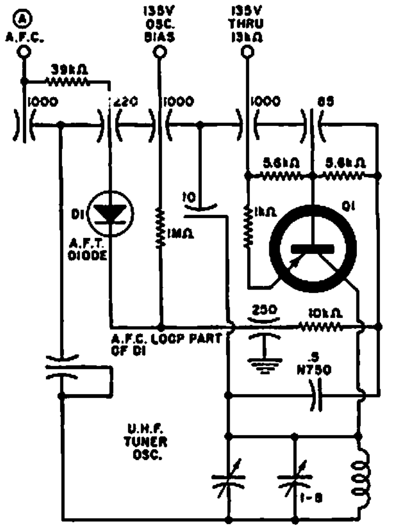

C9
D2
BA145
D3
BA145
D4
BA145
D5
BA145
D6
BA145
D7
BA145
BA148
L4
C8
C10
R22
line flyback
R23
R24
brightness control
R25
R26
+220V
R27
R28
R29
B-Y 200Vp-p
G-Y 100Vp-p
R-Y 170Vp-p
+235V
R6
R11
R12
R16
R17
+25V
L1
C1
L2
C4
L3
C7
R3
R9
R13
TR1
TR3
TR4
BF179C
BF179A
BF179B
R4
R10
R14
G
R
B
luminance
e.h.t.
+25V
B-Y demod
4.4V
4.3Vp-p
R1
R5
R2
TR2
BF194
R8
C3
R15
C5
TR5
BF194
R7
C2
C6
R18
R19
+25V
R20
R21
R-Y demod.
85V
6Vp-p

R_1	4.7 kΩ, pot.
R_2	1 kΩ, ⅛ W
R_3	2.7 kΩ, ⅛ W
R_4	2.2 kΩ, ⅛ W
R_5	100 Ω, ⅛ W
R_6	10 kΩ, 5.5 W
R_7	220 Ω, ⅛ W
R_8	910 Ω, ⅛ W
R_9	1.6 kΩ, ¼ W
R_{10}	1 kΩ, ⅛ W
R_{11}	27 kΩ, 1 W
R_{12}	16 kΩ, 5.5 W
R_{13}	1.8 kΩ, ⅛ W
R_{14}	3.3 kΩ, ⅛ W
R_{15}	620 Ω, ⅛ W
R_{16}	100 kΩ, 1 W
R_{17}	11 kΩ, 5.5 W
R_{18}	680 Ω, ⅛ W
R_{19}	100 Ω, ⅛ W
R_{20}	4.7 kΩ, pot.
R_{21}	2.2 kΩ, ⅛ W
R_{22}	100 Ω, 1 W
R_{23}	1 MΩ, ¼ W
R_{24}	1 MΩ, ¼ W
R_{25}	200 kΩ, pot.
R_{26}	390 kΩ, ¼ W
R_{27}	2.7 kΩ, 1 W
R_{28}	2.7 kΩ, 1 W
R_{29}	2.7 kΩ, 1 W
C_1	2.2 nF, −20, +50%
C_2	390 pF, ± 5%
C_3	82 pF, ± 5%
C_4	2.2 nF, −20, +50%
C_5	120 pF, ± 5%
C_6	56 pF, ± 5%
C_7	2.2 nF, −20, +50%
C_8	47 pF, ± 5%
C_9	10 nF, −20, +50%
C_{10}	10 nF, −20, +50%

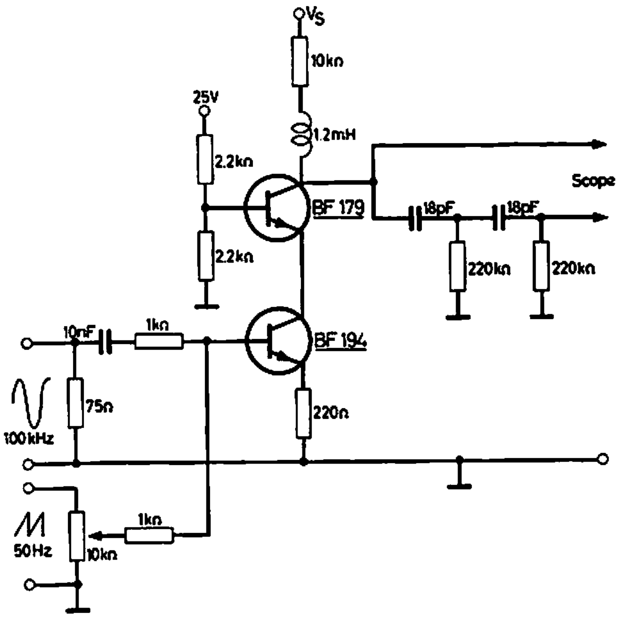
L_1, L_2, L_3: 1.2 mH r.f. chokes

L_4: 35 mH bifilar winding, tapped at 1 : 2 and 1 : 4 turns ratio, with ferrite tuning core.

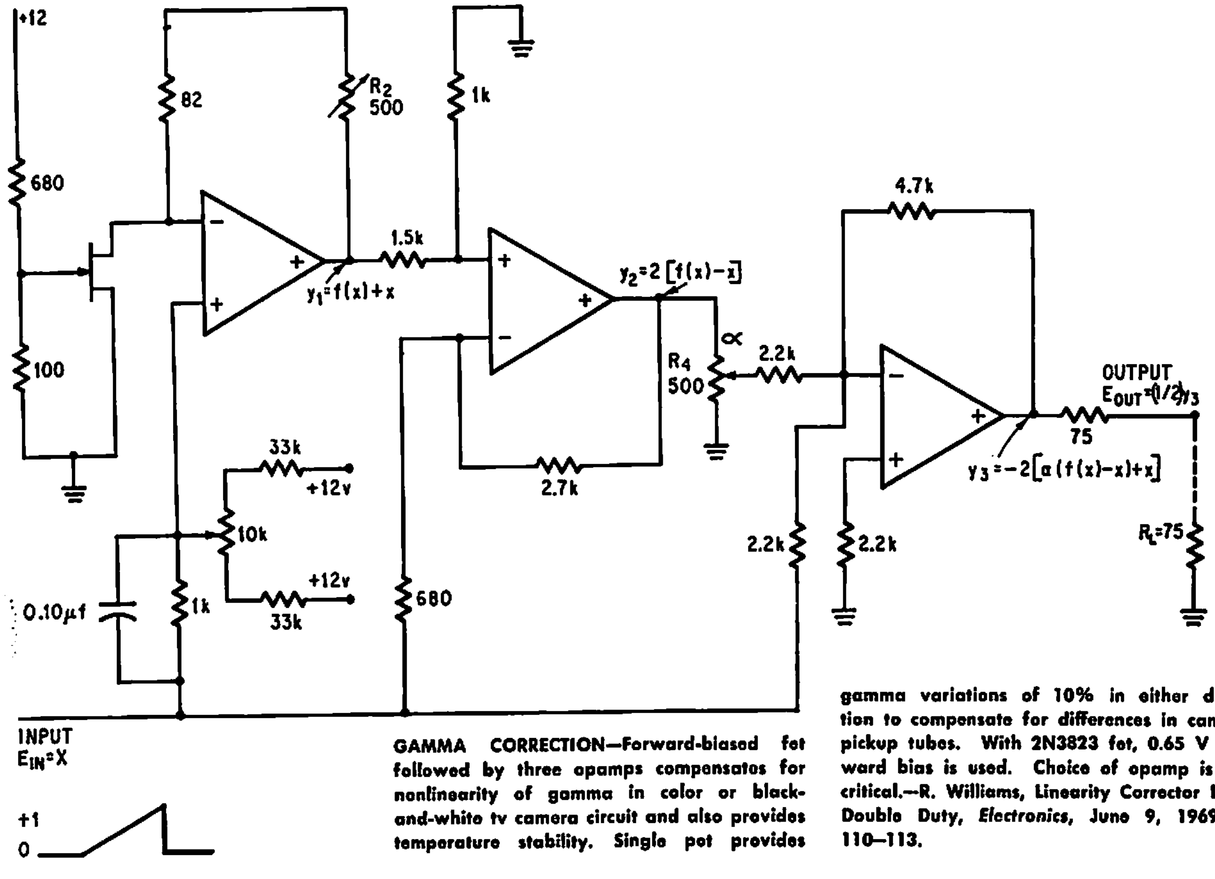
COLOR DIFFERENCE AMPLIFIER—Supplies drive voltages required by each of three electron guns in typical 25-inch shadow-mask color picture tube. Cascode arrangements of two stages minimize crosstalk and ensure maximum bandwidth. Article covers circuit design in detail. Spark gaps protect against flashovers in picture tube.—A. Censo, Recent Developments in Circuits and Transistors for Television Receivers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 4, 1966–1967, p 147–154.


A
A.F.C.
135V OSC. BIAS
135V THRU 13kΩ
39kΩ
1000
220
1000
1000
85
5.6kΩ
5.6kΩ
10
1kΩ
Q1
D1
A.F.T. DIODE
1MΩ
230
10kΩ
A.F.C. LOOP PART OF D1
.5 N750
U.H.F. TUNER OSC.
1-8

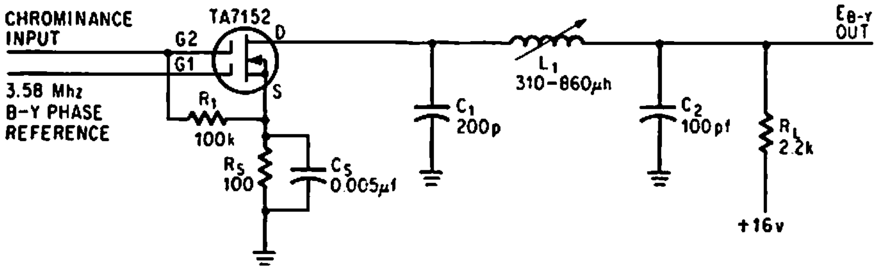
MAGNAVOX AFT TUNER—Shows how control voltage derived from video i-f is applied to diode that controls transistor oscillator of uhf tuner to achieve automatic fine tuning. Complete circuit is given in Magnavox 1968 top-of-line color tv service manuals.—F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.


V_S
10kΩ
1.2mH
25V
2.2kΩ
2.2kΩ
BF 179
18pF
18pF
Scope
220kΩ
220kΩ
10nF
1kΩ
BF 194
75Ω
100kHz
220Ω
1kΩ
50Hz
10kΩ

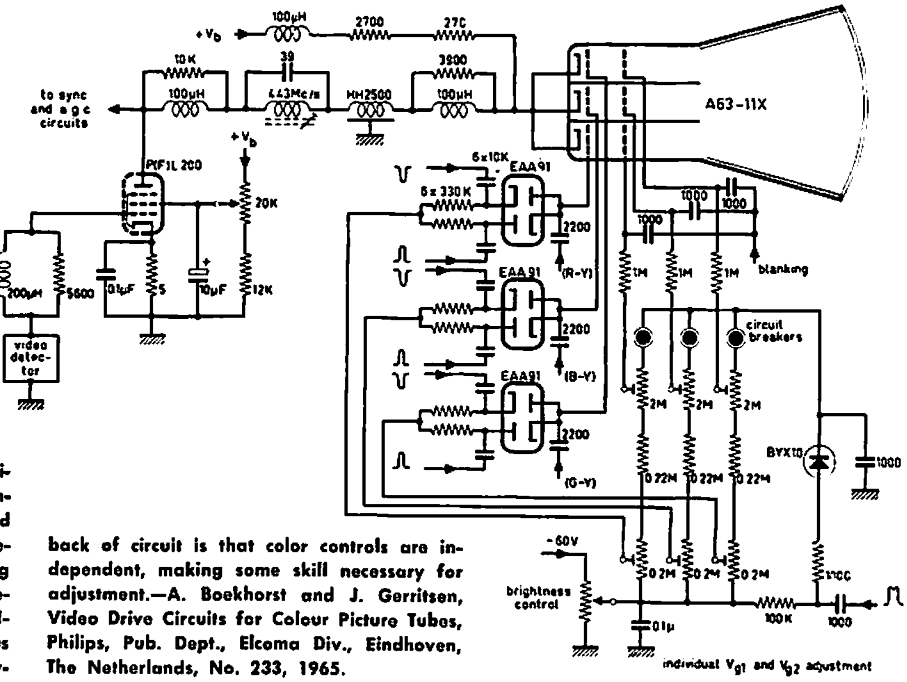
COLOR DIFFERENCE LINEARITY—Circuit for checking linearity of cascaded-transistor color difference amplifier applies two signals to input of amplifier—50-Hz sawtooth with amplitude that drives output stage from cut-off to knee, and 100-kHz sine wave with amplitude of 10 mV p-p. Differentiating network at output of amplifier suppresses sawtooth and applies 100-kHz signal to dual-trace scope, with other trace showing voltage swing at collector of output stage.—A. Cense, Colour Difference Amplifiers Using the N-P-N Silicon Planar Package 40822, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1966.


+12
82
R_2 500
1k
680
1.5k
4.7k
$y_1=f(x)+x$
$y_2=2[f(x)-x]$
∝
R_4 500
2.2k
OUTPUT
$E_{OUT}=(1/2)y_3$
75
$y_3=-2[\alpha(f(x)-x)+x]$
100
33k
+12v
10k
+12v
33k
0.10μf
1k
680
2.7k
2.2k
2.2k
$R_L=75$
INPUT
$E_{IN}=X$
+1
0

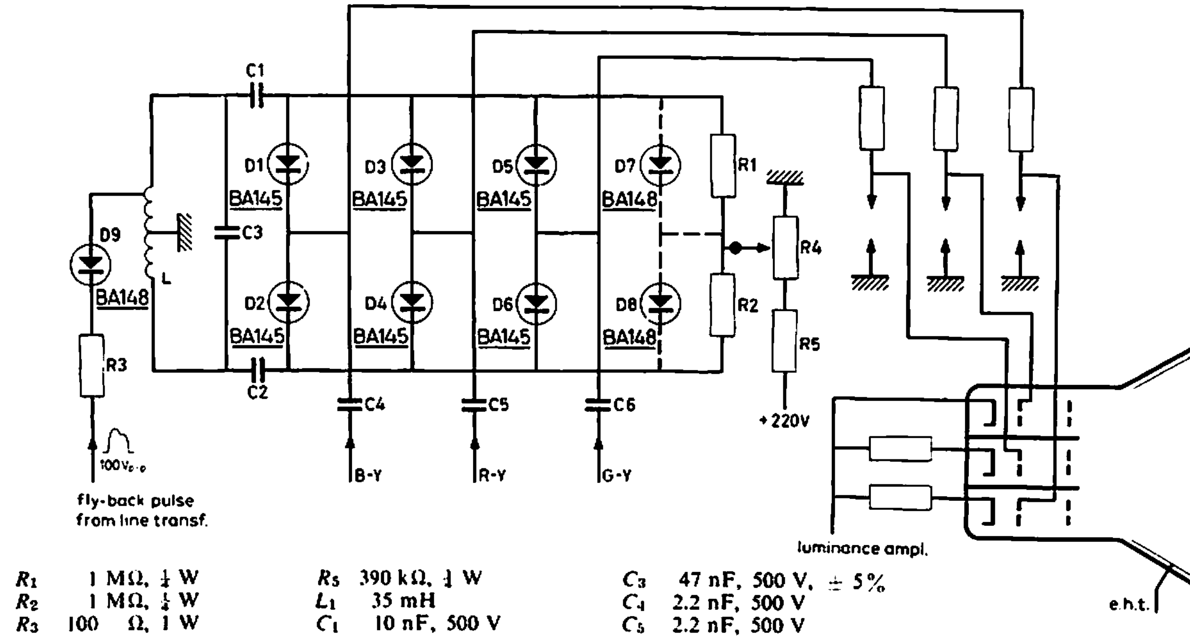
GAMMA CORRECTION—Forward-biased fet followed by three opamps compensates for nonlinearity of gamma in color or black-and-white tv camera circuit and also provides temperature stability. Single pot provides gamma variations of 10% in either direction to compensate for differences in camera pickup tubes. With 2N3823 fet, 0.65 V forward bias is used. Choice of opamp is not critical.—R. Williams, Linearity Corrector Does Double Duty, *Electronics*, June 9, 1969, p 110–113.


CHROMINANCE INPUT
TA7152
G2
G1
D
S
3.58 Mhz B-Y PHASE REFERENCE
R1 100k
RS 100
CS 0.005µf
L1 310-860µh
C1 200p
C2 100pf
RL 2.2k
+16v
EB-Y OUT

COLOR DEMODULATOR—With chrominance information applied to gate 2 of dual-gate transistor and 3.58-MHz reference signal on gate 1, demodulation is accomplished by synchronous detection.—Outlook Bright for Dual-Gate Transistors, *Electronics*, July 10, 1967, p 141–142.

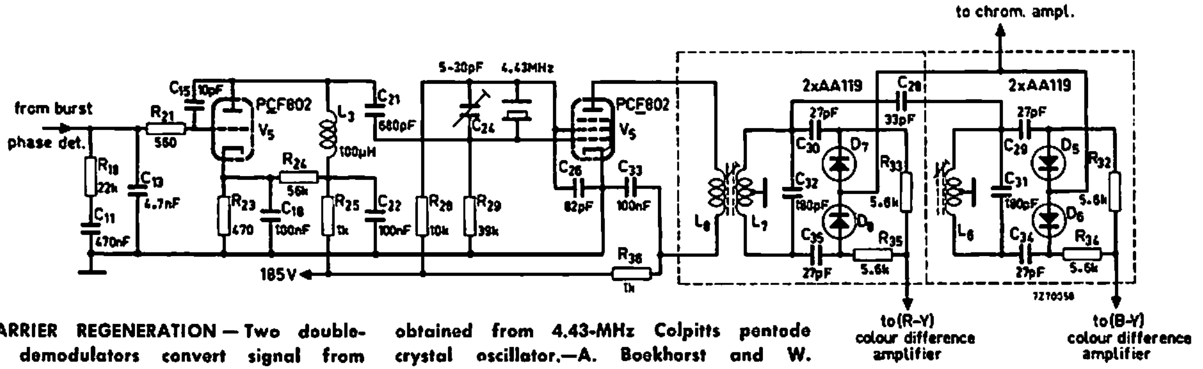

+Vb
100µH
2700
27C
10K
39
3900
to sync and a g c circuits
100µH
4.43Mc/s
HH2500
100µH
A63-11X
+Vb
PL(F)L 200
20K
200µH
5600
0.1µF
5
10µF
12K
video detector
6x10K
EAA91
6x330K
2200
(R-Y)
EAA91
2200
(B-Y)
EAA91
2200
(G-Y)
1000
1000
1000
blanking
1M
1M
1M
circuit breakers
2M
2M
2M
0.22M
0.22M
0.22M
BYX10
1000
-60V
brightness control
0.2M
0.2M
0.2M
0.1µ
100K
1000
individual Vg1 and Vg2 adjustment

EQUAL CATHODE DRIVES FOR GUNS—Luminance amplifier is pentode with contrast control in screen grid circuit. Agc is supplied to anode, to permit grounding of video detector. Symmetrical clamp circuit using double-diode is connected to each picture-tube control grid. Clamping levels are adjusted individually to obtain simultaneous spot cutoff for all three guns. One drawback of circuit is that color controls are independent, making some skill necessary for adjustment.—A. Boekhorst and J. Gerritsen, Video Drive Circuits for Colour Picture Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 233, 1965.


C1
D1 BA145
D3 BA145
D5 BA145
D7 BA148
R1
D9 BA148
C3
L
R4
D2 BA145
D4 BA145
D6 BA145
D8 BA148
R2
R5
R3
C2
C4
C5
C6
+220V
100Vp-p
B-Y
R-Y
G-Y
fly-back pulse from line transf.
luminance ampl.
e.h.t.

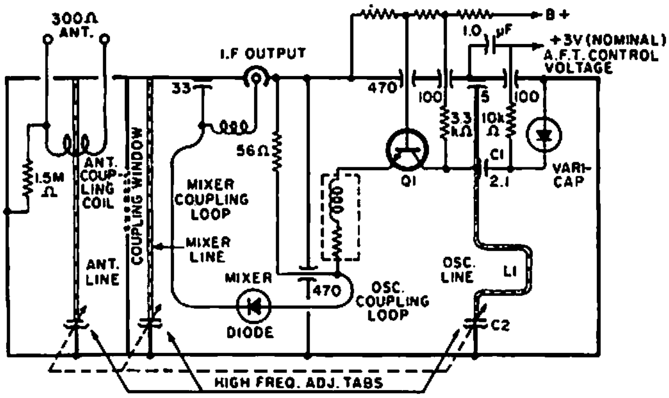
R_1	1 MΩ, ¼ W	R_5	390 kΩ, ¼ W	C_3	47 nF, 500 V, ± 5%
R_2	1 MΩ, ¼ W	L_1	35 mH	C_4	2.2 nF, 500 V
R_3	100 Ω, 1 W	C_1	10 nF, 500 V	C_5	2.2 nF, 500 V
R_4	220 kΩ, potentiometer	C_2	10 nF, 500 V	C_6	2.2 nF, 500 V

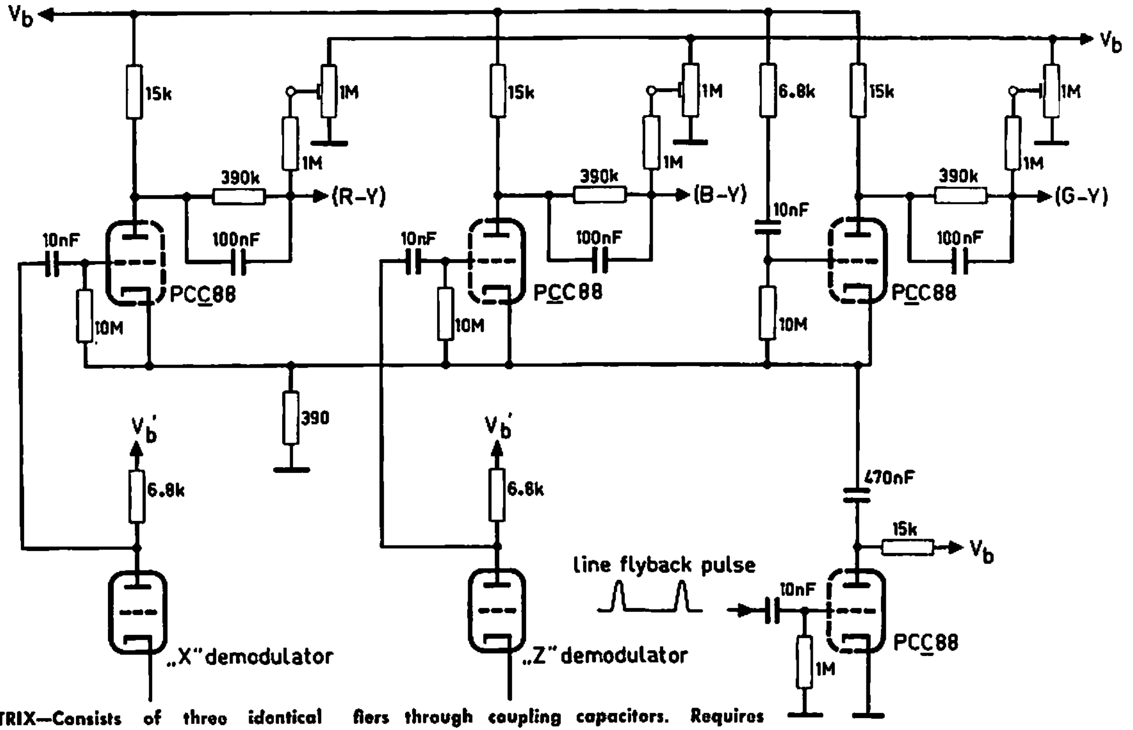
SYNCHRONOUS CLAMP—Used for restoring equal direct voltage levels to three color difference signals. Brightness control R4 establishes reference voltage to which clamping diodes are returned.—A. Cense, Recent Developments in Circuits and Transistors for Television Receivers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 28, No. 1, 1968, p 22–28.


to chrom. ampl.
from burst
phase det.
R21
560
C15
10pF
PCF802
V5
L3
100μH
C21
680pF
5-30pF
4.43MHz
C24
PCF802
V5
R18
22k
C13
4.7nF
C11
470nF
R23
470
C18
100nF
R26
56k
R25
1k
C22
100nF
R28
10k
R29
39k
C26
82pF
C33
100nF
R38
1k
185V
2xAA119
C28
33pF
27pF
C30
D7
R33
C32
180pF
5.6k
L8
L7
C35
27pF
D8
R35
5.6k
2xAA119
27pF
C29
D5
R32
C31
180pF
5.6k
L6
D6
C34
27pF
R34
5.6k
7Z70058
to(R-Y)
colour difference
amplifier
to(B-Y)
colour difference
amplifier

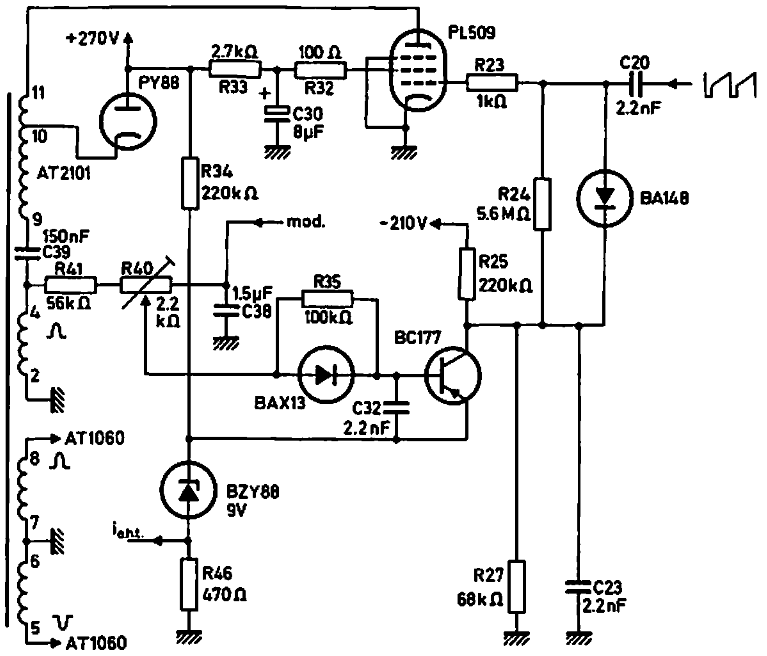
SUBCARRIER REGENERATION—Two double-diode demodulators convert signal from chrominance amplifier into R—Y and B—Y signals. Required subcarrier voltages are obtained from 4.43-MHz Colpitts pentode crystal oscillator.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.

UHF TUNER WITH AFT—Zenith version uses transistor as oscillator, with Varicap receiving correction voltage from control discriminator fed by third i-f, to provide automatic fine tuning for color programs.—F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.

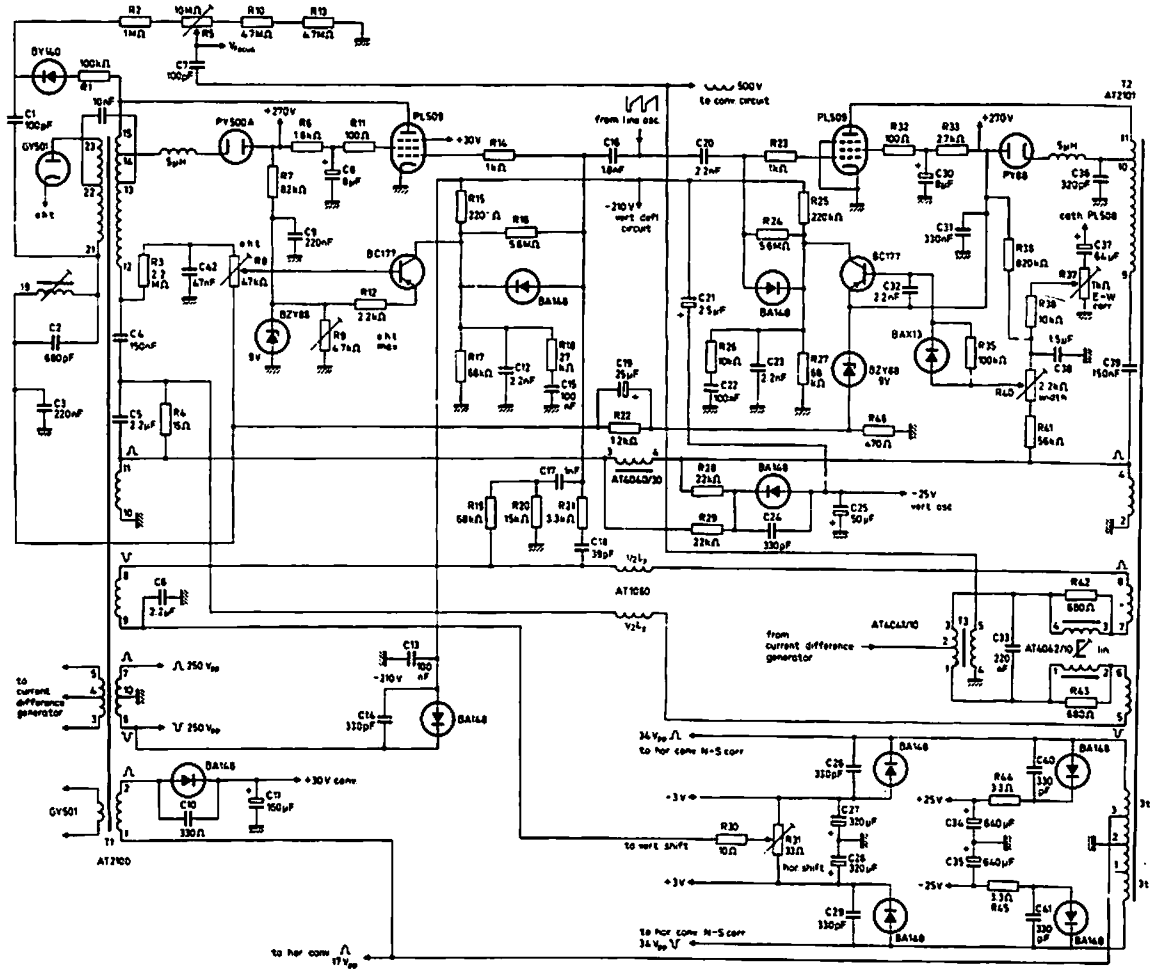

300Ω
ANT.
I.F OUTPUT
B+
1.0 μF
+3V (NOMINAL)
A.F.T. CONTROL
VOLTAGE
33
470
100
5
100
56Ω
3.3 kΩ
10k Ω
1.5M Ω
ANT. COUPLING COIL
COUPLING WINDOW
MIXER COUPLING LOOP
Q1
C1
2.1
VARI-CAP
MIXER LINE
ANT. LINE
MIXER
470
OSC. COUPLING LOOP
OSC. LINE
L1
DIODE
C2
HIGH FREQ. ADJ. TABS


Vb
Vb
15k
1M
1M
390k
(R-Y)
10nF
100nF
PCC88
10M
15k
1M
1M
390k
(B-Y)
10nF
100nF
PCC88
10M
6.8k
10nF
10M
15k
1M
1M
390k
(G-Y)
100nF
PCC88
390
Vb'
6.8k
„X"demodulator
Vb'
6.8k
„Z"demodulator
470nF
15k
Vb
line flyback pulse
10nF
PCC88
1M

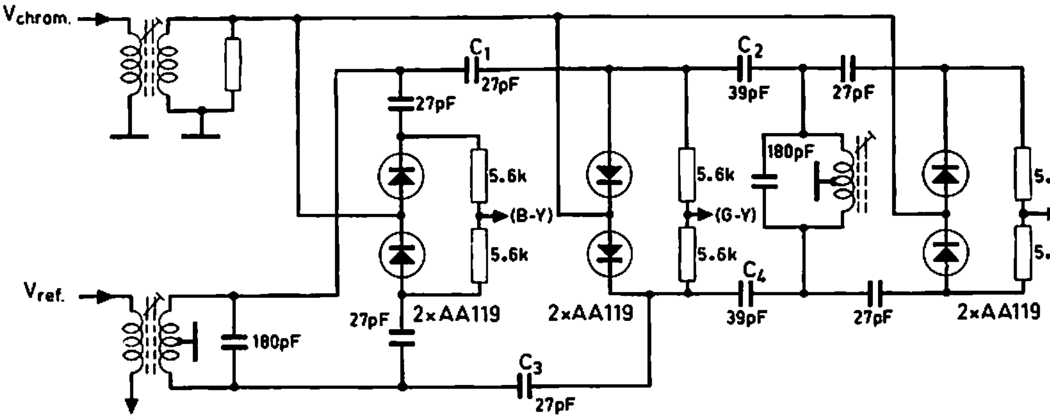
X-Z MATRIX—Consists of three identical color difference amplifiers operating with common cathode resistor, with X and Z signals applied to grids of two triode amplifiers through coupling capacitors. Requires d-c coupling to picture tube, because clamping is impracticable.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.


+270V
PY88
2.7kΩ
R33
100 Ω
R32
C30
8μF
PL509
R23
1kΩ
C20
2.2nF
11
10
AT2101
9
150nF
C39
R41
56kΩ
R40
2.2
kΩ
R34
220kΩ
mod.
1.5μF
C38
R35
100kΩ
BAX13
C32
2.2nF
BC177
-210V
R24
5.6MΩ
BA148
R25
220kΩ
4
2
AT1060
8
7
6
5
AT1060
BZY88
9V
i_eht
R46
470Ω
R27
68kΩ
C23
2.2nF

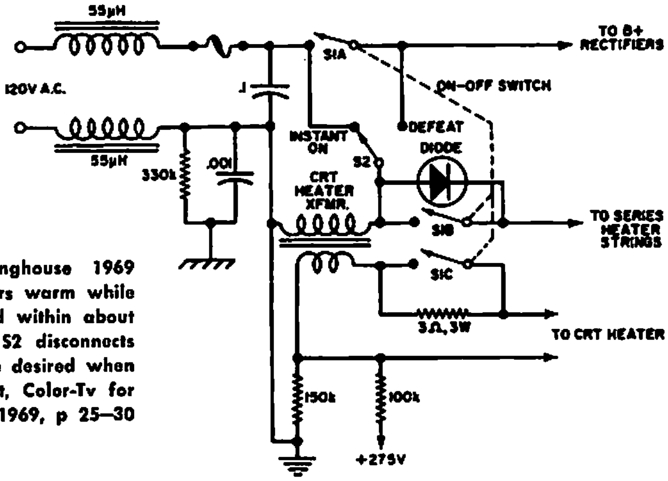
AUXILIARY HORIZONTAL OUTPUT—Pentode stage is stabilized against line voltage variations, to keep picture width from changing with line voltage. Transistor d-c amplifier, with zener holding emitter at 9 V, has sufficiently high gain to provide stabilization and completely compensate for aging of tube or transistor. Stage is modulated to provide East-West raster correction, with modulation such that deflection current is about 13% less at top and bottom of picture than at center.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.


BY140
GY501
PY500A
PL509
BC177
BZY88
BA148
BAX13
PY88
AT2101
AT1060
AT2100
+270V
500V to conv circuit
from line osc
-210V
-25V vert osc
to current difference generator
from current difference generator
+30V conv
to vert shift
hor shift
to hor conv N-S corr
+3V
+25V
-25V
-310V

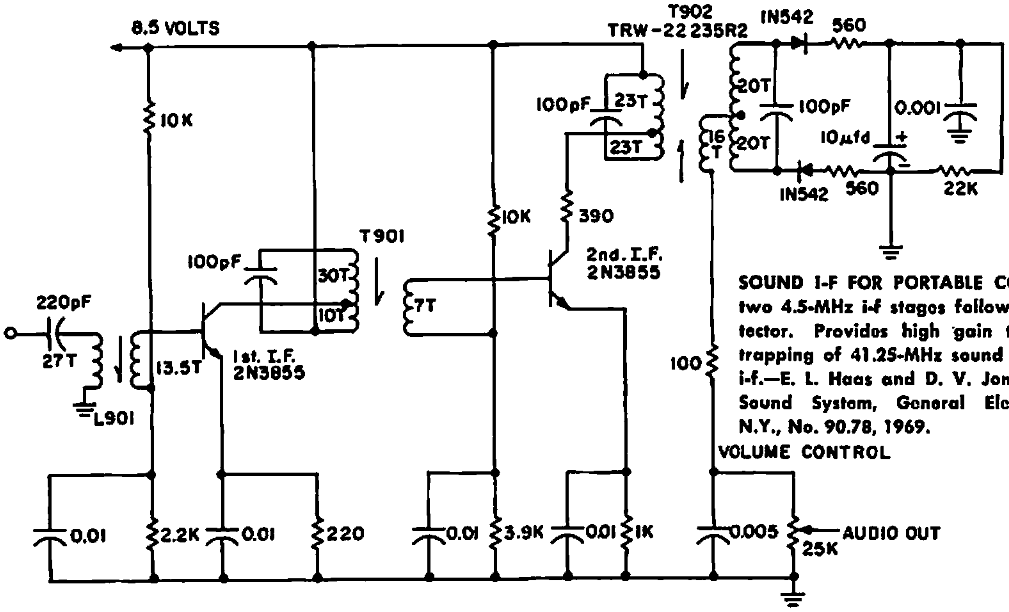
COMPLETE HORIZONTAL DEFLECTION—Includes main stage at left which supplies extra high voltage for 110-deg color picture tube, power for difference current drive, and half of deflection power. Stages at right supply power for shift circuits and other half of deflection power, with modulation to provide East-West master correction.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.


Vchrom.
Vref.
C1
27pF
27pF
5.6k
(B-Y)
5.6k
27pF
2xAA119
2xAA119
C2
39pF
27pF
180pF
5.6k
(G-Y)
5.6k
C4
39pF
27pF
5.6k
(R-Y)
5.6k
2xAA119
180pF
C3
27pF
+

THREE DEMODULATORS—Individual demodulators for R − Y, B − Y, and G − Y stages give greater design flexibility. Resulting color difference signals can be applied to three completely independent color difference amplifiers.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.

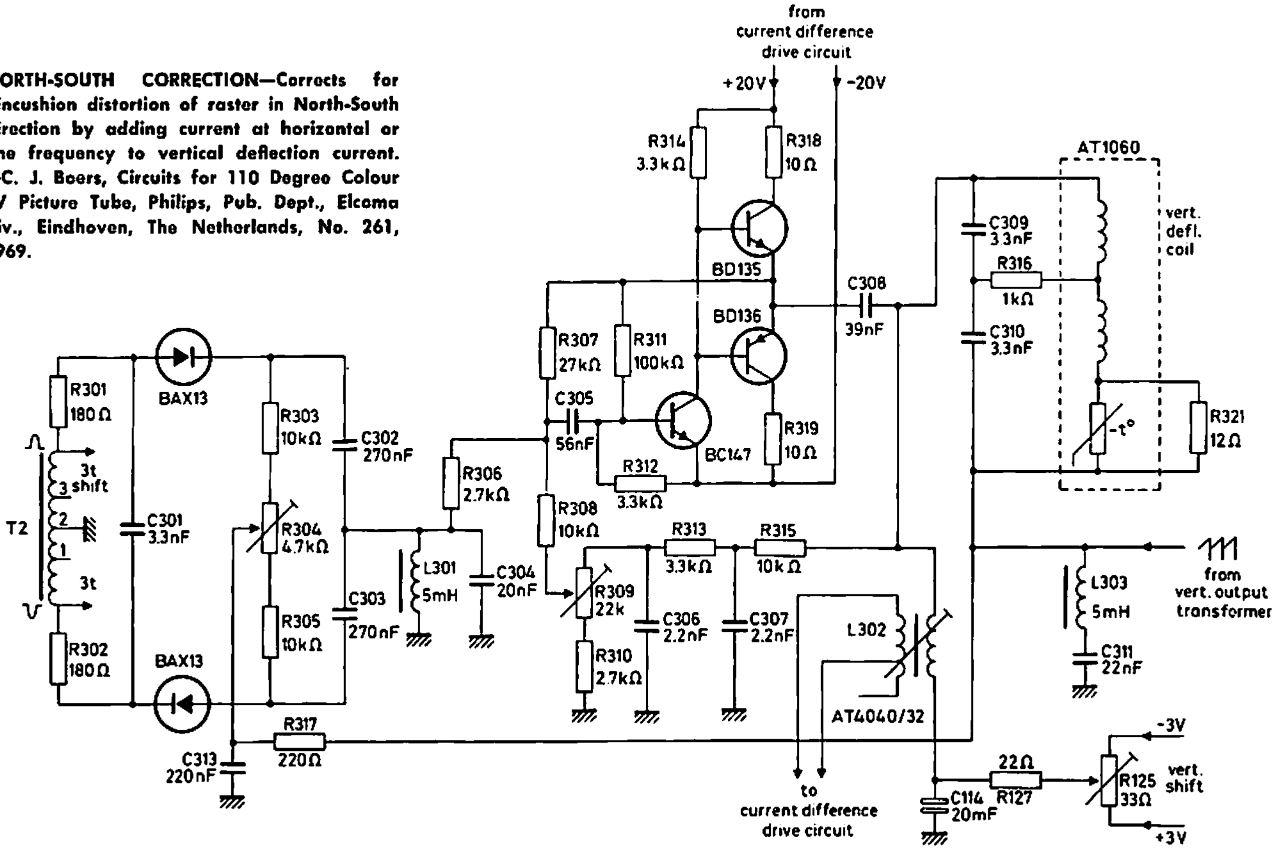

55μH
120V A.C.
55μH
330k
.001
.1
S1A
TO B+ RECTIFIERS
ON–OFF SWITCH
DEFEAT
INSTANT ON
S2
DIODE
CRT HEATER XFMR.
S1B
TO SERIES HEATER STRINGS
S1C
3Ω,3W
TO CRT HEATER
150k
100k
+275V

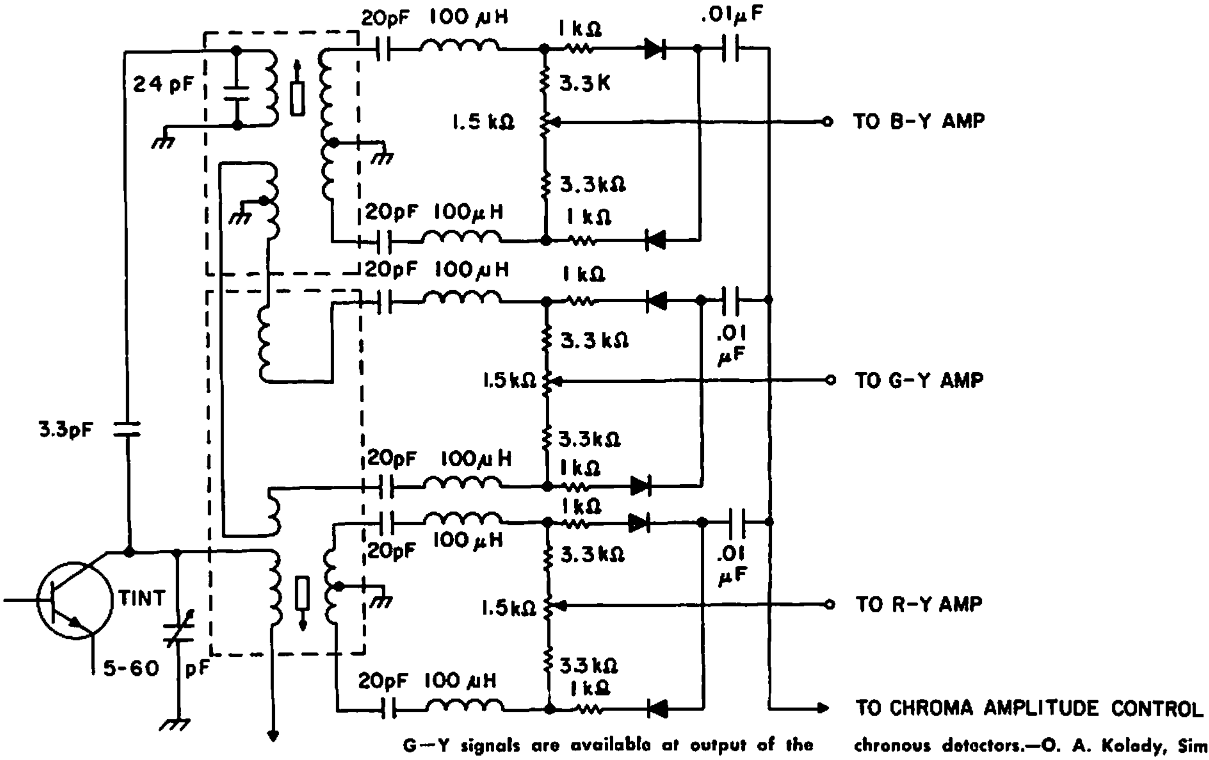
INSTANT-ON—Used in Westinghouse 1969 color sets to keep tube heaters warm while set is off. Picture is obtained within about 4 s after set is turned on. S2 disconnects warm-up feature, as might be desired when going on vacation.—F. H. Belt, Color-Tv for 1969, *Electronics World*, Jan. 1969, p 25–30 and 66–67.


8.5 VOLTS
10K
T902
TRW-22 235R2
IN542
560
100pF
23T
23T
20T
100pF
20T
16 T
0.001
10μfd
+
IN542
560
22K
10K
390
T901
100pF
30T
10T
7T
2nd. I.F.
2N3855
220pF
27T
L901
13.5T
1st. I.F.
2N3855
100
VOLUME CONTROL
0.01
2.2K
0.01
220
0.01
3.9K
0.01
1K
0.005
AUDIO OUT
25K

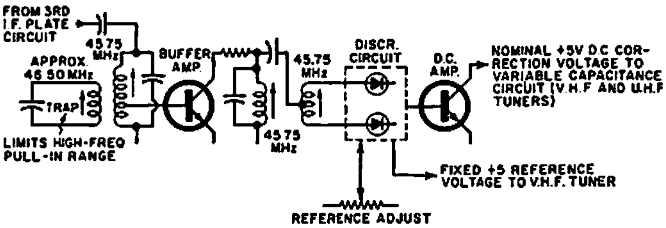
SOUND I-F FOR PORTABLE COLOR SET—Uses two 4.5-MHz i-f stages followed by ratio detector. Provides high gain to offset heavy trapping of 41.25-MHz sound carrier in video i-f.—E. L. Haas and D. V. Jones, Portable TV Sound System, General Electric, Syracuse, N.Y., No. 90.78, 1969.

NORTH-SOUTH CORRECTION—Corrects for pincushion distortion of raster in North-South direction by adding current at horizontal or line frequency to vertical deflection current. —C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.

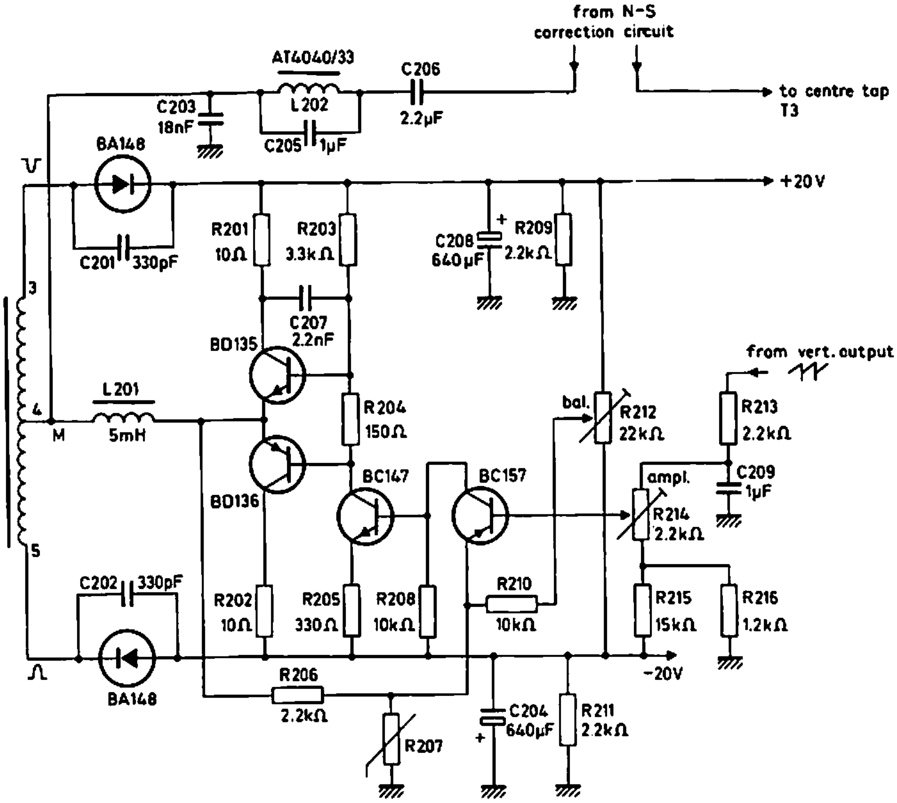

from
current difference
drive circuit
+20V
-20V
R314
3.3kΩ
R318
10Ω
BD135
BD136
C308
39nF
AT1060
C309
3.3nF
R316
1kΩ
C310
3.3nF
vert.
defl.
coil
-t°
R321
12Ω
R307
27kΩ
R311
100kΩ
C305
56nF
BC147
R312
3.3kΩ
R319
10Ω
R301
180Ω
BAX13
R303
10kΩ
C302
270nF
3t
3 shift
2
1
3t
T2
C301
3.3nF
R304
4.7kΩ
R306
2.7kΩ
R308
10kΩ
R313
3.3kΩ
R315
10kΩ
from
vert. output
transformer
L301
5mH
C304
20nF
C303
270nF
R309
22k
C306
2.2nF
C307
2.2nF
L302
L303
5mH
C311
22nF
R305
10kΩ
R310
2.7kΩ
R302
180Ω
BAX13
AT4040/32
R317
220Ω
C313
220nF
to
current difference
drive circuit
22Ω
C114
20mF
R127
-3V
R125
33Ω
vert.
shift
+3V


20pF
100 μH
1 kΩ
.01μF
24 pF
3.3K
1.5 kΩ
TO B-Y AMP
3.3kΩ
20pF
100μH
1 kΩ
20pF
100μH
1 kΩ
3.3 kΩ
.01
μF
1.5kΩ
TO G-Y AMP
3.3pF
3.3kΩ
20pF
100μH
1 kΩ
1 kΩ
20pF
100 μH
3.3 kΩ
.01
μF
TINT
1.5kΩ
TO R-Y AMP
5-60
pF
3.3kΩ
20pF
100 μH
1 kΩ
TO CHROMA AMPLITUDE CONTROL

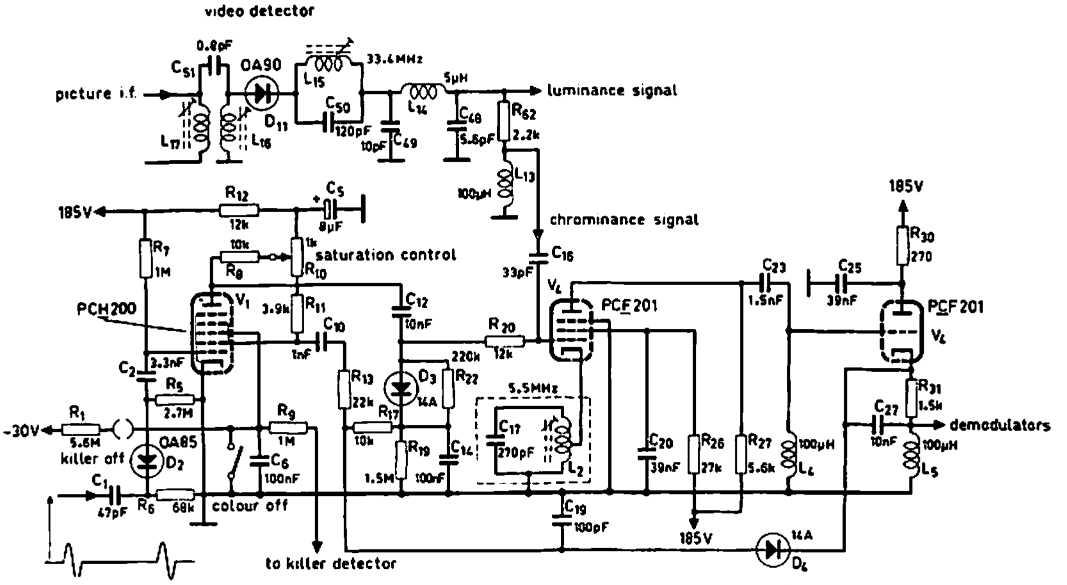
TRANSFORMER MATRIXING—Demodulation transformer (dashed boxes) performs matrixing function, such that R—Y, B—Y, and G—Y signals are available at output of the three synchronous detectors. Both secondary windings and the tertiary winding are center-tapped to maintain a-c balance in synchronous detectors.—O. A. Kolody, Simplified Transistor Color TV Processing Circuitry, General Electric, Syracuse, N.Y., No. 90.63, 1969.


FROM 3RD I.F. PLATE CIRCUIT
45.75 MHz
APPROX. 46.50 MHz
TRAP
LIMITS HIGH-FREQ PULL-IN RANGE
BUFFER AMP.
45.75 MHz
45.75 MHz
DISCR. CIRCUIT
D.C. AMP.
NOMINAL +5V D.C CORRECTION VOLTAGE TO VARIABLE CAPACITANCE CIRCUIT (V.H.F AND U.H.F TUNERS)
FIXED +5 REFERENCE VOLTAGE TO V.H.F. TUNER
REFERENCE ADJUST

RCA AFT CONTROL—Takes signal from 3rd i-f and converts it to d-c correction voltage of up to 5 V for correcting fine tuning of tuner in RCA CTC-28 chassis. Complete version of this simplified circuit is given in RCA service manual.—F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.

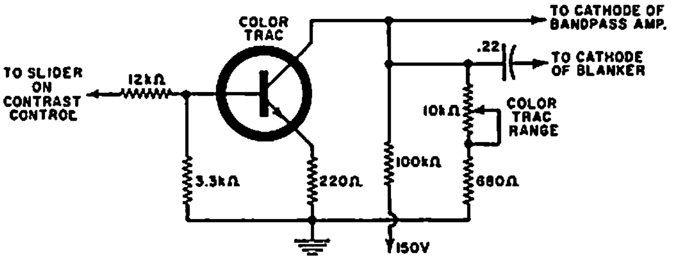

from N-S correction circuit
to centre tap T3
AT4040/33
L202
C205 1μF
C206 2.2μF
C203 18nF
BA148
C201 330pF
+20V
R201 10Ω
R203 3.3kΩ
C208 640μF
R209 2.2kΩ
C207 2.2nF
BD135
BD136
T1
3
4
5
M
L201 5mH
R204 150Ω
BC147
BC157
bal.
R212 22kΩ
from vert.output
R213 2.2kΩ
C209 1μF
ampl.
R214 2.2kΩ
C202 330pF
R202 10Ω
R205 330Ω
R208 10kΩ
R210 10kΩ
R215 15kΩ
R216 1.2kΩ
BA148
R206 2.2kΩ
R207
C204 640μF
R211 2.2kΩ
-20V

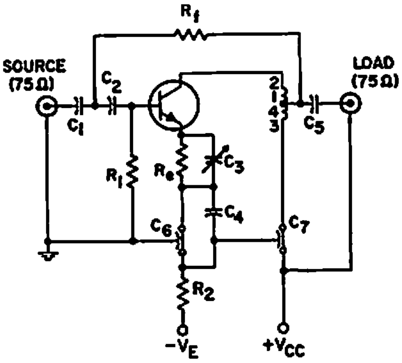
DIFFERENCE CURRENT DRIVE—Used to make beams converge in corners of picture on 110-deg color crt. Includes wave-shaping networks. Report describes circuit operation in detail. Field-frequency voltage that modulates difference current is supplied by transistor amplifier in which feedback loop is shunted to ground by voltage-dependent resistor R207.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.


video detector
picture i.f.
C51 0.8pF
OA90 D11
L17
L16
L15 33.4MHz
C50 120pF
C49 10pF
L14 5μH
C48 5.6pF
R62 2.2k
L13 100μH
luminance signal
chrominance signal
185V
R12 12k
C5 8μF
R7 1M
R8 10k
R10 1k
saturation control
PCH200
V1
R11 3.9k
C10 1nF
C12 10nF
C2 3.3nF
R5 2.7M
R1 5.6M
-30V
killer off
OA85 D2
C1 47pF
R6 68k
colour off
R9 1M
C6 100nF
to killer detector
R13 22k
R17 10k
D3 14A
R22 220k
R19 1.5M
C14 100nF
R20 12k
C16 33pF
V4
PCF201
5.5MHz
C17 270pF
L2
C19 100pF
C20 39nF
R26 27k
R27 5.6k
185V
C23 1.5nF
L4 100μH
D4 14A
C25 39nF
185V
R30 270
PCF201
V4
R31 1.5k
C27 10nF
demodulators
L5 100μH

CHROMINANCE AMPLIFIER—Designed for use in NTSC color television receiver. Consists of gain-controlled pentode and triode cathode follower, with output going to two double-diode demodulators. Gain control is partly automatic, using burst amplitude as reference (obtained by burst amplitude detector D4).—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.

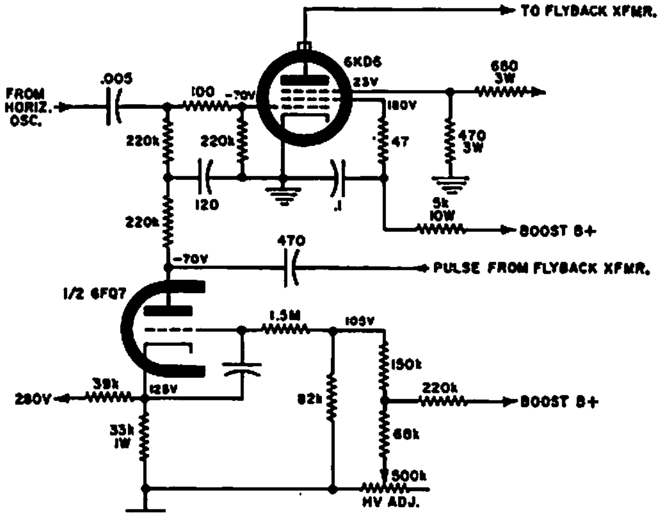
GRAY-SCALE TRACKING—Helps chroma gain to follow the settings of contrast control in Hoffman 1968 color sets. Complete circuit can be found in Hoffman 1968 tv service manuals.—F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.


COLOR TRAC
TO CATHODE OF BANDPASS AMP.
.22
TO CATHODE OF BLANKER
TO SLIDER ON CONTRAST CONTROL
12kΩ
10kΩ
COLOR TRAC RANGE
3.3kΩ
220Ω
100kΩ
680Ω
150V

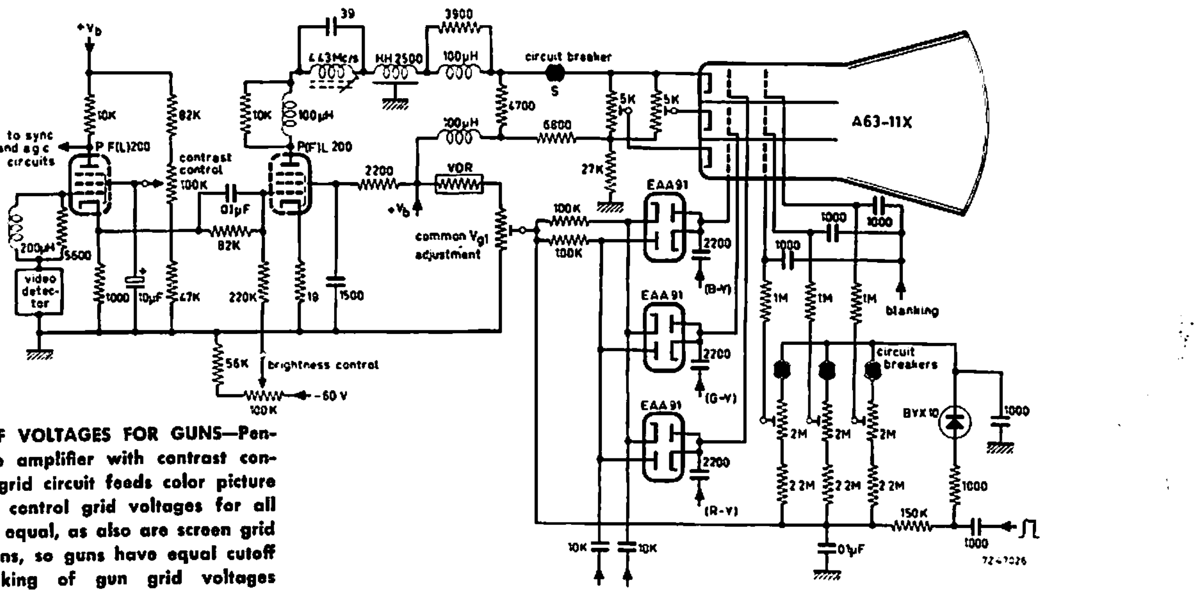

R_f
SOURCE (75Ω)
LOAD (75Ω)
C_2
C_1
2
1
4
3
C_5
R_1
R_e
C_3
C_4
C_6
C_7
R_2
$-V_E$
$+V_{CC}$

C_1, C_2, C_5 = 0.002 μF
C_3 = 8-60 pF, Arco 404 or equiv.
C_4 = 0.03 μF
C_6, C_7 = 1500 pF
R_1 = 390 ohms, ½ watt
R_2 = 330 ohms, 1 watt
R_e = 6.8 ohms, ½ watt
R_f = 200 ohms, ½ watt
T = 4-turn bifilar winding, $\frac{3}{16}$" ID, No. 30 wire; Core: G.I. material Q_1 or equiv.

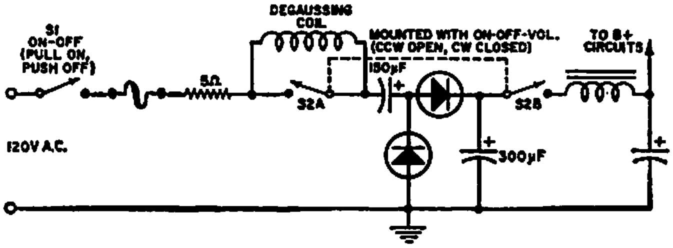
54–216 MHZ WIDEBAND CATV—Uses single 2N5109 transistor to provide gain of 12 dB. Suitable for CATV applications. Uses ferrite-toroid wideband transformer with 4:1 impedance ratio at output to transform 75-ohm load into 300-ohm collector load.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 342.


TO FLYBACK XFMR.
6KD6
FROM HORIZ. OSC.
.005
100
-70V
23V
680 3W
180V
220k
220k
47
470 3W
120
.1
5k 10W
BOOST B+
220k
-70V
470
PULSE FROM FLYBACK XFMR.
1/2 6FQ7
1.5M
105V
150k
39k
280V
125V
220k
BOOST B+
82k
68k
33k 1W
500k
HV ADJ.

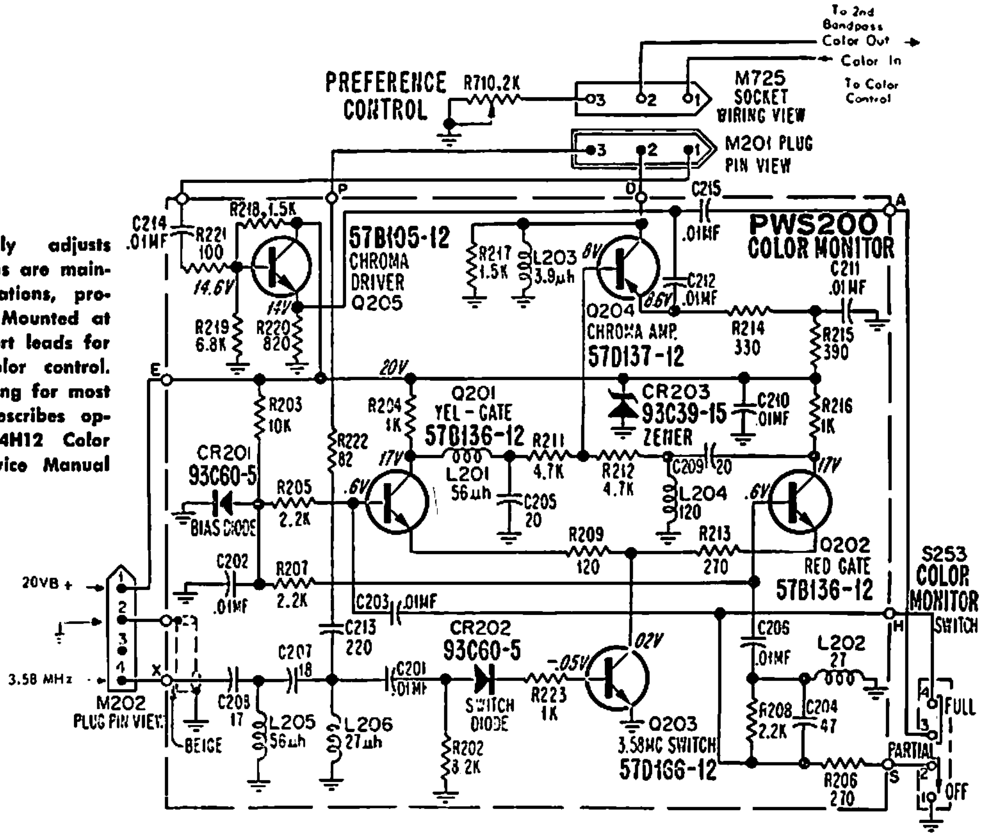
PULSE H-V REGULATOR—Used in Olympic CTC-31 color set to keep high voltage below level of dangerous x-rays. Keying pulse from flyback transformer is applied to anode of triode, to produce negative d-c voltage that increases with pulse amplitude and thereby counteracts increase in high voltage.—F. H. Belt, Color-Tv for 1969, *Electronics World*, Jan. 1969, p 25–30 and 66–67.


+V_b
39
3900
4.43Mc/s
HH 2500
100μH
circuit breaker
S
10K
82K
10K
100μH
4700
5K
5K
A63-11X
to sync and agc circuits
P F(L)200
P(F)L 200
100μH
6800
contrast control 100K
2200
VDR
27K
EAA91
0.1μF
+V_b
100K
82K
common V_{g1} adjustment
100K
2200
(B-Y)
1000
1000
1000
200μH
5600
video detector
1000
10μF
47K
220K
18
1500
1M
1M
1M
blanking
EAA91
2200
(G-Y)
circuit breakers
56K
brightness control
-60 V
100K
EAA91
BYX10
1000
2M
2M
2M
2200
(R-Y)
2.2M
2.2M
2.2M
1000
150K
10K
10K
0.1μF
1000
72-47026
individual V_{g2} adjustment

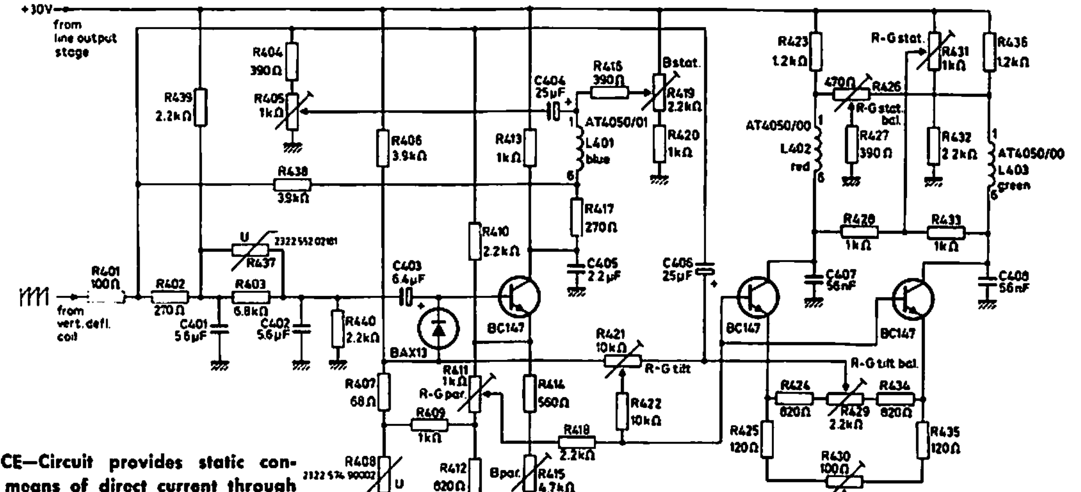
EQUAL CUTOFF VOLTAGES FOR GUNS—Pentode luminance amplifier with contrast control in screen grid circuit feeds color picture tube in which control grid voltages for all three guns are equal, as also are screen grid voltages of guns, so guns have equal cutoff voltages. Tracking of gun grid voltages with voltage of black-level voltage divider is obtained by means of voltage-dependent resistor VDR. Complexity of circuit and limited brightness control range are chief drawbacks.—A. Bookhorst and J. Gerritsen, Video Drive Circuits for Colour Picture Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 233, 1965.


S1
ON-OFF
(PULL ON,
PUSH OFF)
120V A.C.
5Ω
DEGAUSSING
COIL
S2A
MOUNTED WITH ON-OFF-VOL.
(CCW OPEN, CW CLOSED)
150µF
300µF
S2B
TO B+
CIRCUITS

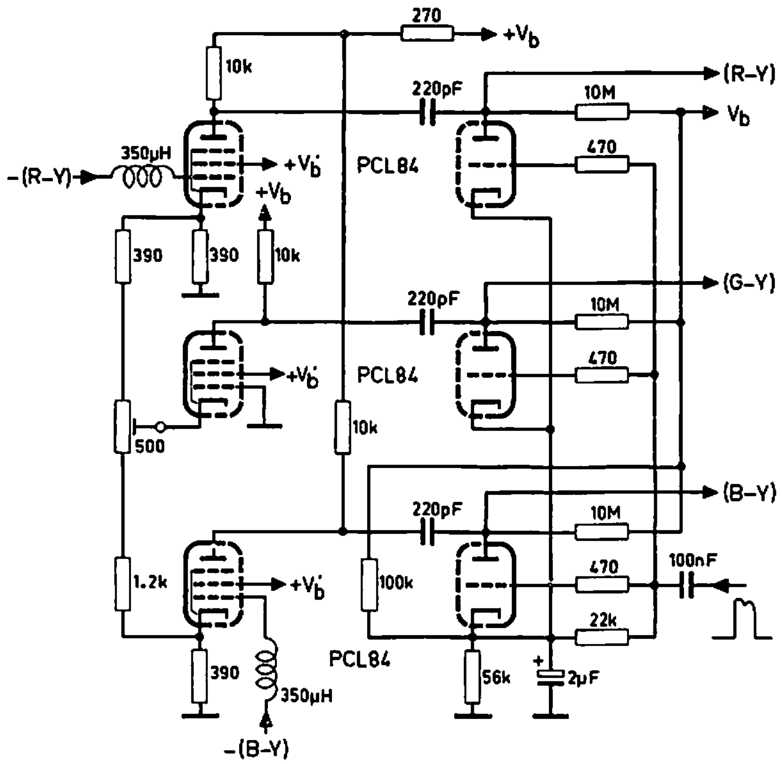
MANUAL DEGAUSSING—Used in Philco 19-FT20 color tv. Normally, switches S2 are closed and degaussing coil is shorted out. For degaussing, volume control is turned further counterclockwise after set is turned off, to open sections of S2. Set is then turned on by pulling outward on volume-control shaft. Coil then degausses crt for few seconds, until voltage-doubler capacitors at right have charged. Volume control is then rotated clockwise to close S2.—F. H. Belt, Color-Tv for 1969, *Electronics World*, Jan. 1969, p 25–30 and 66–67.


To 2nd Bandpass Color Out
Color In
To Color Control
PREFERENCE CONTROL
R710.2K
M725 SOCKET WIRING VIEW
M201 PLUG PIN VIEW
C214 .01MF
R221 100
R218 1.5K
14.6V
14V
R219 6.8K
R220 820
57B105-12 CHROMA DRIVER Q205
R217 1.5K
L203 3.9µh
8V
8.5V
C212 .01MF
C215 .01MF
Q204 CHROMA AMP. 57D137-12
R214 330
PWS200 COLOR MONITOR
C211 .01MF
R215 390
20V
R203 10K
R204 1K
Q201 YEL-GATE 57D136-12
R211 4.7K
R212 4.7K
CR203 93C39-15 ZENER
C210 .01MF
R216 1K
CR201 93C60-5 BIAS DIODE
R222 82
17V
L201 56µh
C205 20
C209 20
L204 120
17V
R205 2.2K
.6V
.6V
R209 120
R213 270
Q202 RED GATE 57B136-12
20VB+
C202 .01MF
R207 2.2K
C203 .01MF
S253 COLOR MONITOR SWITCH
3.58 MHz
M202 PLUG PIN VIEW
BEIGE
C208 17
C207 18
C213 220
C201 .01MF
CR202 93C60-5 SWITCH DIODE
-.05V
.02V
R223 1K
Q203 3.58MC SWITCH 57D166-12
R202 8.2K
L205 56µh
L206 27µh
C206 .01MF
L202 27
R208 2.2K
C204 47
R206 270
FULL
PARTIAL
OFF
P D A E H X S

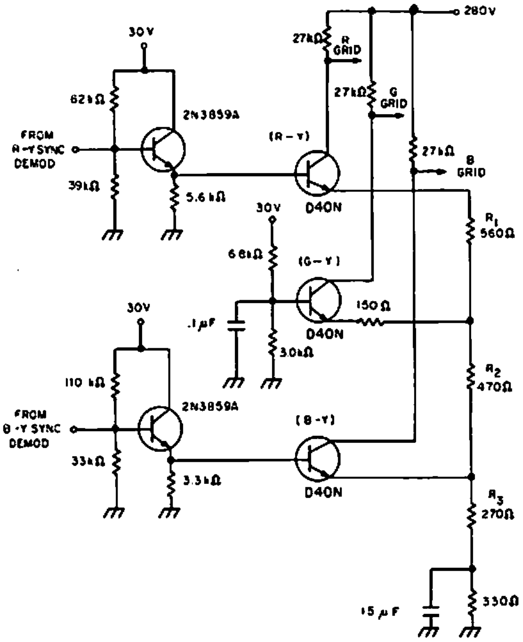
COLOR MONITOR—Automatically adjusts color signal so correct flesh tones are maintained during switching of stations, programs, tv cameras, or scenes. Mounted at rear of vhf tuner, to permit short leads for picking up color signal at color control. Preference control permits adjusting for most pleasing flesh tone. Manual describes operation of circuit in detail.—14H12 Color Television Chassis, Admiral Service Manual Supplement S1062N, 1970.


+30V
from line output stage
from vert. defl. coil
R401 100Ω
R402 270Ω
R403 6.8kΩ
C401 5.6µF
C402 5.6µF
R439 2.2kΩ
R437 U 2322 552 02181
R404 390Ω
R405 1kΩ
R438 3.9kΩ
R440 2.2kΩ
R406 3.9kΩ
C403 6.4µF
BAX13
R407 68Ω
R408 2322 574 90002 U
R409 1kΩ
R410 2.2kΩ
R411 1kΩ R-G par.
R412 820Ω
R413 1kΩ
BC147
R414 560Ω
R415 4.7kΩ Bpar.
C404 25µF
R416 390Ω
Bstat.
R419 2.2kΩ
R420 1kΩ
AT4050/01 L401 blue
R417 270Ω
C405 2.2µF
R421 10kΩ R-G tilt
R422 10kΩ
R418 2.2kΩ
C406 25µF
R423 1.2kΩ
R426 470Ω R-G stat. bal.
R427 390Ω
AT4050/00 L402 red
R-G stat.
R431 1kΩ
R432 2.2kΩ
R436 1.2kΩ
AT4050/00 L403 green
R428 1kΩ
R433 1kΩ
C407 56nF
C408 56nF
BC147
BC147
R-G tilt bal.
R424 820Ω
R429 2.2kΩ
R434 820Ω
R425 120Ω
R435 120Ω
R430 100Ω
R-G par. bal

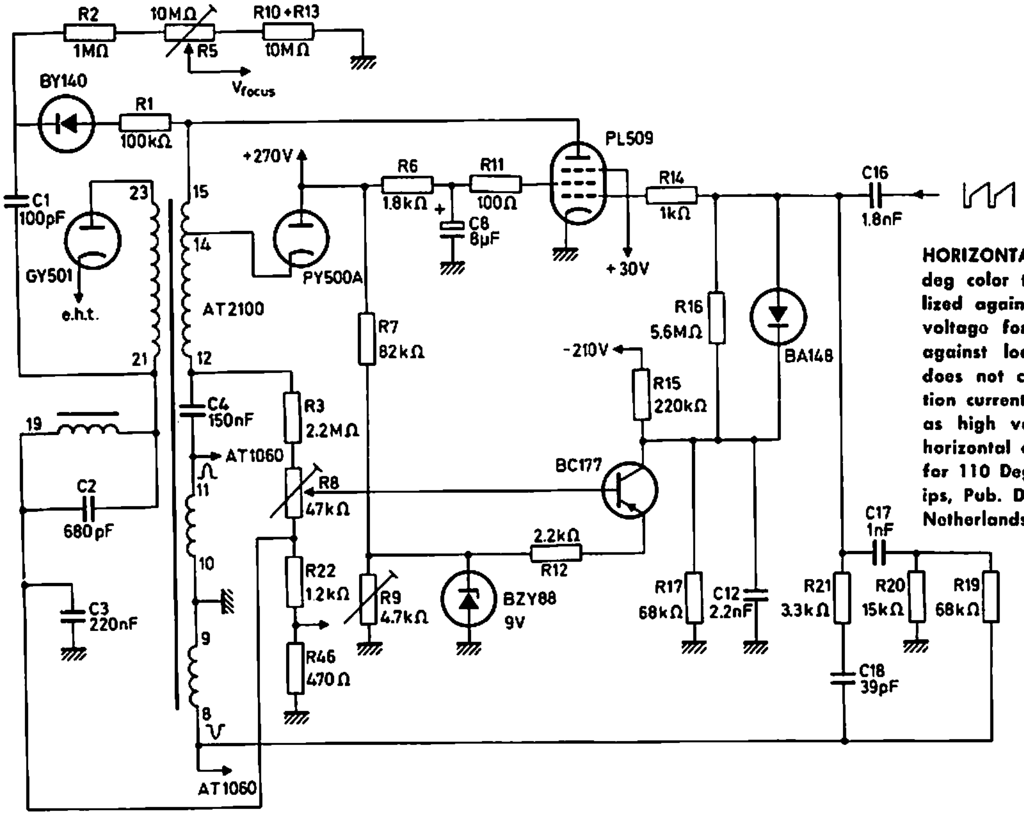
CONVERGENCE—Circuit provides static convergence by means of direct current through vertical convergence coils. Complete diagram of vertical convergence circuit is shown. Report describes operation of circuit in detail.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.


270
+Vb
10k
220pF
10M
(R-Y)
Vb
350µH
-(R-Y)
+V'b
+Vb
PCL84
470
390
390
10k
(G-Y)
220pF
10M
+V'b
PCL84
470
500
10k
(B-Y)
220pF
10M
1.2k
+V'b
100k
470
100nF
22k
390
350µH
PCL84
56k
2µF
-(B-Y)

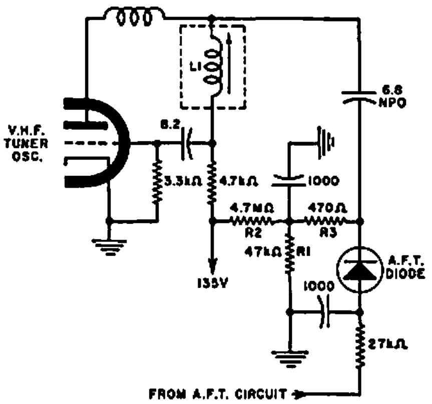
KEYED-DIODE CLAMPING—Color difference amplifier uses triodes as keyed diodes to provide asymmetrical clamping of color difference signals. Requires that blanking be applied to chrominance amplifier during flyback time.—A. Bookhorst and W. Groot, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.


280V
30V
27kΩ
R GRID
27kΩ
G GRID
62kΩ
2N3859A
(R-Y)
27kΩ
B GRID
FROM R-Y SYNC DEMOD
39kΩ
5.6kΩ
30V
D40N
R1 560Ω
6.8kΩ
(G-Y)
.1µF
150Ω
D40N
30V
3.0kΩ
110kΩ
2N3859A
R2 470Ω
FROM B-Y SYNC DEMOD
(B-Y)
33kΩ
3.3kΩ
D40N
R3 270Ω
15µF
330Ω

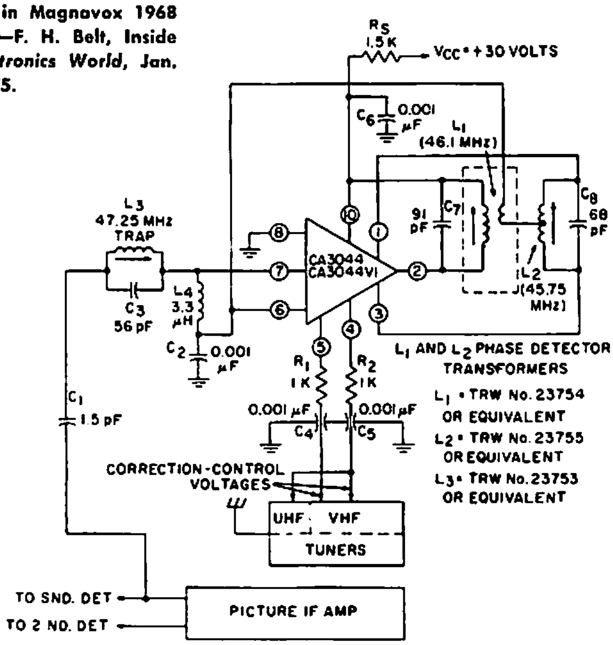
COLOR DIFFERENCE AMPLIFIER—Used in transistor color tv receiver to amplify R—Y and B—Y color difference signals coming from synchronous detectors and matrix the signals to get required G—Y color difference signal.—O. A. Kolody, Simplified Transistor Color TV Processing Circuitry, General Electric, Syracuse, N.Y., No. 90.63, 1969.


R2
1MΩ
10MΩ
R5
R10+R13
10MΩ
Vfocus
BY140
R1
100kΩ
PL509
C1
100pF
23
15
+270V
R6
1.8kΩ
R11
100Ω
R14
1kΩ
C16
1.8nF
GY501
14
C8
8µF
PY500A
+30V
e.h.t.
AT2100
R7
82kΩ
R16
5.6MΩ
-210V
BA148
21
12
R15
220kΩ
19
C4
150nF
R3
2.2MΩ
AT1060
C2
680pF
11
R8
47kΩ
BC177
C17
1nF
10
2.2kΩ
R12
R22
1.2kΩ
R9
4.7kΩ
BZY88
9V
R17
68kΩ
C12
2.2nF
R21
3.3kΩ
R20
15kΩ
R19
68kΩ
C3
220nF
9
R46
470Ω
C18
39pF
8
AT1060

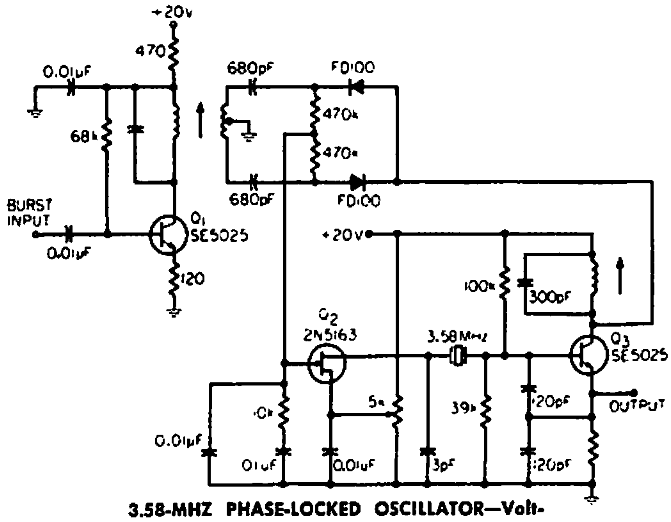
HORIZONTAL OUTPUT—Developed for 110-deg color tube. Output stage is not stabilized against line voltage changes, but high voltage for picture tube (eht) is stabilized against load variations. Width of picture does not change because horizontal deflection current is made to change half as much as high voltage, using stabilized auxiliary horizontal output stage.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.


V.H.F. TUNER OSC.
L1
8.2
6.8 NPO
3.3kΩ
4.7kΩ
1000
4.7MΩ R2
470Ω R3
47kΩ R1
135V
1000
A.F.T. DIODE
27kΩ
FROM A.F.T. CIRCUIT

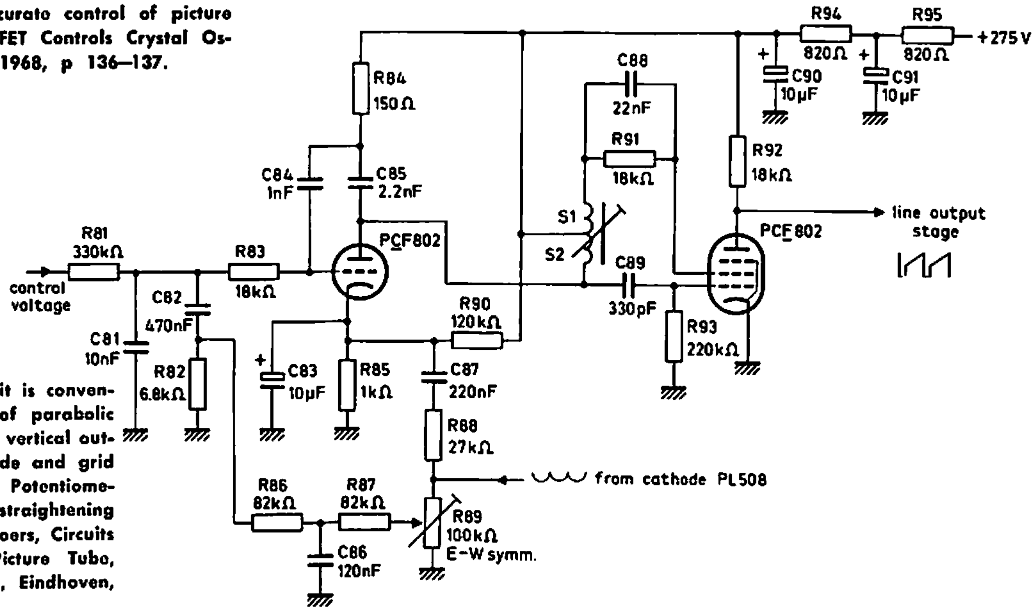
MAGNAVOX VHF AFT TUNER—Automatic fine tuning voltage derived from 3rd video i-f is applied to semiconductor diode that controls tuned circuit of triode oscillator. Complete circuit is given in Magnavox 1968 color tv service manuals.—F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.


R5 1.5K
VCC = +30 VOLTS
C6 0.001 μF
L1 (46.1 MHz)
L3 47.25 MHz TRAP
C3 56 pF
L4 3.3 μH
C2 0.001 μF
CA3044 CA3044V1
91 pF
C7
C8 68 pF
L2 (45.75 MHz)
L1 AND L2 PHASE DETECTOR TRANSFORMERS
L1 = TRW No. 23754 OR EQUIVALENT
L2 = TRW No. 23755 OR EQUIVALENT
L3 = TRW No. 23753 OR EQUIVALENT
R1 1K
R2 1K
0.001 μF C4
0.001 μF C5
C1 1.5 pF
CORRECTION-CONTROL VOLTAGES
UHF VHF TUNERS
TO SND. DET
TO 2 ND. DET
PICTURE IF AMP

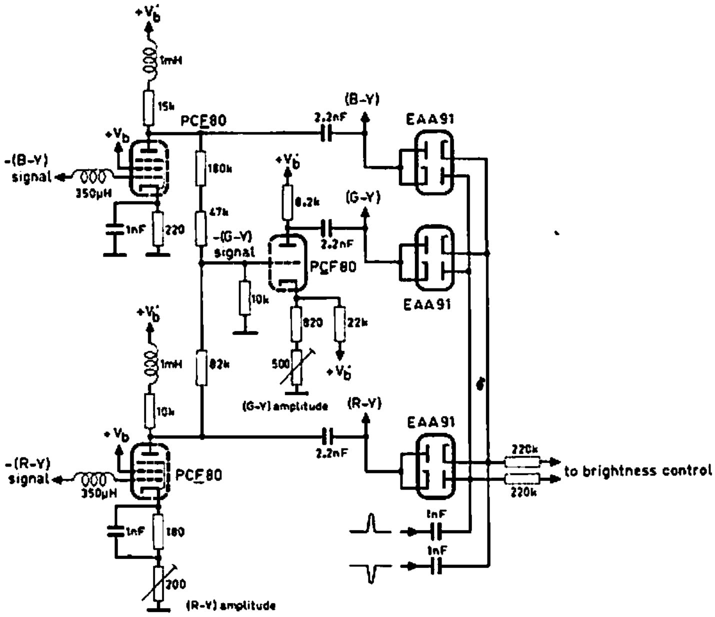
COLOR AFT SYSTEM—Uses RCA special-function IC to provide accurate tuning reference. System locks on picture-carrier i-f and holds tuner oscillator within 25 kHz of picture carrier to give high-quality picture at all times. Report describes operation and gives performance graphs.—W. M. Austin, H. M. Kleinman, and J. Sundburg, Application of the RCA-CA3044 and CA3044V1 Integrated Circuits in Automatic-Fine-Tuning Systems, RCA, Harrison, N.J., ICAN-5831, 1968.


+20v
470
0.01μF
68k
BURST INPUT
0.01μF
Q1 SE5025
120
680pF
FD100
470k
470k
680pF
FD100
+20v
100k
300pF
Q2 2N5163
3.58MHz
Q3 SE5025
OUTPUT
0.01μF
10k
01μF
0.01μF
5k
39k
3pF
120pF
120pF

3.58-MHZ PHASE-LOCKED OSCILLATOR—Voltage-dependent resistance characteristic of fet is used to vary effective tuning capacitance of crystal subcarrier oscillator for color tv. Permits fine adjustment of oscillator frequency to give accurate control of picture tint.—N. P. Doyle, FET Controls Crystal Oscillator, *EEE*, Aug. 1968, p 136–137.

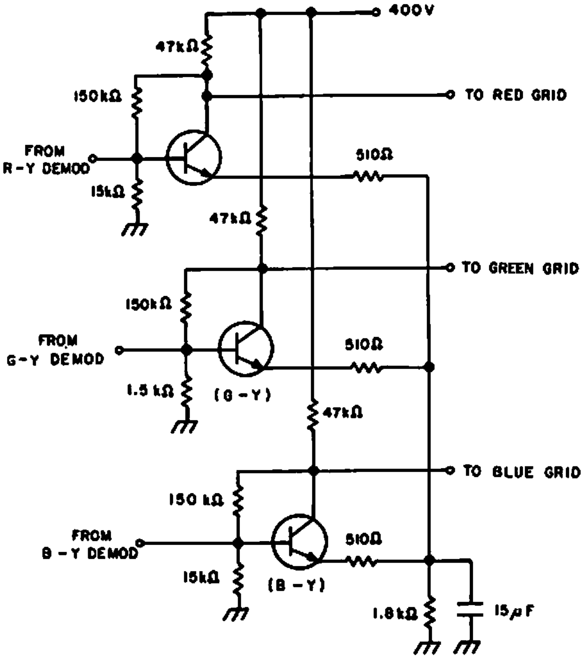

R94 820Ω
R95 820Ω
+275V
C90 10μF
C91 10μF
R84 150Ω
C88 22nF
R91 18kΩ
R92 18kΩ
C84 1nF
C85 2.2nF
line output stage
R81 330kΩ
R83 18kΩ
PCF802
S1
S2
PCF802
C89 330pF
control voltage
C82 470nF
C81 10nF
R82 6.8kΩ
C83 10μF
R85 1kΩ
R90 120kΩ
C87 220nF
R93 220kΩ
R88 27kΩ
from cathode PL508
R86 82kΩ
R87 82kΩ
R89 100kΩ E-W symm.
C86 120nF

HORIZONTAL OSCILLATOR—Circuit is conventional except that small part of parabolic voltage derived from cathode of vertical output tube PL508 is fed to cathode and grid both in PCF802 reactance tube. Potentiometer R89 can then be used for straightening vertical lines in picture.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.



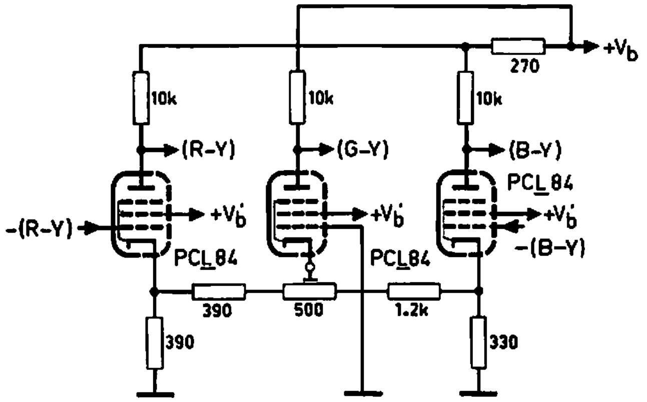
+V'b
1mH
15k
PCF80
+Vb
-(B-Y) signal
350μH
1nF
220
180k
47k
-(G-Y) signal
82k
(B-Y)
2.2nF
EAA91
+V'b
8.2k
(G-Y)
2.2nF
PCF80
10k
820
22k
500
+V'b
(G-Y) amplitude
(R-Y)
2.2nF
EAA91
EAA91
+V'b
1mH
10k
+Vb
-(R-Y) signal
350μH
PCF80
1nF
180
200
(R-Y) amplitude
1nF
1nF
220k
220k
to brightness control

SYMMETRICAL CLAMPING—Chief advantage of circuit is immunity to noise, making blanking unnecessary.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.



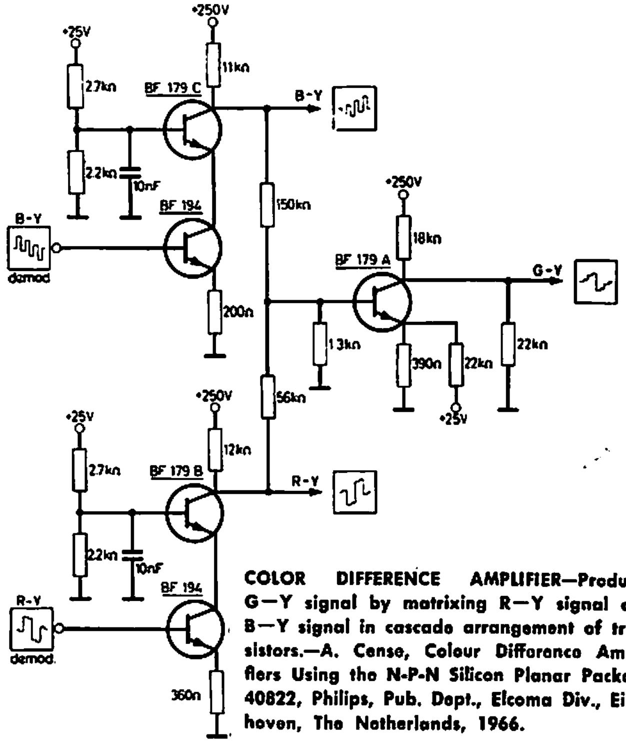
400V
47kΩ
150kΩ
TO RED GRID
FROM R-Y DEMOD
15kΩ
510Ω
47kΩ
TO GREEN GRID
150kΩ
FROM G-Y DEMOD
510Ω
1.5 kΩ
(G-Y)
47kΩ
TO BLUE GRID
150 kΩ
FROM B-Y DEMOD
510Ω
15kΩ
(B-Y)
1.8kΩ
15μF

COLOR DIFFERENCE AMPLIFIER—Nonmatrixing amplifiers use D40N transistors. Input impedance of G−Y transistor is 1,000 ohms and that of other transistor is 6,000 ohms, to provide different voltage levels required for driving picture tube.—O. A. Kolody, Simplified Transistor Color TV Processing Circuitry, General Electric, Syracuse, N.Y., No. 90.63, 1969.



+Vb
270
10k
10k
10k
(R-Y)
(G-Y)
(B-Y)
-(R-Y)
+V'b
+V'b
PCL84
+V'b
-(B-Y)
PCL84
PCL84
390
500
1.2k
390
330

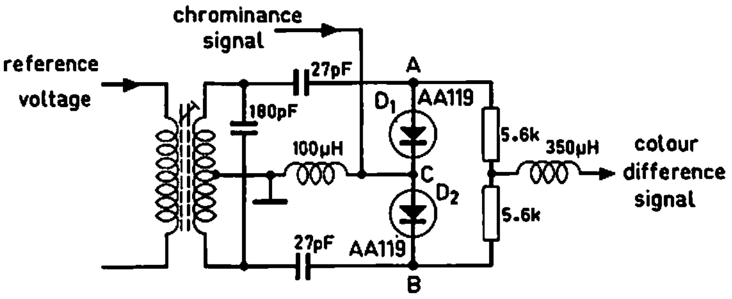
G−Y CATHODE MATRIX—Crosstalk between R−Y and B−Y amplifiers is a few percent, but offsetting advantage is that eventual hum on anode voltages of these stages is not phase-inverted on G−Y amplifier anode. Pentodes are used throughout to provide required gain.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.

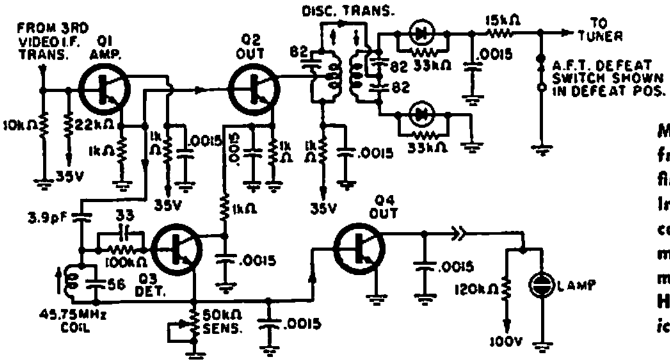


+250V
+25V
11kΩ
27kΩ
BF 179 C
B-Y
22kΩ
10nF
BF 194
B-Y
demod
150kΩ
+250V
18kΩ
BF 179 A
G-Y
200Ω
1.3kΩ
390Ω
22kΩ
22kΩ
+25V
+250V
56kΩ
+25V
12kΩ
27kΩ
BF 179 B
R-Y
22kΩ
10nF
BF 194
R-Y
demod.
360Ω

COLOR DIFFERENCE AMPLIFIER—Produces G−Y signal by matrixing R−Y signal and B−Y signal in cascode arrangement of transistors.—A. Censo, Colour Difference Amplifiers Using the N-P-N Silicon Planar Package 40822, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, 1966.

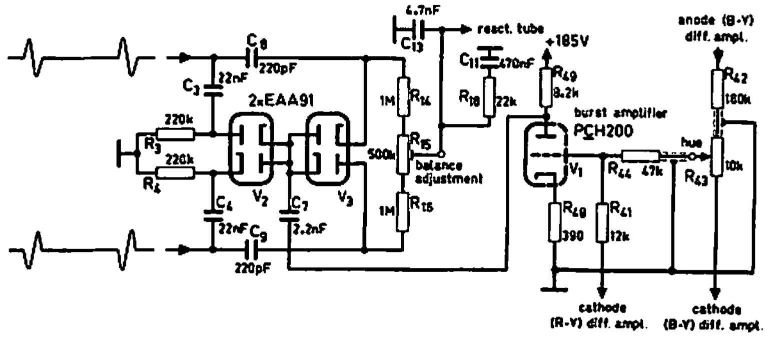
DOUBLE-DIODE DEMODULATOR—Used for phase demodulation of chrominance signals. Desired signal provides output voltages with equal phases from both diode circuits, to give color difference signal at junction of load resistors. Provides no gain, but has efficiency of about 80% with load values shown.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.

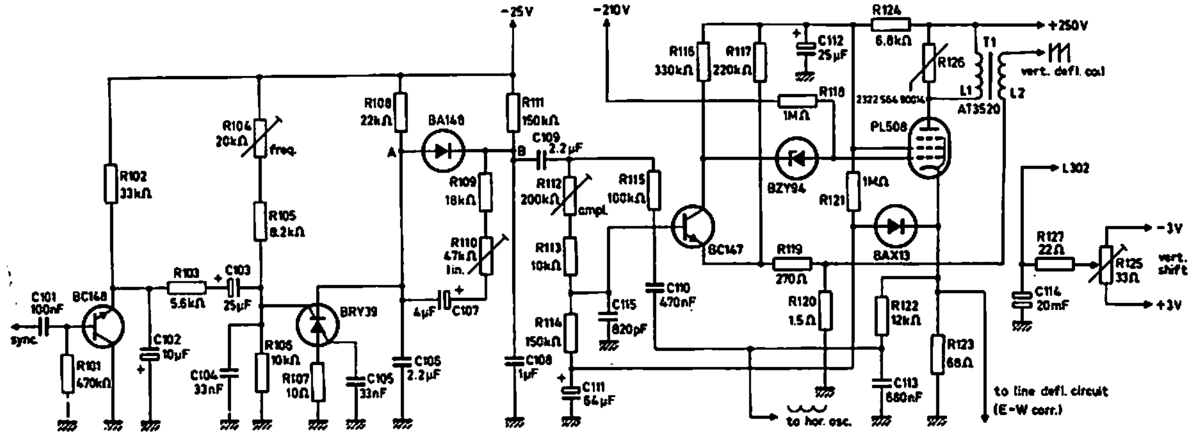

chrominance signal
reference voltage
27pF
180pF
100μH
A
D1
AA119
C
D2
27pF
AA119
B
5.6k
5.6k
350μH
colour difference signal


FROM 3RD VIDEO I.F. TRANS.
Q1 AMP.
Q2 OUT
DISC. TRANS.
82
82
82
33kΩ
33kΩ
15kΩ
.0015
TO TUNER
A.F.T. DEFEAT SWITCH SHOWN IN DEFEAT POS.
10kΩ
22kΩ
1kΩ
35V
1k Ω
.0015
.0015
1k Ω
1k Ω
.0015
35V
35V
3.9pF
33
100kΩ
Q3 DET.
1kΩ
.0015
56
45.75MHz COIL
50kΩ SENS.
.0015
Q4 OUT
.0015
120kΩ
LAMP
100V

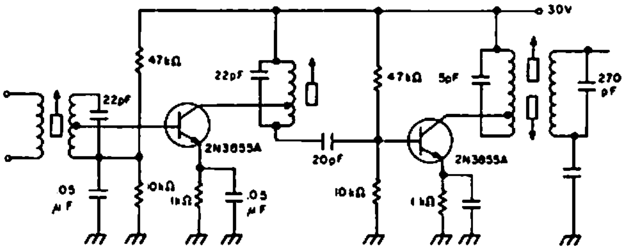
MOTOROLA AFT CONTROL—Takes signal from 3rd i-f and converts it to d-c automatic fine tuning voltage for tuner of color set. Includes neon-lamp indicator circuit to indicate when fine tuning needs manual adjustment. Complete circuit is given in service manuals for 1968 Motorola color sets.—F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.

BURST PHASE DETECTOR—Demodulated R—Y color difference signal, in which burst is zero if phase of burst is correctly received, is amplified by triode V1, fed to clamp V2 to reduce blanking level to zero, then applied to phase detector V3 to detect any deviation of burst from zero.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.

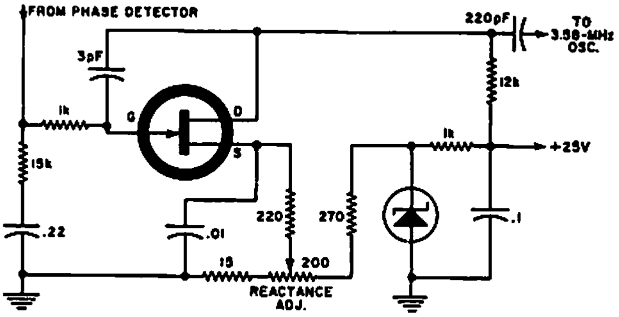

C8
220pF
C3
22nF
2xEAA91
220k
R3
220k
R4
V2
C4
22nF
C9
220pF
C7
2.2nF
V3
4.7nF
C13
react. tube
C11
470nF
R18
22k
+185V
R49
8.2k
1M
R14
500k
R15
balance adjustment
1M
R15
burst amplifier
PCH200
V1
R48
390
R41
12k
R44
47k
hue
anode (B-Y) diff. ampl.
R42
180k
R43
10k
cathode (R-Y) diff. ampl.
cathode (B-Y) diff. ampl.


-25V
-210V
+250V
R124
6.8kΩ
R116
330kΩ
R117
220kΩ
C112
25μF
R126
2322 564 90014
T1
L1
L2
AT3520
vert. defl. coil
R118
1MΩ
PL508
R102
33kΩ
R104
20kΩ
freq.
R105
8.2kΩ
R108
22kΩ
A
BA148
B
R111
150kΩ
C109
2.2μF
R109
18kΩ
R110
47kΩ
lin.
R112
200kΩ
ampl.
R115
100kΩ
BZY94
R121
1MΩ
L302
R113
10kΩ
BC147
R119
270Ω
BAX13
R127
22Ω
R125
33Ω
vert. shift
-3V
+3V
C101
100nF
sync.
BC148
R101
470kΩ
R103
5.6kΩ
C103
25μF
C102
10μF
C104
33nF
R106
10kΩ
BRY39
R107
10Ω
C105
33nF
4μF
C107
C106
2.2μF
C108
1μF
R114
150kΩ
C111
64μF
C115
820pF
C110
470nF
R120
1.5Ω
R122
12kΩ
C113
680nF
R123
68Ω
C114
20mF
to hor. osc.
to line defl. circuit (E-W corr.)

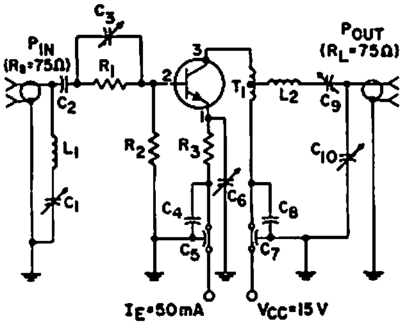
VERTICAL DEFLECTION—Sawtooth voltage is derived from synchronized relaxation oscillator using BRY39 scs. Sync signal is amplified by BC148 transistor before being applied to scs. Integrating network R122-C113 in cathode circuit of output pentode provides required S-correction of deflection current.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.


30V
47kΩ
22pF
2N3855A
.05 μF
10kΩ
1kΩ
.05 μF
20pF
47kΩ
5pF
10kΩ
1kΩ
2N3855A
270 pF

PEAKER FOR CHROMA BANDPASS AMPLIFIER—Simple a-c coupled peaker stage for transistor color tv receiver improves performance of chroma bandpass amplifier. No automatic color control is used on this stage.—O. A. Kolody, Simplified Transistor Color TV Processing Circuitry, General Electric, Syracuse, N.Y., No. 90.63, 1969.

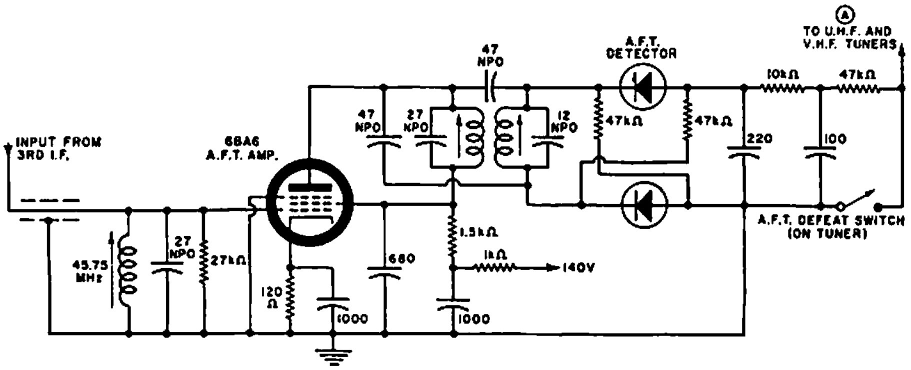

FROM PHASE DETECTOR
220pF
TO 3.58-MHz OSC.
3pF
12k
1k
G
D
S
1k
+25V
15k
.22
.01
220
270
.1
15
200
REACTANCE ADJ.

JFET 3.58-MHZ OSCILLATOR—Junction fet serves as reactance control for oscillator in chroma section of Admiral K10-2A 1969 color tv.—F. H. Belt, Color-Tv for 1969, *Electronics World*, Jan. 1969, p 25–30 and 66–67.

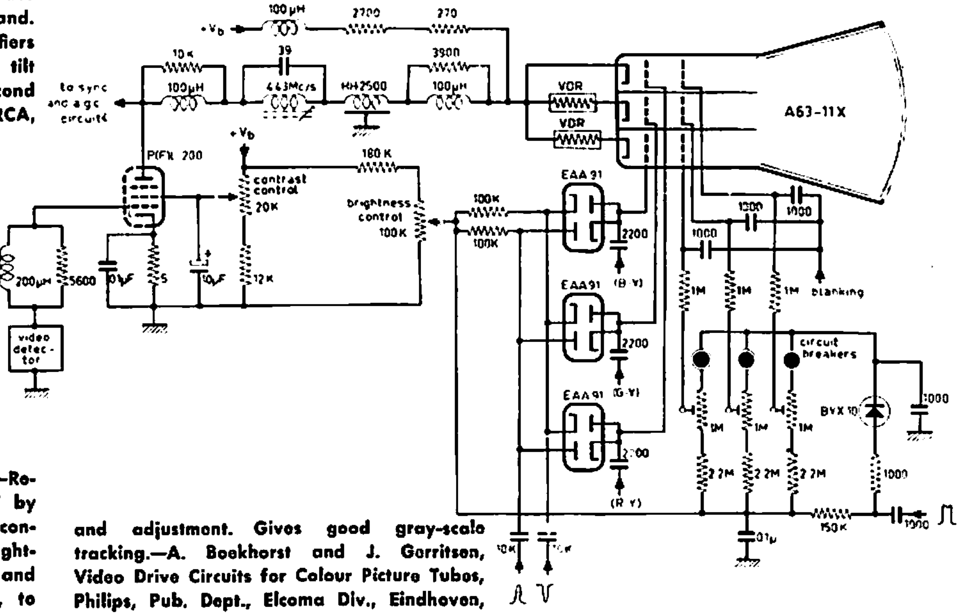

C_3
P_{IN} (R_s=75Ω)
R_1
C_2
L_1
C_1
R_2
R_3
2
3
1
T_1
L_2
C_9
P_{OUT} (R_L=75Ω)
C_{10}
C_4
C_5
C_6
C_7
C_8
I_E=50mA
V_{CC}=15V

C_1 = 1.5 — 20 pF
C_2 = 0.002 pF
C_3 = 55 — 300 pF
C_4, C_8 = 0.02 pF
C_5, C_7 = 1000 pF
C_6 = 32 — 250 pF
C_9 = 7 — 100 pF
C_{10} = 8 — 60 pF
L_1 = 7 turns, 1/16" diameter, No. 26 wire
L_2 = 3 turns, 1/16" diameter, No. 26 wire
R_1 = 30 ohms
R_2 = 390 ohms
R_3 = 220 ohms
T = 4-turn bifilar winding, 3/16" ID; Core: G.I. material Q_1 or equiv.

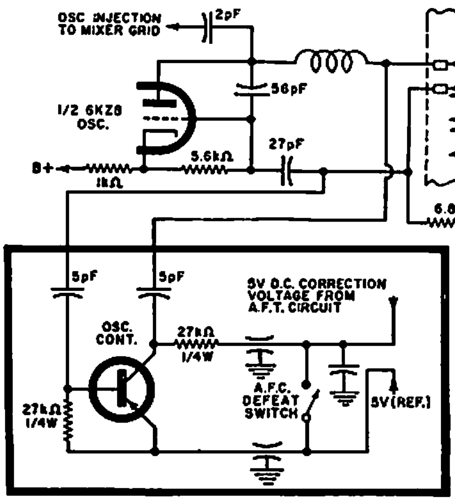
54–216 MHZ CATV AMPLIFIER—Sophisticated wideband amplifier uses variety of matching, peaking, and feedback techniques to increase gain-bandwidth product. Provides minimum gain of 14 dB over entire band. Used in trunk line and bridger amplifiers usually having two to four stages, with tilt control generally incorporated only in second stage.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 342.


Ⓐ TO U.H.F. AND V.H.F. TUNERS
47 NPO
A.F.T. DETECTOR
10kΩ
47kΩ
47 NPO
27 NPO
12 NPO
47kΩ
47kΩ
INPUT FROM 3RD I.F.
6BA6 A.F.T. AMP.
220
100
A.F.T. DEFEAT SWITCH (ON TUNER)
45.75 MHz
27 NPO
27kΩ
1.5kΩ
1kΩ
140V
680
120 Ω
1000
1000

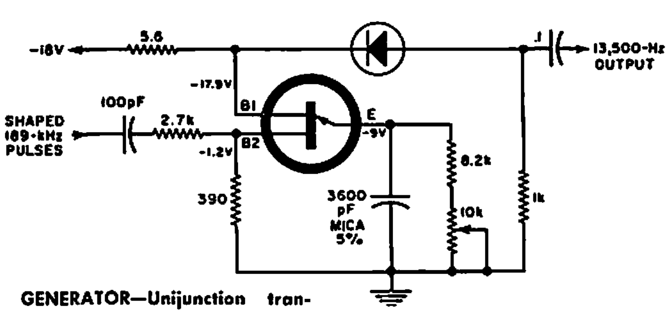
AUTOMATIC FINE TUNING—Used in Magnavox top-of-line sets to adjust tuner accurately so color burst is not lost. Article gives operating principle.—F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.


+V_b
100μH
2700
270
10K
39
3900
to sync and agc circuits
100μH
4.43Mc/s
HH2500
100μH
VDR
VDR
A63-11X
P(F)L 200
+V_b
180 K
contrast control 20K
brightness control 100K
100K
100K
EAA 91
2200
(B-Y)
1000
1000
1000
1M
1M
1M
blanking
200μH
5600
0.1μF
5
10μF
12K
video detector
EAA91
2200
(G-Y)
circuit breakers
EAA91
2200
(R-Y)
BYX10
1000
1M
1M
1M
2.2M
2.2M
2.2M
1000
150K
1000
0.1μ
10K
10K

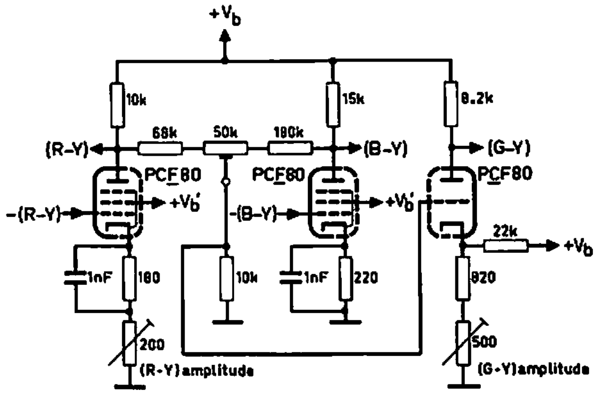
VDR FEEDBACK IN GUN CATHODES—Required drive ratio for guns is obtained by cathode feedback, with screen grid and control grid voltages being held equal. Brightness control varies both control grid and screen grid voltages by same amount, to avoid color shift. Circuit is simple in setup and adjustment. Gives good gray-scale tracking.—A. Boekhorst and J. Gerritsen, Video Drive Circuits for Colour Picture Tubes, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 233, 1965.


OSC INJECTION TO MIXER GRID
2pF
56pF
1/2 6KZ8 OSC.
5.6kΩ
27pF
B+
1kΩ
CH.13
CH.12
CH.11
6.8kΩ
B+
5pF
5pF
5V D.C. CORRECTION VOLTAGE FROM A.F.T. CIRCUIT
OSC. CONT.
27kΩ 1/4W
A.F.C. DEFEAT SWITCH
5V(REF.)
27kΩ 1/4W

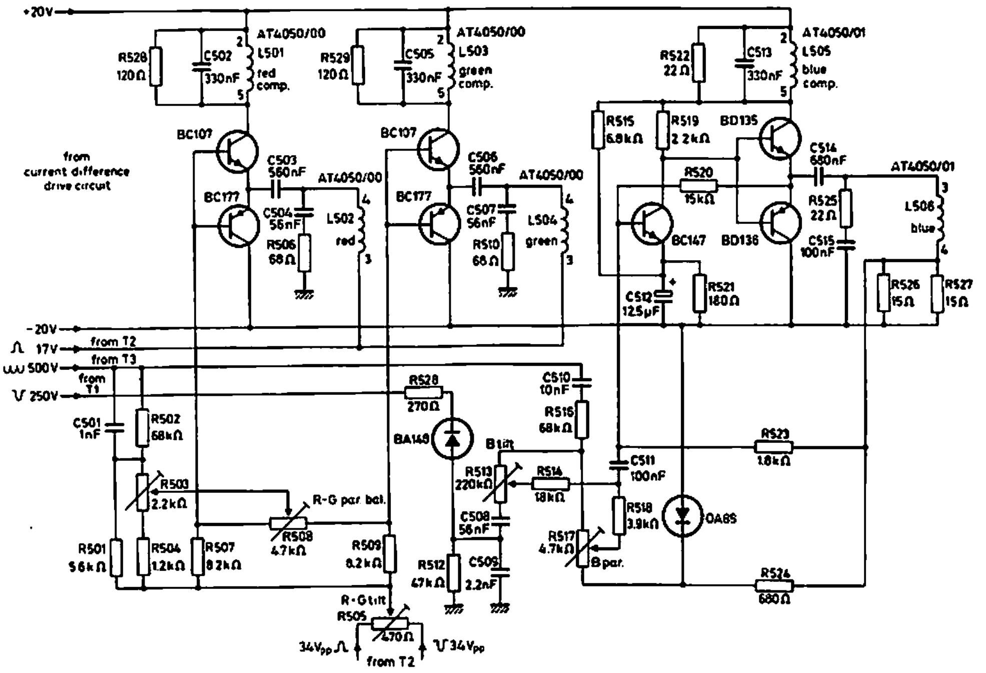
RCA AFT—Shows method of applying automatic fine tuning control voltage to oscillator control transistor in RCA KRK-131 vhf tuner. Complete circuit can be found in RCA service manual for CTC-28 color chassis. —F. H. Belt, Inside the 1968 Color Sets, *Electronics World*, Jan. 1968, p 41–45 and 72–75.


-18V
5.6
.1
13,500-Hz OUTPUT
-17.9V
B1
100pF
SHAPED 189-kHz PULSES
2.7k
B2
E
-9V
-1.2V
390
3600 pF MICA 5%
8.2k
10k
1k

COLOR-BAR GENERATOR—Unijunction transistor serves as down-counter, triggered by every 14th pulse of its input, in B&K Model 1242 keyed-rainbow color generator. Diode aids stability and shapes output pulses for next stage. Generator uses total of four ujt's.—F. H. Belt, Color Generators Reach the Solid State, *Electronics World*, May 1968, p 25–29 and 64–65.


+V_b
10k
15k
8.2k
68k
50k
180k
(R-Y)
(B-Y)
(G-Y)
PCF80
PCF80
PCF80
-(R-Y)
+V_b'
-(B-Y)
+V_b'
22k
+V_b
1nF
180
10k
1nF
220
820
200
(R-Y)amplitude
500
(G-Y)amplitude

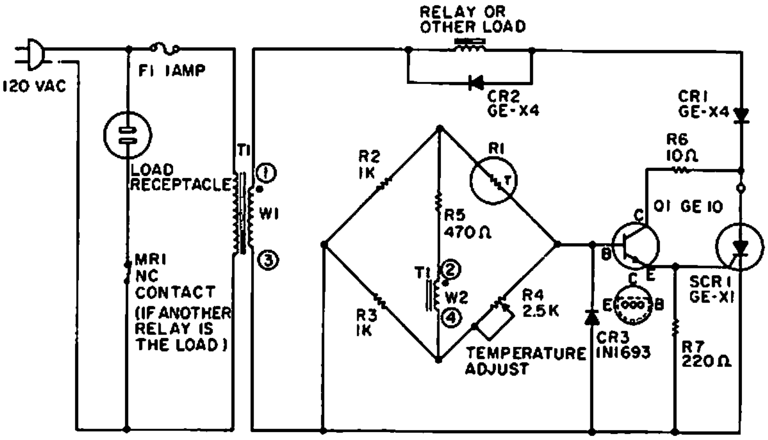
G—Y ANODE MATRIX—Provides two-phase pentode demodulation, with triode as phase inverter and amplifier for G—Y signal. Advantages include minimum crosstalk.—A. Boekhorst and W. Graat, Chrominance Circuits for N. T. S. C. Colour Television Receivers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 234, 1966.


+20V
AT4050/00
L501 red comp.
R528 120Ω
C502 330nF
AT4050/00
L503 green comp.
R529 120Ω
C505 330nF
AT4050/01
L505 blue comp.
R522 22Ω
C513 330nF
BC107
BC177
C503 560nF
AT4050/00
C504 56nF
L502 red
R506 68Ω
BC107
BC177
C506 560nF
AT4050/00
C507 56nF
L504 green
R510 68Ω
from current difference drive circuit
R515 6.8kΩ
R519 2.2kΩ
BD135
C514 680nF
AT4050/01
R520 15kΩ
R525 22Ω
L506 blue
BC147
BD136
C515 100nF
C512 125μF
R521 180Ω
R526 15Ω
R527 15Ω
-20V
17V from T2
500V from T3
250V from T1
C501 1nF
R502 68kΩ
R503 2.2kΩ
R-G par bal.
R508 4.7kΩ
R501 56kΩ
R504 1.2kΩ
R507 82kΩ
R528 270Ω
BA148
B tilt
C510 10nF
R516 68kΩ
R513 220kΩ
R514 18kΩ
C511 100nF
R518 3.9kΩ
OA85
R523 1.8kΩ
C508 56nF
R517 4.7kΩ
B par.
R509 8.2kΩ
R512 47kΩ
C509 2.2nF
R524 680Ω
R-G tilt
R505 470Ω
34V_pp
34V_pp
from T2

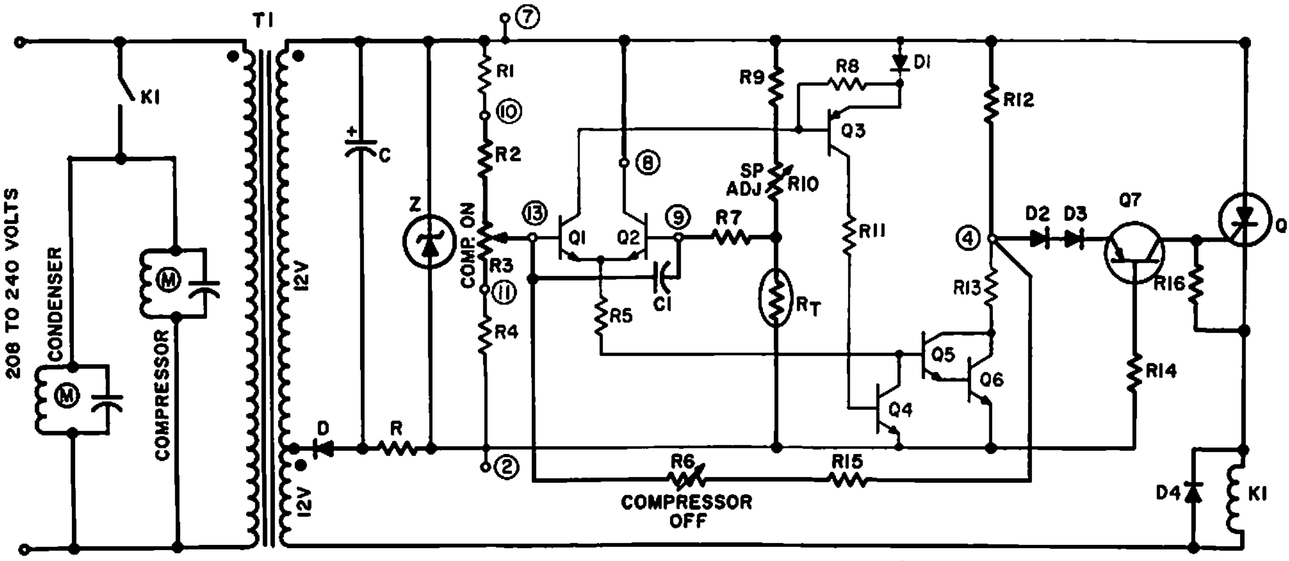
HORIZONTAL DYNAMIC CONVERGENCE—Complementary pair of emitter-followers is used for each convergence coil. Report describes operation of circuit and gives waveforms of horizonal convergence currents and fields.—C. J. Boers, Circuits for 110 Degree Colour TV Picture Tube, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 261, 1969.

CHAPTER 87
Temperature Control Circuits

4-A SCR CONTROL FOR RELAY—Permits control of high-current loads plugged into load receptacle. R1 can be GE 1D303 thermistor having 1,000 ohms at 70 F, cadmium sulfide photocell, or other sensor. Relay can be 6-V d-c such as Potter & Brumfield PT11.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 160.



RELAY OR OTHER LOAD
120 VAC
F1 1AMP
LOAD RECEPTACLE
T1
①
W1
③
MR1 NC CONTACT (IF ANOTHER RELAY IS THE LOAD)
CR2 GE-X4
CR1 GE-X4
R2 1K
R1
R5 470Ω
T1 ②
W2
④
R3 1K
R4 2.5K
TEMPERATURE ADJUST
R6 10Ω
Q1 GE 10
C
B
E
SCR1 GE-X1
CR3 1N1693
R7 220Ω



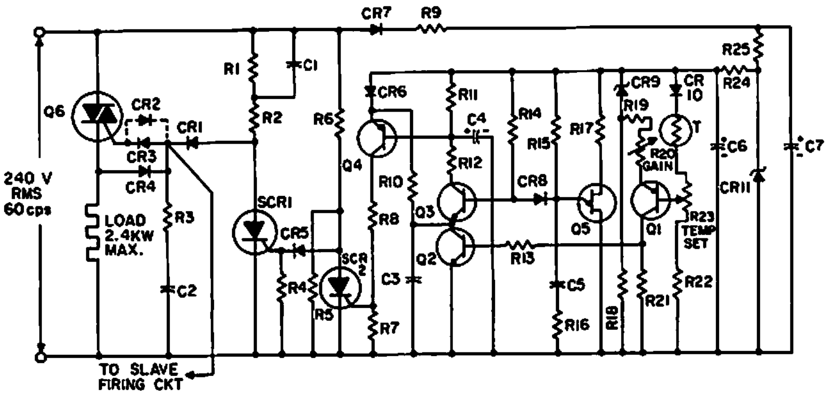
208 TO 240 VOLTS
K1
CONDENSER
COMPRESSOR
M
T1
12V
12V
C
Z
D
R
⑦
R1
⑩
R2
COMP. ON
R3
⑪
R4
②
⑬
Q1
Q2
⑧
⑨
R7
C1
R5
R9
R8
D1
Q3
SP ADJ
R10
RT
R11
Q4
Q5
Q6
R12
R13
④
D2
D3
Q7
Q8
R16
R14
R6
R15
COMPRESSOR OFF
D4
K1

$R_1, R_4, R_5, R_8, R_{11}, R_{13}$ - in PA424
R_2, R_3, R_{16} ——— 1K ohm
R_6 ——— 5 megohm
R_7 ——— 12K ohm
R_9 ——— 3.3K ohm
R_{10} ——— 5K ohm
R_{12} ——— 2.2K ohm
R_{14} ——— 82K ohm
R_{15} ——— 220K ohm
R_T ——— GE 2R114
R ——— 120 ohm

C - GE 43F9723AA9 250μfd 25V
C_1 - GE 75F1R5A103 .01μfd 50V
D_1 - in PA424
D, D_2, D_3, D_4 - GE A14F
Q_1 thru Q_6 - in PA424
Q_7 - GE D29A4
Q_8 - GE C106F
Z - GE Z4XL12
K1 - 24V Coil; Contacts as req.
T1 { 220V PRI
24V CT SEC
25 WATT

AIR CONDITIONER CONTROL—Incorporates PA424 IC, shown in thin lines, and uses electromechanical relay to handle relatively high compressor surge current (60 A or higher) of larger units. Also controls condenser fan. Hysteresis of control is adjustable from 0.25 to 4 F with R6. Can be combined with heater control, for regulating room temperature under all weather conditions.—T. A. Penkalski, Better Room Conditioning via Solid State Controls, General Electric, Syracuse, N.Y., No. 200.51, 1967, p 6.

2.4-KW FULL-WAVE PROPORTIONAL CONTROL—Provides zero-voltage switching in which ratio of load on time to off time varies as function of thermistor error signal. May be used to slave-drive additional triac-load combinations each having all components at left of R4.—J. L. Brookmire, Temperature Controls Incorporating Zero Voltage Switching, General Electric, Syracuse, N.Y., No. 200.45, 1966, p 9.


CR7
R9
R25
R24
CR9
CR 10
R19
T
R20 GAIN
C6
C7
CR11
R1
C1
R2
R6
CR6
R11
C4
R14
R15
R17
R12
Q4
R10
CR8
Q3
Q5
Q1
R23 TEMP SET
Q6
CR2
CR1
CR3
CR4
240 V RMS 60cps
LOAD 2.4KW MAX.
R3
SCR1
CR5
R8
Q2
R13
C5
R16
R18
R21
R22
R4
SCR 2
R5
C3
R7
C2
TO SLAVE FIRING CKT

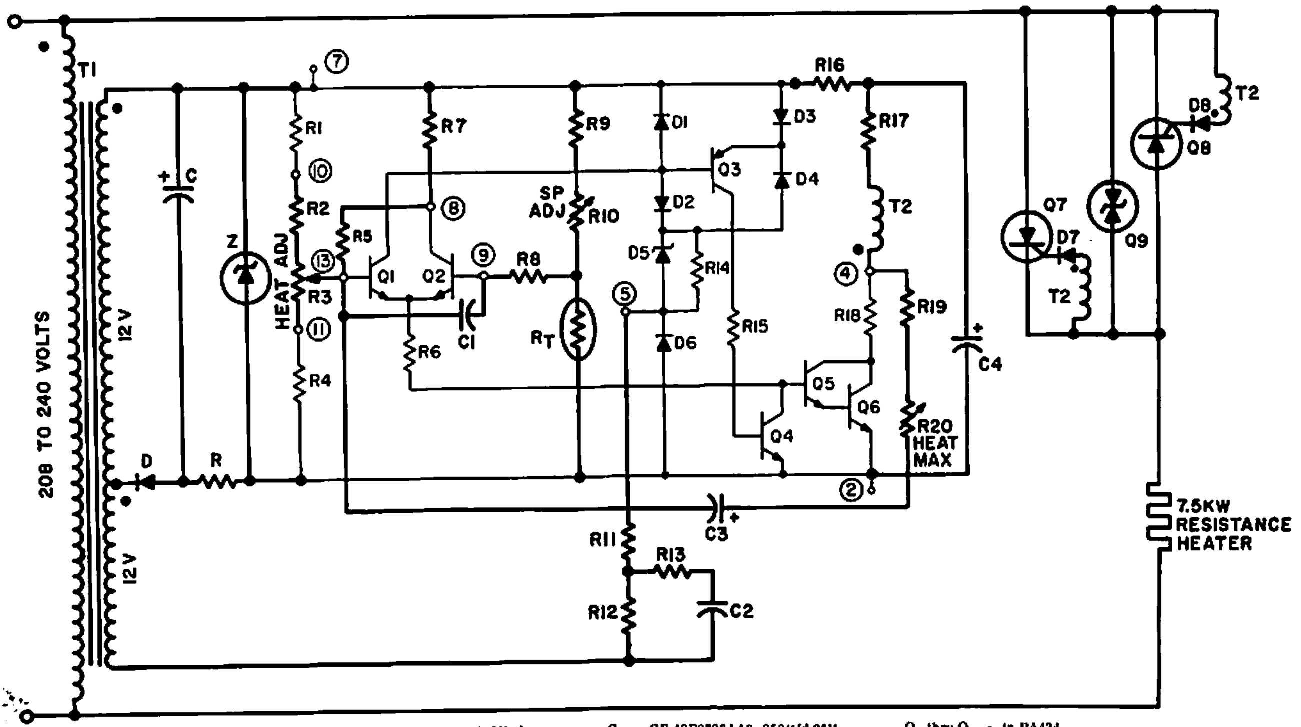
CR1 - G.E. A13B - A14B
CR2 - G.E. A13F - A14F
CR3 - G.E. A13F - A14F
CR4 - G.E. A13F - A14F
CR5 - G.E. A13F - A14F
CR6 - G.E. 1N4009
CR7 - G.E. A13B - A14B
CR8 - G.E. 1N4009
CR9 - G.E. Z4XL6.2
CR10 - G.E. 1N4009
CR11 - G.E. Z4XL16
R1 - 3K, 10W
R2 - 56, 1W

R3 - 470, 1W
R4 - 1K
R5 - 15K, 1W
R6 - 15K, 2W
R7 - 1K
R8 - 4.7K
R9 - 6.8K, 5W
R10 - 22K
R11 - 22K
R12 - 22K
R13 - 12K
R14 - 1MEG
R15 - 1MEG

R16 - 100
R17 - 220
R18 - 6.8K
R19 - 1K
R20 - 10K POT
R21 - 10K
R22 - 4.7K
R23 - 10K POT
R24 - 47
R25 - 150
C1 - 0.82 UF, 20%, 400 VDC
C2 - 0.47 UF, 20%, 400 VDC
C3, C5 - 1 UF, 10%, 15 VDC (MYLAR OR LOW LEAKAGE TYPE)

C4 - 3 UF, 20 WVDC
C6 - 100 UF, 20 WVDC
C7 - 500 UF, 25 WVDC
Q1, Q4 - 2N3638 (Fairchild)
Q2, Q3 - G.E. 2N2923
T - 5K THERMISTOR AT OPERATING TEMPERATURE } G.E. TYPE 2H502 - 5K AT 25°C.
Q5 - G.E. 2N2646

SCR1 - G.E. C5DX280
SCR2 - G.E. C6B OR C106B
Q6 - TRIAC - G. E. SC45D - 10 AMP
G. E. SC40D - 6 AMP


T1
⑦
R16
R1
R7
R9
D1
D3
R17
T2
D8
Q8
+ C
⑩
⑧
SP ADJ
R10
D2
Q3
D4
Z
R2
R5
HEAT ADJ
⑬
Q1
Q2
⑨
R8
D5
R14
Q7
D7
Q9
R3
⑪
C1
RT
⑤
D6
R15
R18
R19
④
T2
C4
R6
R4
Q5
Q6
Q4
R20 HEAT MAX
208 TO 240 VOLTS
12V
D
R
②
C3
R11
R13
R12
C2
12V
7.5KW RESISTANCE HEATER

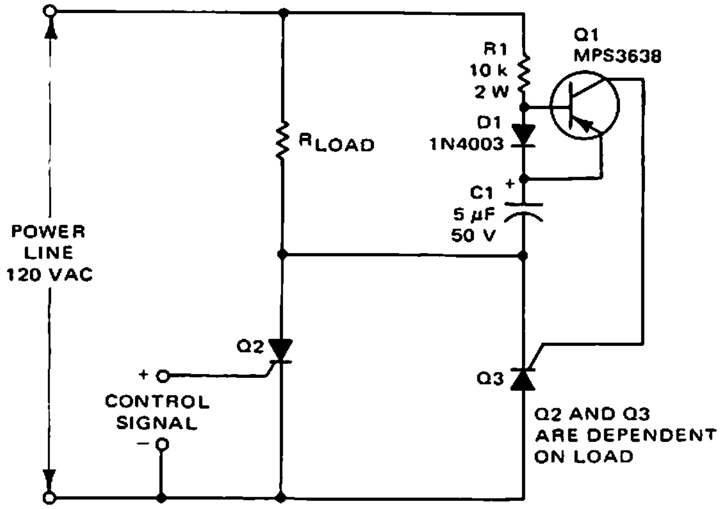
R_1, R_4, R_6, R_{14}, R_{15}, R_{18} - in PA424
R_2 —— 1.5K ohm
R_3, R_{11}, R_{12} —— 1K ohm
R_5, R_8 —— 47K ohm
R_7 —— 4.7K ohm
R_9 —— 3.3K ohm
R_{10} —— 5K ohm

R_{13} —— 2.2K ohm
R_{16}, R_{19} —— 100 ohm
R_{17} —— 47 ohm
R_{20} —— 10K ohm
R_T —— GE 2R114
R —— 120 ohm

C - GE 43F9723AA9 250μfd 25V
C_1 - 220μμ 50V
C_2 - GE 75F7R5A105 1μfd 50V
C_3 - GE 76F02KE220 22μfd 25V
C_4 - GE 76F02KM101 100μfd 25V
D, D_7, D_8 - GE A14F
D_1 thru D_6 - in PA424

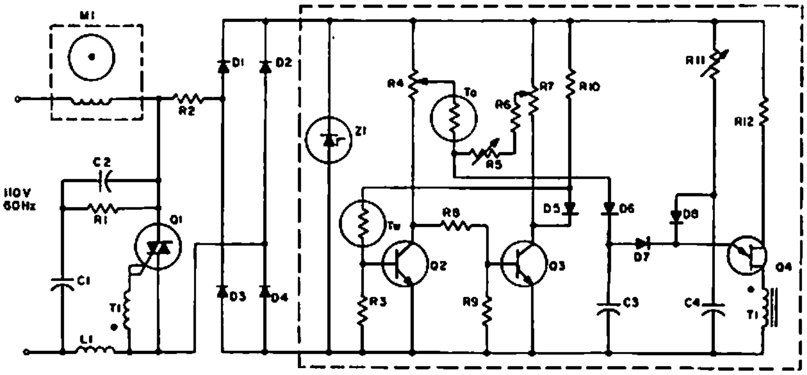
Q_1 thru Q_6 - in PA424
Q_7, Q_8 - GE C30D
Q_9 - GE 6RS21A12D12
Z - GE Z4XL12
T_2 - Alladdin 02-2062
T_1 - 220 PRI 24V CT SEC 25 WATT

IC PROPORTIONAL FOR 7.5-KW HEATER—Uses inverse parallel scr combination Q7-Q8 operating from a-c line, with triggering circuit operated from low-voltage secondary of transformer. This isolates thermostat from high-voltage power line. Components in General Electric PA424 IC are shown in thin lines. Can be combined with control for air conditioner, for regulating room temperature under all weather conditions.—T. A. Penkalski, Better Room Conditioning via Solid State Controls, General Electric, Syracuse, N.Y., No. 200.51, 1967, p 5.


Q1
MPS3638
R1
10 k
2 W
D1
1N4003
C1
5 μF
50 V
+
RLOAD
POWER
LINE
120 VAC
Q2
Q3
+
CONTROL
SIGNAL
−
Q2 AND Q3
ARE DEPENDENT
ON LOAD

SCR SLAVE—Slave circuit Q1-Q3, added to half-wave control scr Q2, gives full-wave control. Each time Q2 turns on, it feeds single power pulse through Q1 to gate of scr Q3, making Q3 turn on and pass load current for half-cycle following that in which Q2 was on. Control signal at gate of Q2, either d-c or power pulse, will thus act on both Q2 and Q3 to give full-wave control. If control pulse is synchronized with a-c line, switching occurs only at zero point.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–13.

3-A BLOWER CONTROL—Phase-controlled blower regulates temperature produced by external heat source. May be used in systems having single blower for regulating both room heating and cooling. Room temperature is monitored by feedback thermistor Ta. Feedback signal is compared in ujt error detector with reference R5, and resulting error fed to triac Q1 which supplies power to blower motor. Thermistor Tw and flip-flop Q2-Q3 sense water temperature when water is used either for heating or cooling. Circuit provides rfi suppression. Will maintain temperature within 3% of thermistor resistance for 10% variation in line voltage.—"SCR Manual," 4th Edition, General Electric, 1967, p 287–288.


M1
D1
D2
R2
R4
To
R6
R7
R10
R11
R12
Z1
R5
C2
110V
60Hz
R1
Q1
Tw
R8
D5
D6
D8
Q2
Q3
D7
Q4
C1
T1
L1
D3
D4
R3
R9
C3
C4
T1

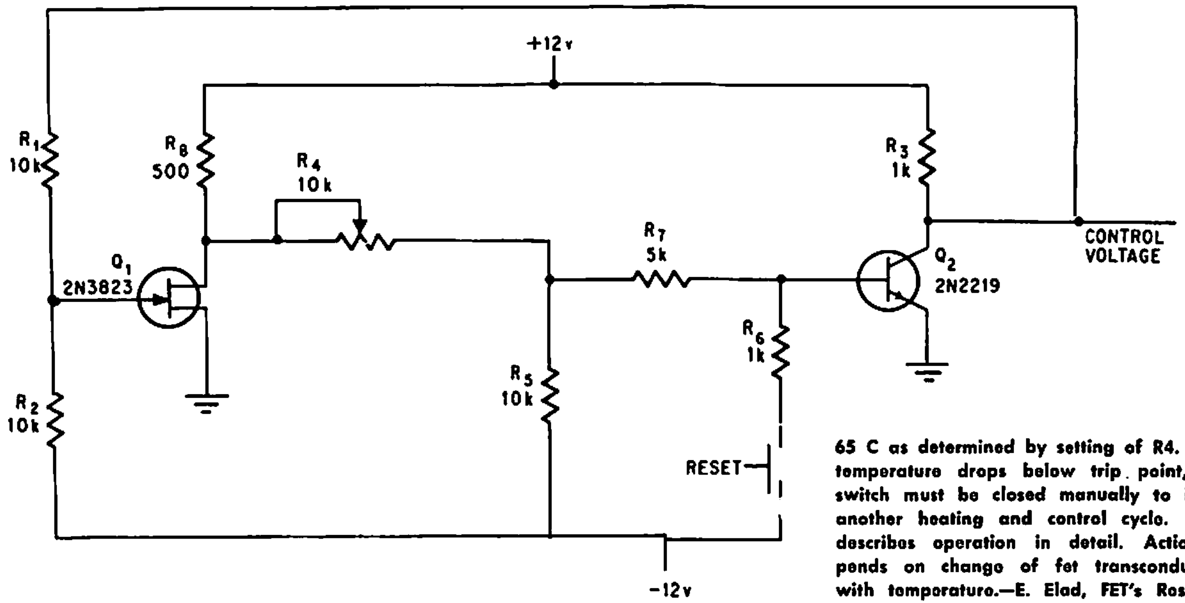
R1 - 82 Ω
R2 - 4.7KΩ, 4W
R3 - 1KΩ
R4 - 5KΩ POT, 1/2W
R5 - 5KΩ POT, 1/2W
R6 - 3.3KΩ
R7 - 5KΩ POT, 1/2W
R8 - 22KΩ

R9 - 3.3KΩ
R10 - 4.7KΩ
R11 - 100Ω, 1/2 W
R12 - 1KΩ
C1 - 0.22μfd, 200V
C2 - .05μfd, 200V
C3 - 0.1μfd, 50V
C4 - 0.1μfd, 50V

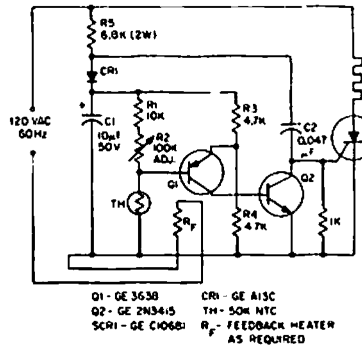
D1 THRU D4 - GE 6RS16PB1LAJ1
D5 THRU D8 - GE A13F
Q1 - GE SC41B
Q2, Q3 - GE 2N2712
Q4 - GE 2N2646
Z1 - GE Z4XL20
Tw - GE 1D103, 5K @ 25°C THERMISTOR
Te - GE 1D103, 5K @ 25°C THERMISTOR

M1 - 3 AMP SHADED POLE MOTOR
T1 - SPRAGUE 11Z12 PULSE TRANSFORMER

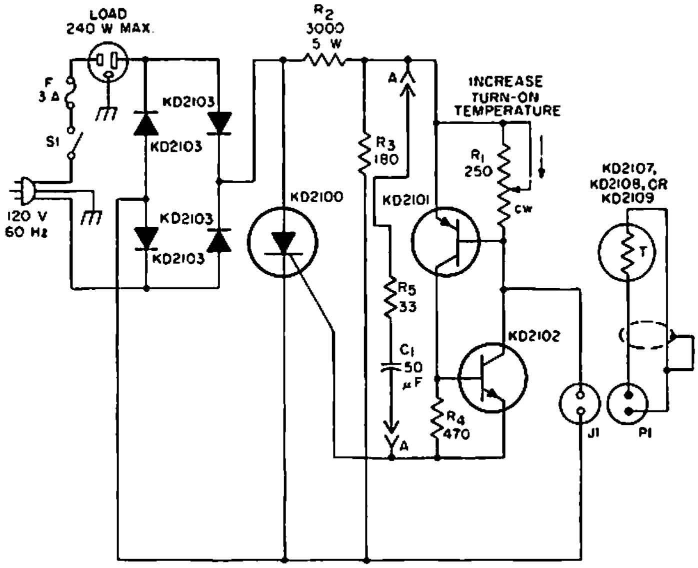
NOTE: ALL RESISTANCES 1/2 W, ±10% UNLESS OTHERWISE SPECIFIED.


+12 v
R_1
10k
R_8
500
R_4
10 k
R_3
1k
CONTROL
VOLTAGE
Q_1
2N3823
R_7
5k
Q_2
2N2219
R_6
1k
R_5
10k
R_2
10k
RESET
−12v

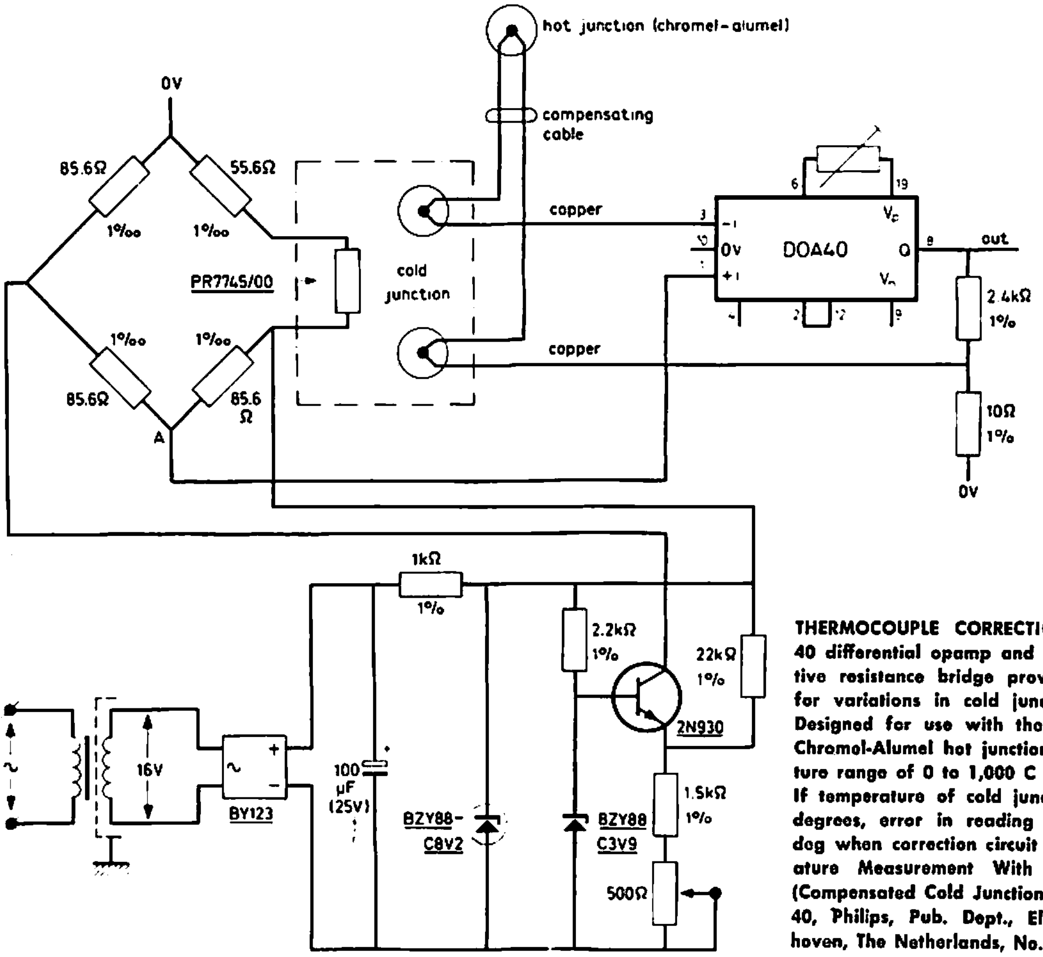
HIGH-TEMPERATURE CUTOFF—Fet circuit placed in heat chamber provides control voltage for cutting off heater when temperature reaches desired maximum between 35 and 65 C as determined by setting of R4. After temperature drops below trip point, reset switch must be closed manually to initiate another heating and control cycle. Article describes operation in detail. Action depends on change of fet transconductance with temperature.—E. Elad, FET's Resistance Change Trips Heater Control, *Electronics*, April 29, 1968, p 65–66.


R5
6.8K (2W)
CR1
180 WATT HEATER LOAD
120 VAC
60Hz
C1
10μf
50V
R1
10K
R2
100K
ADJ.
R3
4.7K
C2
0.047
μF
SCR1
Q1
Q2
TH
RF
R4
4.7K
1K
Q1 - GE 3638
Q2 - GE 2N3415
SCR1 - GE C106B1
CR1 - GE A13C
TH - 50K NTC
RF - FEEDBACK HEATER AS REQUIRED

HALF-WAVE ZERO-VOLTAGE SWITCHING—Duplicates function of bimetallic switch normally used in electric blankets. Scr is fired either at beginning of alternate half-cycles or biased off completely. On-off cycle repeats at rate determined by room temperature, so ON time increases when temperature is low. Switching at zero voltage minimizes rfi, eliminating need for filter.—"SCR Manual," 4th Edition, General Electric, 1967, p 149–150.

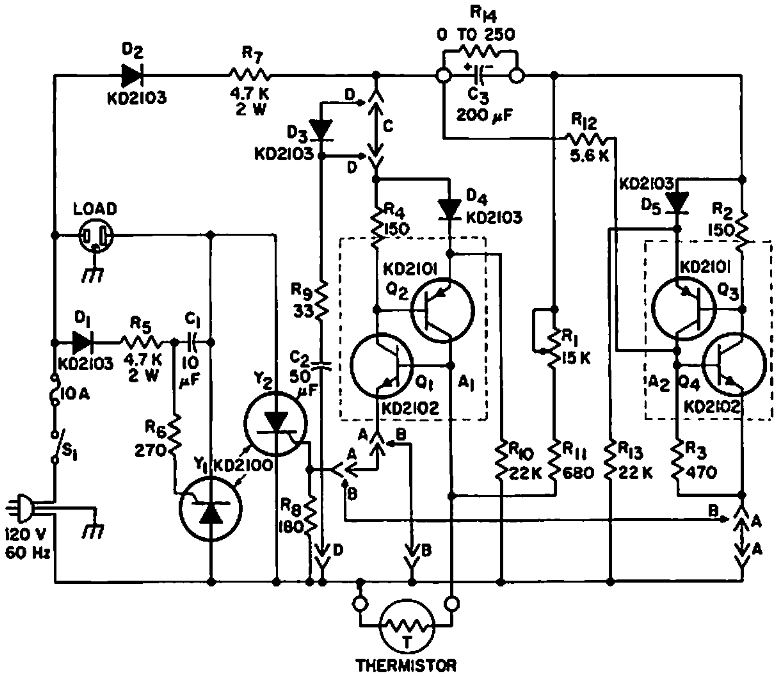

LOAD
240 W MAX.
F
3 A
S1
120 V
60 Hz
KD2103
KD2103
KD2103
KD2103
R2
3000
5 W
KD2100
R3
180
A
INCREASE TURN-ON TEMPERATURE
R1
250
CW
KD2101
R5
33
C1
50
μF
A
R4
470
KD2102
KD2107, KD2108, OR KD2109
T
J1
P1

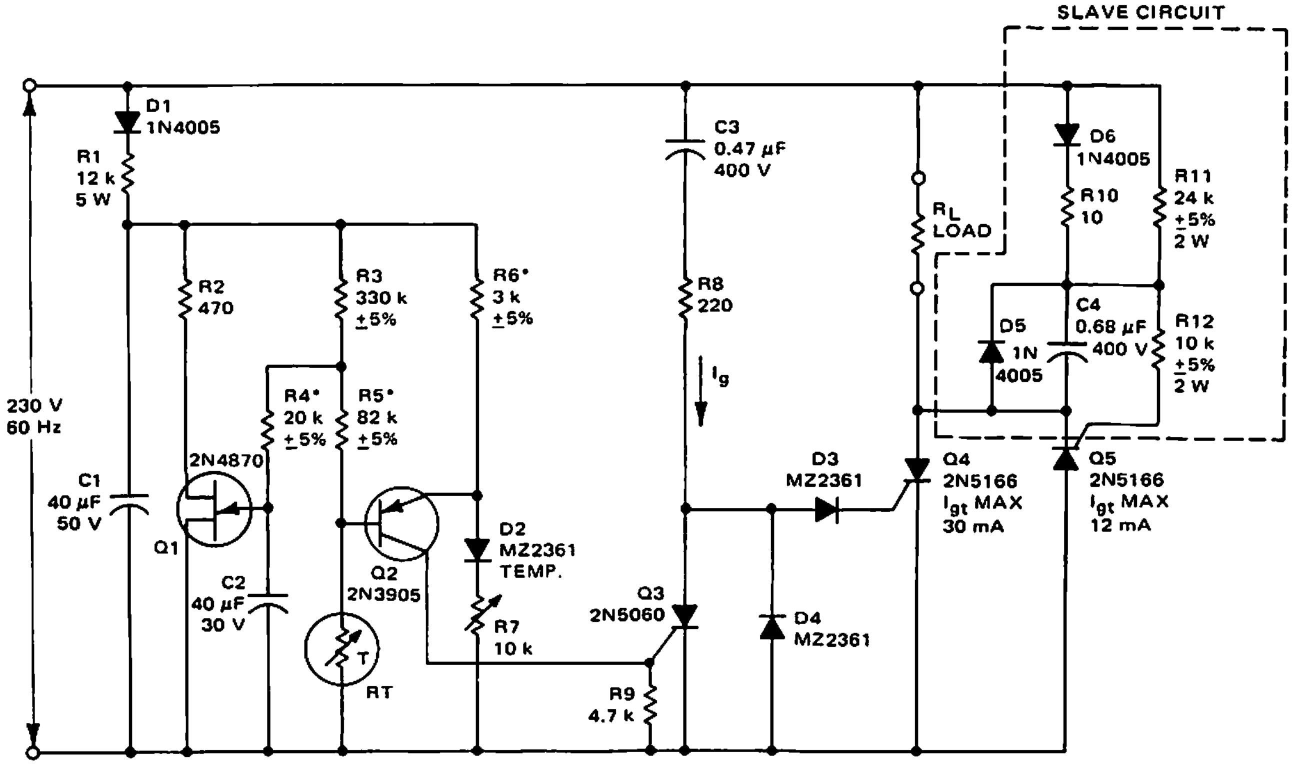
240-W COOLING CONTROL—When thermistor T senses that temperature is above that called for by setting of R1, transistor switch and scr are retriggered early in each succeeding half-cycle of a-c input to give full-wave current through cooling fan or other load, without rfi. Optional latching circuit R5-C1 would, if used, keep fan on until line switch S1 is opened.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 110.


hot junction (chromel-alumel)
compensating cable
0V
85.6Ω
55.6Ω
1°/oo
1°/oo
PR7745/00
1°/oo
1°/oo
85.6Ω
85.6 Ω
A
cold junction
copper
copper
6
19
3
−i
0V
+i
DOA40
Vc
Q
Vn
out
2.4kΩ
1%
10Ω
1%
0V
1kΩ
1%
2.2kΩ
1%
22kΩ
1%
2N930
~
16V
~
+
−
BY123
100 μF (25V)
BZY88-C8V2
BZY88 C3V9
1.5kΩ
1%
500Ω

THERMOCOUPLE CORRECTION—Philips DOA-40 differential opamp and temperature-sensitive resistance bridge provide compensation for variations in cold junction temperature. Designed for use with thermocouple having Chromel-Alumel hot junction giving temperature range of 0 to 1,000 C with 15-V supply. If temperature of cold junction increases 80 degrees, error in reading is only about 6 deg when correction circuit is used.—Temperature Measurement With a Thermocouple (Compensated Cold Junction) Using the DOA-40, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 26.

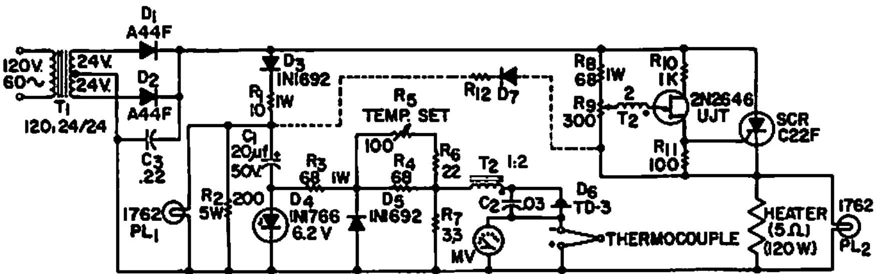
MULTIPURPOSE TEMPERATURE CONTROL—Different combinations of wiring give choice of operating methods. With wiring A, load is turned off when temperature increases, for heating applications. Wiring B gives opposite effect, for cooling applications. With wiring C, circuit does not lock in either mode. Wiring D will latch control in either mode, depending on whether used with A or B. With D, R14 and C3 should be removed and replaced by jumper.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 117.


D2
KD2103
R7
4.7 K
2 W
R14
0 TO 250
C3
200 μF
D
C
D3
KD2103
D
R12
5.6 K
KD2103
D5
R2
150
LOAD
R4
150
D4
KD2103
KD2101
Q2
KD2101
Q3
R9
33
R1
15 K
D1
R5
C1
KD2103
4.7 K
2 W
10
μF
10 A
C2
50
μF
Y2
Q1
A1
A2
Q4
KD2102
KD2102
S1
R6
270
Y1
KD2100
A
B
R10
22K
R11
680
R13
22 K
R3
470
B
R8
180
B
A
A
120 V
60 Hz
D
B
T
THERMISTOR


SLAVE CIRCUIT
D1
1N4005
R1
12 k
5 W
C3
0.47 μF
400 V
D6
1N4005
R11
24 k
±5%
2 W
R10
10
RL
LOAD
R2
470
R3
330 k
±5%
R6*
3 k
±5%
R8
220
C4
0.68 μF
400 V
D5
1N
4005
R12
10 k
±5%
2 W
Ig
230 V
60 Hz
R4*
20 k
±5%
R5*
82 k
±5%
D3
MZ2361
Q4
2N5166
Igt MAX
30 mA
Q5
2N5166
Igt MAX
12 mA
C1
40 μF
50 V
2N4870
Q1
D2
MZ2361
TEMP.
C2
40 μF
30 V
Q2
2N3905
Q3
2N5060
D4
MZ2361
R7
10 k
T
RT
R9
4.7 k

*LOW TEMP. COEFFICIENT
FENWELL QR51J1 100 k THERMISTOR

4-KW MODULATED-SCR CONTROL WITH ZERO-POINT SWITCHING—Designed for 230-V a-c line operation. Each time master scr Q4 applies positive half-cycle of power to load, it energizes slave circuit that fires Q5 and applies following negative half-cycle of power to load. Modulation involves dividing line frequency into 12-cycle groups and applying 1 to 12 cycles of each group to load, for modulation in 8% steps from 0 to 100% duty cycle. C2 controls number of cycles per group. Intended primarily for industrial applications where separate transformers are available for supplying banks of heaters, because switching of load power on and off at 6 Hz may cause undesirable flickering of incandescent lamps connected to same line.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–8.

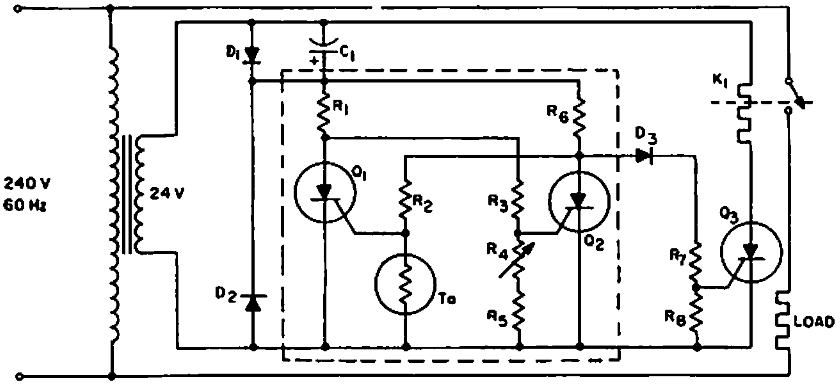

D1
A44F
120V
60~
24V
24V
D2
A44F
T1
120, 24/24
C3
.22
1762
PL1
R2
5W
200
D3
1N1692
R1
10
1W
C1
20μf
50V
R3
68
1W
D4
1N766
6.2 V
R5
TEMP. SET
100
R4
68
D5
1N692
R6
22
R7
33
MV
T2 1:2
C2
.03
D6
TD-3
THERMOCOUPLE
R12 D7
R8
68
1W
R9
300
2
T2
R10
1K
2N2646
UJT
R11
100
SCR
C22F
HEATER
(5Ω)
(120W)
1762
PL2

R_{12}, D_7 OPTIONAL FOR DIFFERENTIAL ACTION (HYSTERESIS)

T_2: SPRAGUE 93Z20

CONTROLLING HEATER AT 800 F—Tunnel diode compares output of thermocouple with reference voltage appearing only at beginning of each half-cycle. When tunnel diode switches, pulse is applied to ujt operating in latching mode, for triggering scr at beginning of each half-cycle. Will hold temperature within 20 F of 800 F set point.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 11.

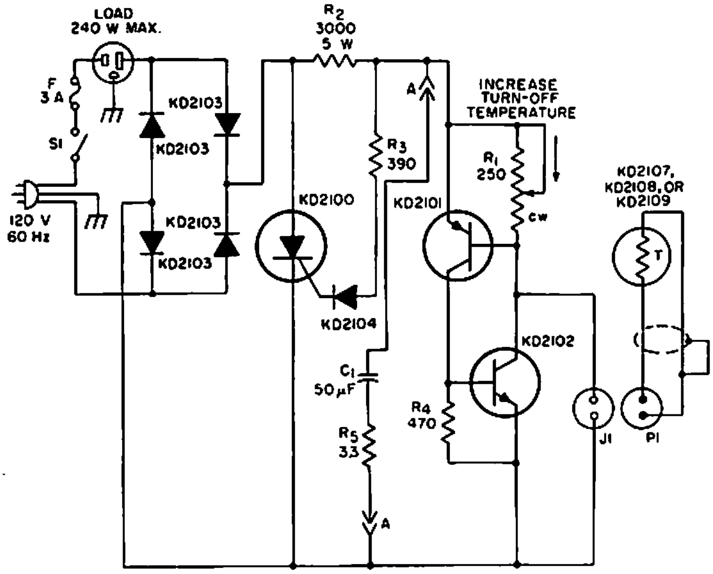
5-KW ON-OFF—Uses half-wave zero-voltage switching to control low-power hot-wire relay that in turn switches large heater or other load operating directly across power line. Feedback element, reference, and error detector (in dashed block) regulate within 0.2% of thermistor resistance over 10% variation in line voltage.—"SCR Manual," 4th Edition, General Electric, 1967, p 281–282.


240 V
60 Hz
24 V
D1
C1
R1
R6
K1
D3
Q1
R2
R3
Q2
R4
Ta
D2
R5
R7
R8
Q3
LOAD

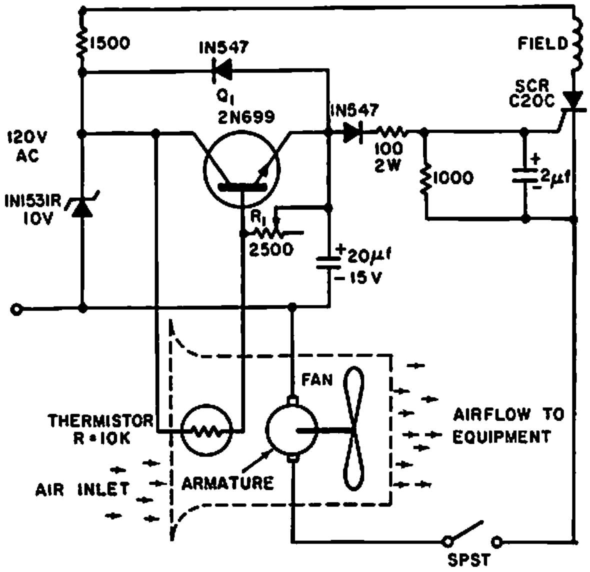
R_1, R6 – 560Ω, 1W
R_2, R_3 – 1.8KΩ
R_4 – 1KΩ POT 1/2 W
R_5 – 100Ω
R_7, R_8 – 1KΩ

C_1 – 20μfd, 100V
Q_1, Q_2, Q_3 – GE C106F
D_1, D_2, D_3 – GE A13A
T_a – GE 20102, 1K@25°C THERMISTOR
K_1 – KING SEELEY 63552 (10Ω COIL)
LOAD – 5KW HEATER

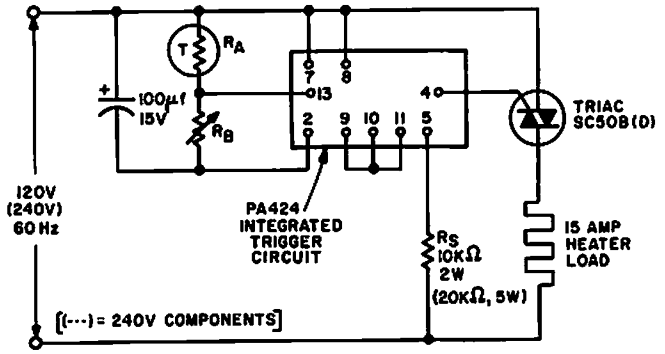
NOTE: ALL RESISTANCES 1/2 W, ±10% UNLESS OTHERWISE SPECIFIED


LOAD
240 W MAX.
F
3 A
S1
120 V
60 Hz
KD2103
KD2103
KD2103
KD2103
R2
3000
5 W
KD2100
KD2104
R3
390
A
INCREASE
TURN-OFF
TEMPERATURE
R1
250
CW
KD2101
KD2102
C1
50μF
R5
33
R4
470
A
KD2107,
KD2108, OR
KD2109
T
J1
P1

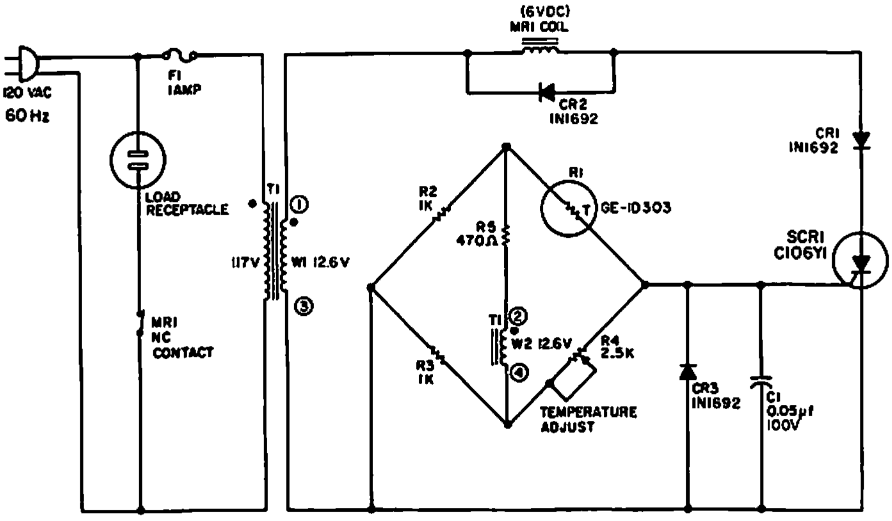
240-W HEATER CONTROL—When thermistor T senses that temperature is below that called for by setting of R1, transistor switch and scr are retriggered early in each succeeding half-cycle of a-c input to give full-wave current through load, without rfi. Optional latching circuit R5-C1 would, if used, keep heater on until line switch S1 is opened.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 113.


1500
1N547
Q1
2N699
1N547
FIELD
SCR
C20C
120V
AC
1N1531R
10V
100
2W
1000
2μf
R1
2500
20μf
15 V
FAN
THERMISTOR
R = 10K
AIRFLOW TO
EQUIPMENT
AIR INLET
ARMATURE
SPST

COOLING FAN CONTROL—Maintains equipment at preselected temperature by adjusting volume of cooling air with fan motor speed control circuit, to compensate for variations in air inlet temperature as sensed by thermistor. Temperature variation of about 10 C will change speed of universal motor linearly from standstill to full speed.—H. B. Opladen, Control Circuit Maintains Constant Operating Temperature, *Electronic Design*, Oct. 26, 1964, p 55–56.

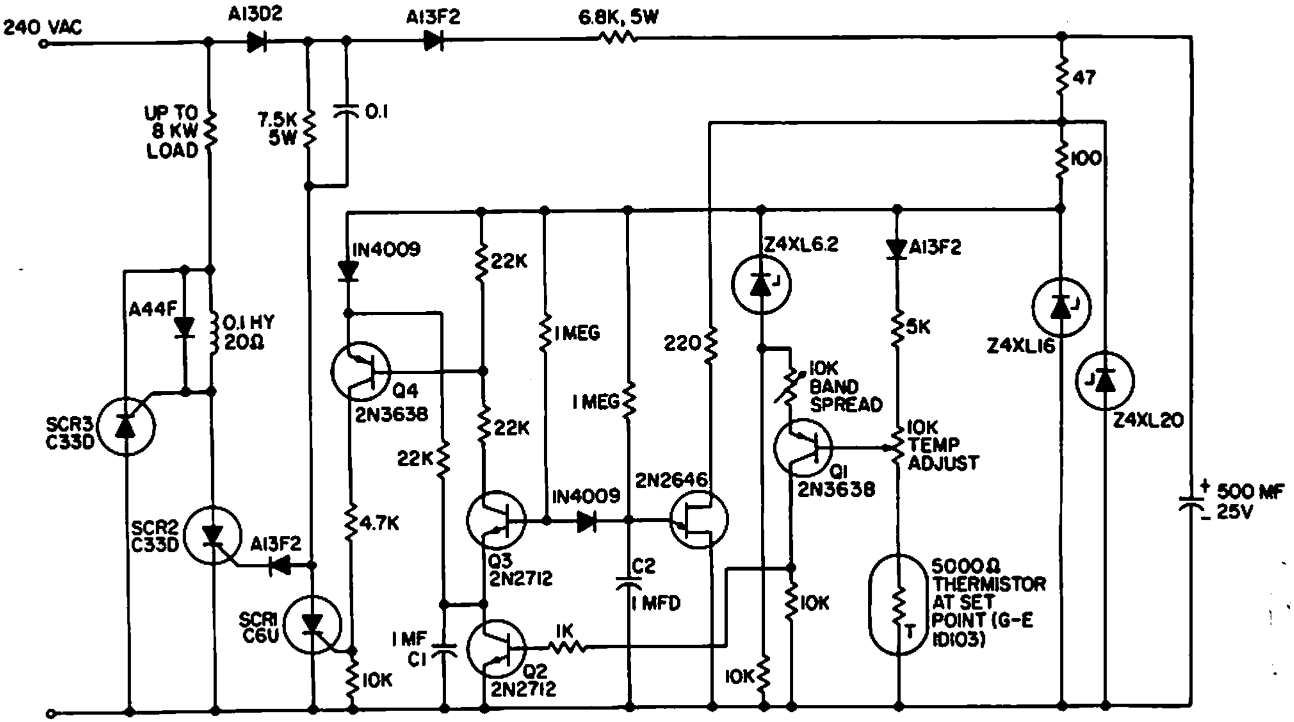

T
RA
+
100µf
15V
RB
7 8
13
4
2 9 10 11 5
TRIAC
SC50B(D)
120V
(240V)
60 Hz
PA424
INTEGRATED
TRIGGER
CIRCUIT
RS
10KΩ
2W
(20KΩ, 5W)
15 AMP
HEATER
LOAD
[(---) = 240V COMPONENTS]

15-A IC-TRIAC HEATER CONTROL—Uses PA-424 IC zero-voltage switching trigger combined with triac to give equivalent of thermostat having differential of less than 0.2 F, response time of only a few seconds, and no rfi. Controlled temperature must fluctuate in order to operate switch, and resultant hunting may be unacceptable for some applications.—E. K. Howell, Integrated Circuits for Sophisticated, Low Cost AC Power Control, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 23.

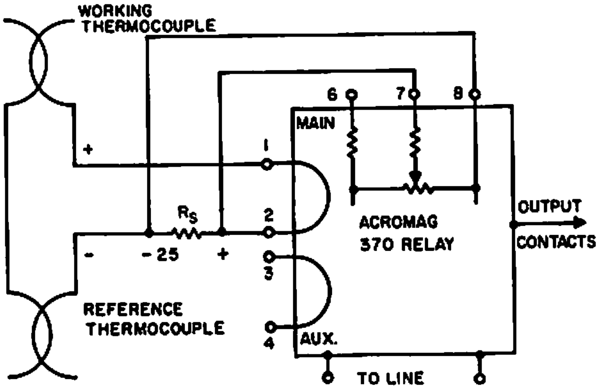

(6VDC)
MR1 COIL
120 VAC
60 Hz
F1
1AMP
CR2
1N1692
CR1
1N1692
LOAD
RECEPTACLE
T1
①
117V
W1 12.6V
③
R1
T
GE-ID303
R2
1K
R5
470Ω
SCR1
C106Y1
MR1
NC
CONTACT
T1
②
W2 12.6V
④
R4
2.5K
R3
1K
TEMPERATURE
ADJUST
CR3
1N1692
C1
0.05µf
100V

T1-UTC FTIO OR EQUIV.

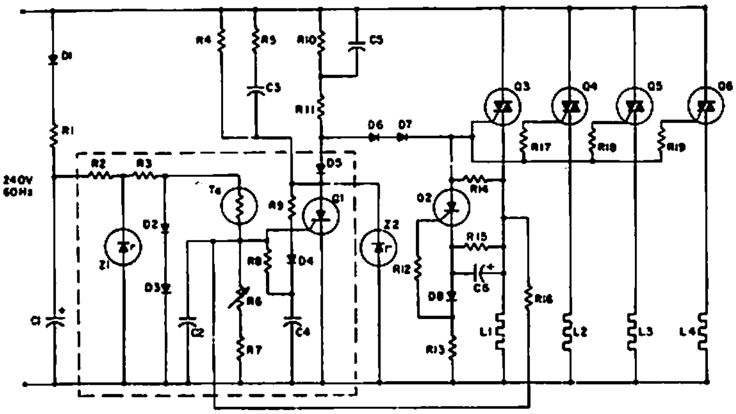
BATH CONTROL—Low-cost thermistor-operated controller is ideal for molten lead and other fluid baths, soldering irons, temperature ovens, and other heat loads. May also be used to control cooling system such as fan or air conditioner, by connecting load to normally open contact on relay or by reversing connections to secondary winding W2 in bridge. Will hold temperature within 1 deg of desired value in range of 20 to 150 F.—D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 30.


240 VAC
A13O2
A13F2
6.8K, 5W
47
UP TO
8 KW
LOAD
7.5K
5W
0.1
100
1N4009
22K
Z4XL6.2
A13F2
A44F
0.1 HY
20Ω
1MEG
220
5K
Z4XL16
Q4
2N3638
1 MEG
10K
BAND
SPREAD
Z4XL20
SCR3
C33D
22K
10K
TEMP
ADJUST
22K
Q1
2N3638
4.7K
1N4009
2N2646
500 MF
25V
SCR2
C33D
A13F2
Q3
2N2712
C2
1 MFD
5000Ω
THERMISTOR
AT SET
POINT (G-E
ID103)
SCR1
C6U
1 MF
C1
1K
10K
Q2
2N2712
10K
10K

PROPORTIONAL CONTROL WITH 8-KW SYNCHRONOUS A-C SWITCH—Under control of thermistor, heater is switched on and off in whole number of cycles, thereby eliminating rfi and making r-f filters unnecessary. High-gain control circuit, consisting of thermistor in bridge followed by error-signal amplifier Q1-Q2 driving SCR2 and SCR3 through Q3, Q4, and SCR1, maintains temperature of system within 1 F of set point.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 11.


WORKING THERMOCOUPLE
6
7
8
MAIN
+
1
Rs
2
-
-25
+
3
ACROMAG 370 RELAY
OUTPUT CONTACTS
REFERENCE THERMOCOUPLE
4
AUX.
TO LINE

THERMOCOUPLE-DRIVEN CONTROLLER—Low-level solid-state relay serves as inexpensive trip control that responds to voltage difference between thermocouples in range of 0–50 mV. Arrangement is particularly useful when ambient temperature is fairly constant.—Microvolt DC Relay Makes Inexpensive Thermocouple Trip, *Electronic Design*, Nov. 29, 1965, p 81.


240V 60Hz
D1
R1
C1
R2
R3
Z1
D2
D3
C2
T4
R8
R6
R7
R4
R5
C3
R9
D4
C4
R10
C5
R11
D5
Q1
Z2
R12
D6
D7
Q2
R14
R15
C6
D8
R13
R16
L1
Q3
Q4
Q5
Q6
R17
R18
R19
L2
L3
L4

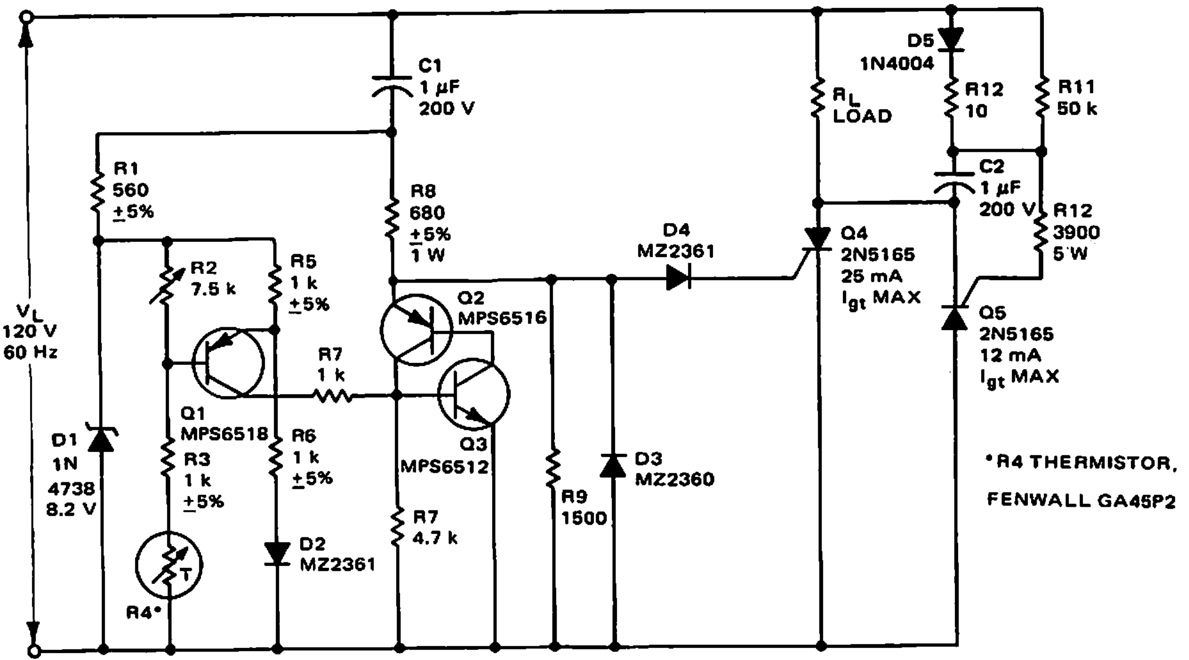
R1 - 22KΩ 2W
R2 - 470Ω
R3 - 5.6KΩ
R4 - 39KΩ, 2W
R5 - 22KΩ, 7W
R6 - 1KΩ POT, 1/2W
R7 - 220Ω
R8 - 220KΩ
R9 - 220KΩ

R10 - 3K, 10W
R11 - 56Ω
R12 - 10KΩ
R13 - 22K, 2W
R14 - 100Ω
R15 - 22KΩ
R16 - 6.8MΩ
R17 - 10Ω
R18 - 10Ω

R19 - 10Ω
C1 - 50μfd, 25V
C2 - .001μfd, 25V
C3 - 0.1μfd, 400V
C4 - 0.47μfd, 25V
C5 - 0.82μfd, 400V
C6 - 5μfd, 15V
Q1, Q2 - GE C106Y1
Q3 THRU Q6 - GE SC46D

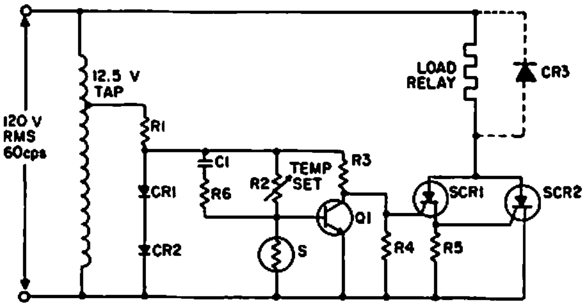
D1, D5, D6, D7 - GE A13D
D2 D3, D8 - GE A13A
D4 - GE A13F
Z1 - GE Z4XL16
Z2 - GE Z4XL91
T4 - GE 2D102 1K@25°C THERMISTOR
L1 THRU L4 - 2.4KW HEATERS
NOTE ALL RESISTORS 1/2 W, ±10% UNLESS OTHERWISE SPECIFIED

9.6-KW ZERO-VOLTAGE SWITCHING—Provides either proportional or on-off control of four 2.4-kW heaters, using master triac Q3 and three slaved triacs Q4-Q5-Q6. Control circuit, in dashed block, consisting of feedback element, reference, and error detector, has regulating accuracy of 0.5% of thermistor resistance for 10% variation in line voltage.—"SCR Manual," 4th Edition, General Electric, 1967, p 280–281.


C1
1 μF
200 V
R1
560
±5%
R2
7.5 k
R5
1 k
±5%
R8
680
±5%
1 W
Q2
MPS6516
D4
MZ2361
VL
120 V
60 Hz
R7
1 k
Q1
MPS6518
R3
1 k
±5%
R6
1 k
±5%
Q3
MPS6512
D1
1N
4738
8.2 V
R4*
D2
MZ2361
R7
4.7 k
R9
1500
D3
MZ2360
D5
1N4004
RL
LOAD
R12
10
R11
50 k
C2
1 μF
200 V
R12
3900
5 W
Q4
2N5165
25 mA
Igt MAX
Q5
2N5165
12 mA
Igt MAX

*R4 THERMISTOR, FENWALL GA45P2

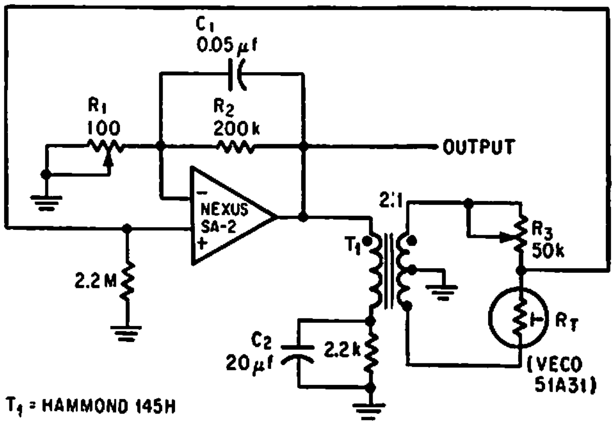
2-KW CONTROL WITH ZERO-POINT SWITCHING—Cycling rate is controlled by temperature, so it will overshoot slightly because of time lag between heat source, surface being controlled, and thermistor R4. Cycling rate can be made slow enough, such as once per minute, so it will not cause objectionable blinking of lights or changes in tv picture size when heater is switched on and off without proportional control.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–11.


120 V
RMS
60cps
12.5 V
TAP
R1
CR1
CR2
C1
R6
R2
TEMP
SET
S
R3
Q1
R4
R5
SCR1
SCR2
LOAD
RELAY
CR3

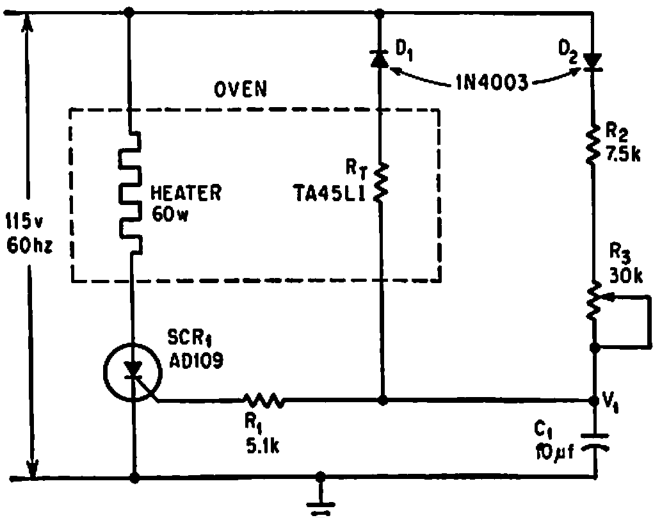
R1 - 28 OHMS, 4W
CR1 - CR2 - G.E. A13F - A14F
R2 - 250 OHM POT.
S - < 1 OHM THRU 100 OHMS
R3 - 1K
R4 - 1K
R6 - 1K
R5 - 1K
LOAD - 12 WATTS TESTED
(RESISTIVE)

Q1 - G.E. 2N3390, 2N3391 OR LOWER GAIN TYPES
SUCH AS 2N2925 OR 2N2711 SERIES.
SCR1 - G.E. C106B } C6B MAY BE SUBSTITUTED
SCR2 - G.E. C106B }

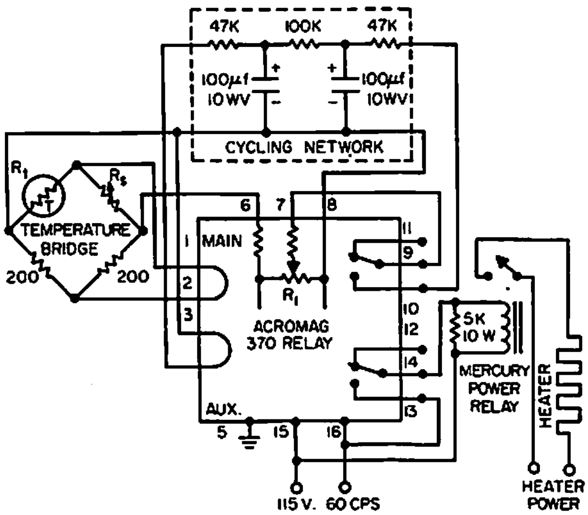
HALF-WAVE CONTROL WITH 1-OHM SENSOR—Uses pulse and pedestal zero-voltage switching, with sensors ranging from fraction of ohm to 100 ohms. Differential is 0.5% of sensor resistance at set temperature. C1 is not needed in this circuit, but may be required when using different type of transformer, to give some differentiation for more zero-voltage switching action. Circuit is best for resistive loads because it is not entirely free from rfi. Diode CR3 (A13B) is not needed if load is thermal relay.—J. L. Brookmire, Temperature Controls Incorporating Zero Voltage Switching, General Electric, Syracuse, N.Y., No. 200.45, 1966, p 5.


C1
0.05 μf
R1
100
R2
200 k
OUTPUT
NEXUS
SA-2
2.2 M
2:1
T1
R3
50k
RT
(VECO
51A31)
C2
20 μf
2.2 k
T1 = HAMMOND 145H

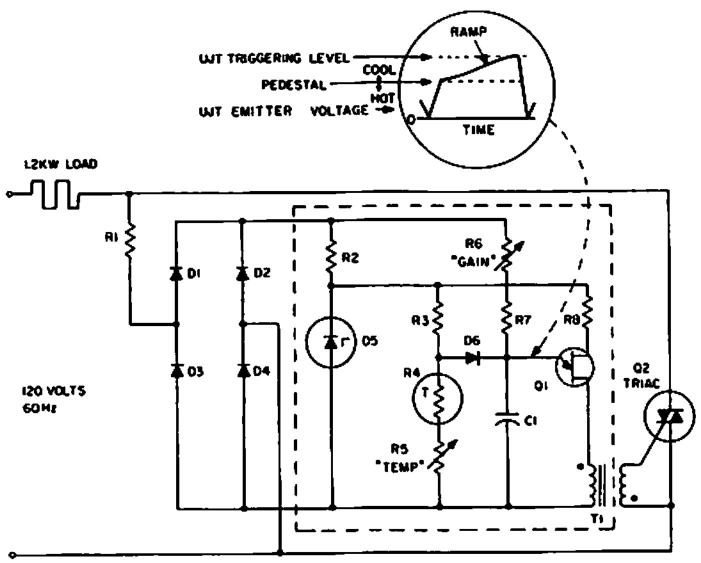
PROPORTIONAL CONTROL WITH OPAMP—Feedback between IC operational amplifier and temperature-sensing bridge gives proportional temperature control and long-term stability. With amplifier operating as 100-Hz oscillator, output power increases as sensed temperature decreases. Response is obtained to changes as small as 0.01 C. Thermistor used as sensor is 100K at 25 C. Article gives design equation.—H. D. Valliant, Exact Temperature Control With Operational Amplifier, *Electronics*, April 3, 1967, p 97–98.


115v
60hz
OVEN
HEATER
60w
RT
TA45L1
D1
D2
1N4003
R2
7.5k
R3
30k
SCR1
AD109
R1
5.1k
V1
C1
10 μf

SCR OVEN CONTROL—Circuit varies charge on capacitor to control firing angle of scr. This, in turn, controls the time that current flows through heating coil, for regulation of oven temperature. Potentiometer R3 adjusts temperature control point.—D. E. La Plante, Scr Triggered by Capacitor Lowers Cost of Oven Control, *Electronics*, Nov. 28, 1966, p 83–84.


47K
100K
47K
100μf
10WV
100μf
10WV
CYCLING NETWORK
R1
Rs
TEMPERATURE
BRIDGE
200
200
6
7
8
1
MAIN
2
3
R1
ACROMAG
370 RELAY
11
9
10
12
14
13
AUX.
5
15
16
5K
10 W
MERCURY
POWER
RELAY
HEATER
115 V. 60 CPS
HEATER
POWER

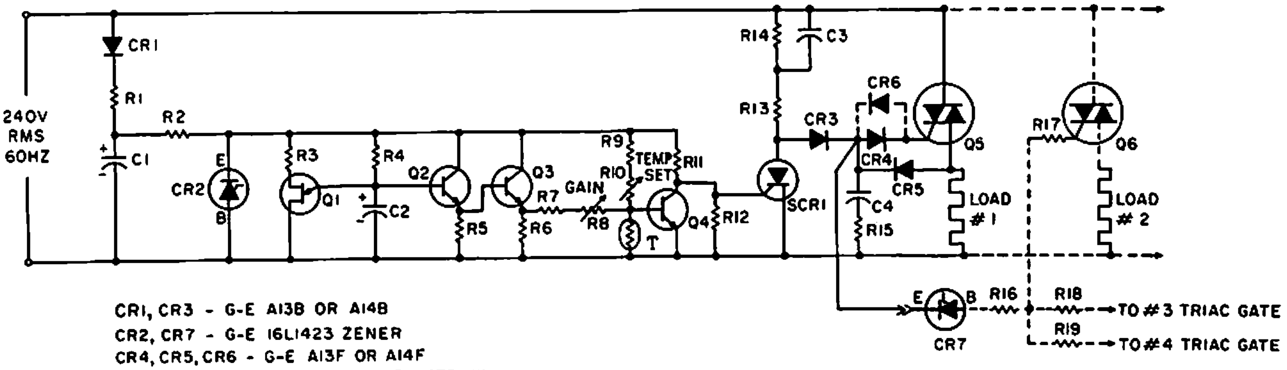
RESPONDS TO 0.02 C CHANGE—Bridge circuit feeding ultrasensitive solid-state relay serves as precision temperature controller for small oven. Rs is adjusted to equal thermistor resistance at desired set-point temperature, which is from 350 ohms at 50 C to 70 ohms at 100 C.—Ultrasensitive Relay Forms Precise Temperature Controller, *Electronic Design*, Nov. 29, 1965, p 76.


RAMP
UJT TRIGGERING LEVEL
COOL
PEDESTAL
HOT
UJT EMITTER VOLTAGE
0
TIME
1.2KW LOAD
R1
D1
D2
D3
D4
120 VOLTS
60HZ
R2
D5
R6
"GAIN"
R3
R7
R8
D6
Q1
R4
T
C1
R5
"TEMP"
Q2
TRIAC
T1

R1,R2 = 2200 OHMS, 2 WATTS
R3 = 4700 OHMS, 1/2 W
R4 = THERMISTOR, APPROX 5000 OHMS AT
OPERATING TEMPERATURE, GE-4H
R5 = 10,000 OHMS W.W. POTENTIOMETER
R6 = 5 MEGOHM POTENTIOMETER
R7 = 100KΩ, 1/2W
R8 = 1000 OHMS, 1/2 W

Q1 = GE 2N2646
Q2 = GE SC46B
T1 = SPRAGUE 35ZM923
OR EQUIVALENT
D1-D4 = GE 1N1693
D5 = GE Z4XL22
D6 = GE 1N1692
C1 = 0.1μfd, 30V

1.2-KW REGULATOR—Phase-controlled precision temperature regulator uses cosine-modified ramp-and-pedestal phase control. Triac supplies full-wave phase-controlled a-c power to heater load. Feedback-circuit thermistor R4 senses temperature for comparison with R5 reference signal in ujt error detector, to control turn-on of triac. Will control temperature to within 2% of thermistor resistance despite 10% variation in line voltage.—"SCR Manual," 4th Edition, General Electric, 1967, p 278–279.

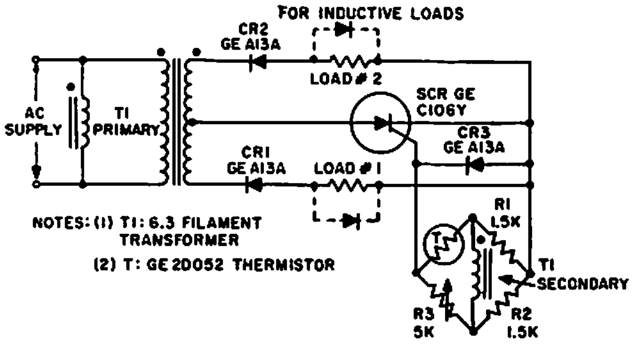

240V
RMS
60HZ
CR1
R1
R2
C1
E
CR2
B
R3
Q1
R4
C2
Q2
Q3
R5
R6
R7
GAIN
R8
R9
R10
TEMP SET
R11
T
Q4
R12
R14
C3
R13
CR3
SCR1
CR6
CR4
CR5
C4
R15
Q5
LOAD #1
R17
Q6
LOAD #2
E
B
CR7
R16
R18
R19
TO #3 TRIAC GATE
TO #4 TRIAC GATE

CR1, CR3 - G-E A13B OR A14B
CR2, CR7 - G-E 16L1423 ZENER
CR4, CR5, CR6 - G-E A13F OR A14F
R1 - 15K, 2W
R2 - 470
R3 - 1K
R4 - 1 MEG.
R5 - 100K
R6 - 1K
R7 - 22K
R8 - 250K POT
R9 - 15K
R10' - 10K POT
R11 - 5.6 K
R12 - 1K
R13 - 56 OHM, 1W
R14 - 3K, 10W

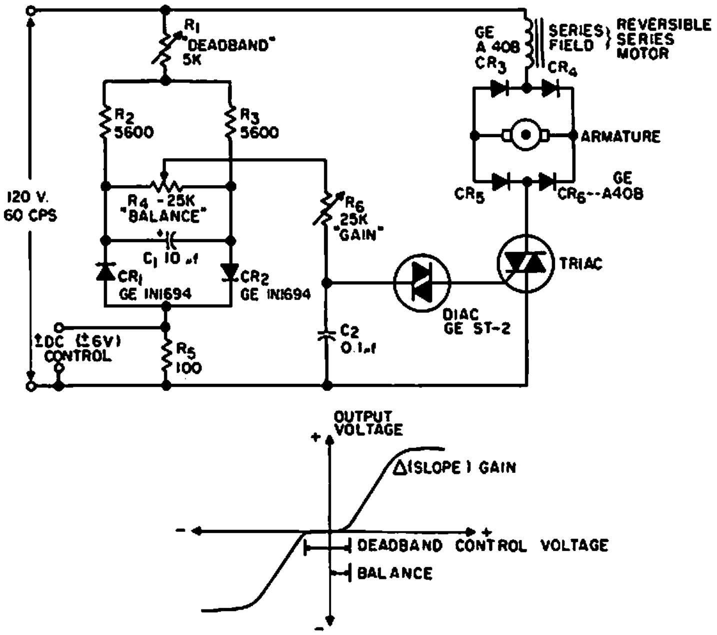
R15 - 470, 1W
R16 - 220
R17, R18, R19 - 100
C1 - 100 μF, 15 WVDC
C2 - 100 μF, 25 WVDC (115 SEC. PERIOD)
C3 - 0.82 μF, 20%, 400 VDC
C4 - 0.47 μF, 20%, 400 VDC
Q1 - G-E 2N2646
Q2, Q3, Q4 - G-E 2N2923
Q5, Q6 - G-E TRIAC (SC45D, 10 AMP
OR SC40D, 6AMP)
SCR1 - G-E C5DX280
T - 2K AT SENSING TEMPERATURE
(G-E BEAD TYPE 818-20202)

FOR 120 VOLT OPERATION	
CHANGE	TO
R1	10K, 1W
R13	150 OHMS, 2W
R14	1.2K, 7W
R15	1K, 2W
C3	2 μF, 200 VDC
C4	1 μF, 200 VDC
SCR1	C106B OR C6B
Q5, Q6	SC40B OR SC45B

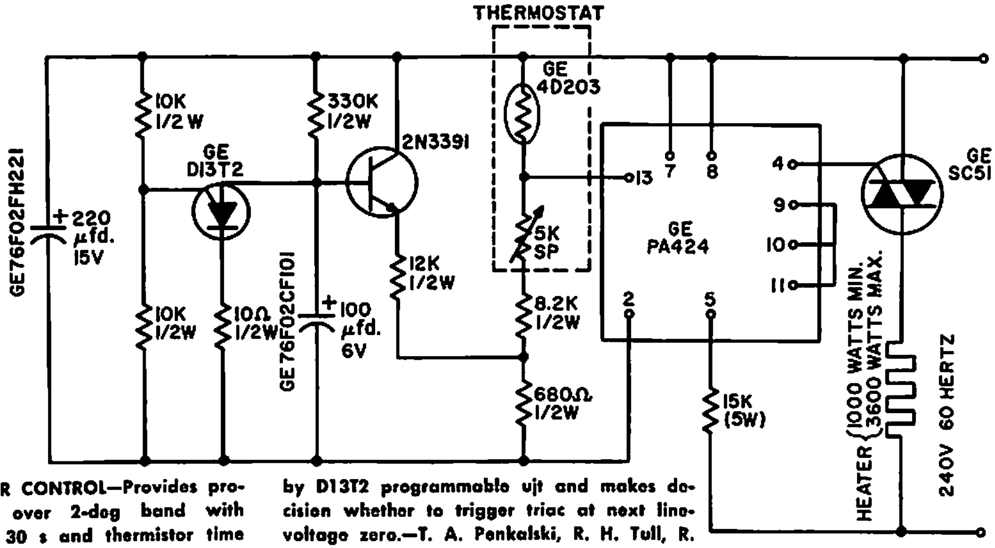
PROPORTIONAL CONTROL WITH RFI SUPPRESSION—Precision control for convection baseboard heating systems and combined central air conditioning and electric heating systems has manually adjustable gain control. At low gain, spread is 21 F from full on to off for load power, and only 2 F for high gain. Load can be over 10 kW. Cycling period (ON plus OFF time) may be changed in steps from 1 to 115 s by changing value of C2; that shown is for 115 s. Circuit includes free-running sawtooth generator Q1-Q2-Q3 whose period of oscillation is determined by C2 and R4. Dashed lines show method of slave-driving additional triacs.—J. L. Brookmire, Proportional Zero Voltage Switching Temperature Control, General Electric, Syracuse, N.Y., No. 201.20, 1966.


FOR INDUCTIVE LOADS
CR2 GE A13A
LOAD # 2
SCR GE C106Y
AC SUPPLY
T1 PRIMARY
CR3 GE A13A
CR1 GE A13A
LOAD # 1
R1 1.5K
T
T1 SECONDARY
R3 5K
R2 1.5K
NOTES: (1) T1: 6.3 FILAMENT TRANSFORMER
(2) T: GE 2D052 THERMISTOR

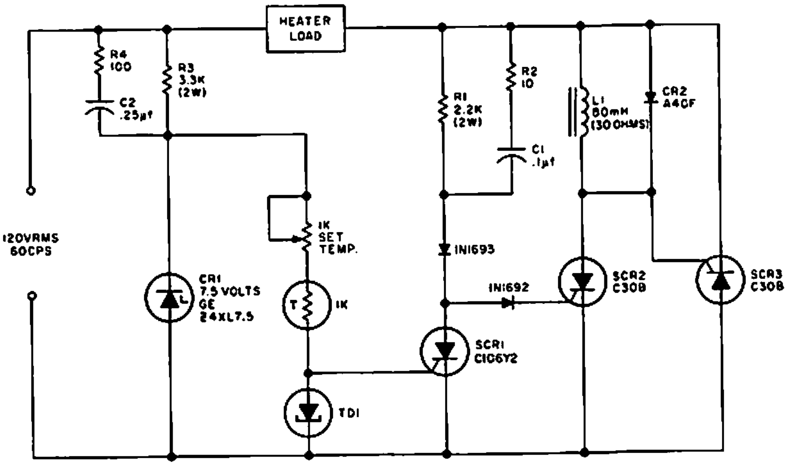
DUAL-OUTPUT MONITOR—Can be used to drive lamps or relays responding to both high and low temperatures. Secondary of T1 is connected inside bridge (lower right). When bridge is balanced, its a-c output is zero and scr receives no gate signal. If bridge is unbalanced by raising or lowering ambient temperature of thermistor T, a-c voltage will appear across gate-cathode of scr, in phase with a-c supply for load-1 current and 180 deg out of phase for load-2 current. Circuit responds to temperature changes of 1 to 2 C.—"SCR Manual," 4th Edition, General Electric, 1967, p 167–168.


R1 "DEADBAND" 5K
R2 5600
R3 5600
R4 - 25K "BALANCE"
C1 10 µf
CR1 GE 1N1694
CR2 GE 1N1694
R6 25K "GAIN"
C2 0.1 µf
120 V. 60 CPS
±DC (±6V) CONTROL
R5 100
DIAC GE ST-2
TRIAC
GE A 408 CR3
SERIES FIELD
REVERSIBLE SERIES MOTOR
CR4
ARMATURE
CR5
GE CR6--A408
OUTPUT VOLTAGE
Δ(SLOPE) GAIN
DEADBAND
CONTROL VOLTAGE
BALANCE

10-KW CLIMATE-CONTROLLED HEATER—When temperature drops below reference level determined by setting of 5K rheostat, left-hand 2N3417 transistor of differential input stage conducts more and turns on 2N3251 to give faster pulsing of 2N489 ujt. As a result, triac is triggered more often through output transistor and transformer, to increase heater load current.—D. Cooper, SCR's and Triacs—the Revolution Continues, *Electronics World*, Aug. 1968, p 25–28.


THERMOSTAT
GE 4D203
10K 1/2 W
GE D13T2
330K 1/2W
2N3391
GE76F02FH221
+220 µfd. 15V
10K 1/2W
10Ω 1/2W
GE76F02CF101
+100 µfd. 6V
12K 1/2W
5K SP
8.2K 1/2W
680Ω 1/2W
GE PA424
13
7
8
4
9
10
11
2
5
15K (5W)
GE SC51DX1
HEATER {1000 WATTS MIN. 3600 WATTS MAX.
240V 60 HERTZ

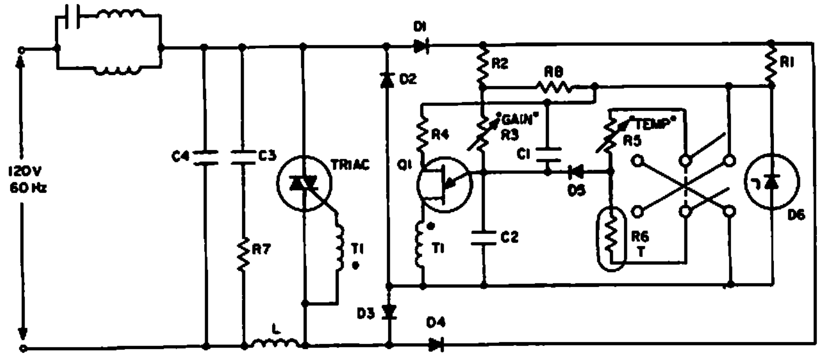
3,600-W IC HEATER CONTROL—Provides proportional control over 2-deg band with repetition rate of 30 s and thermistor time constant of 19 s. IC compares thermostat information with reference sawtooth generated by D13T2 programmable ujt and makes decision whether to trigger triac at next line-voltage zero.—T. A. Penkalski, R. H. Tull, R. C. Cape, Optimum Solid State Control Parameters for Improved Performance of In-Space Electric Heating Systems, General Electric, Syracuse, N.Y., No. 671.12, 1968, p 53.


HEATER LOAD
R4 100
C2 .25μf
R3 3.3K (2W)
120VRMS 60CPS
CR1 7.5 VOLTS GE 24XL7.5
1K SET TEMP.
T 1K
TD1
R1 2.2K (2W)
R2 10
C1 .1μf
IN1693
IN1692
SCR1 C106Y2
L1 80mH (30 OHMS)
CR2 A40F
SCR2 C30B
SCR3 C30B

TDI :- GE IN2930 OR RCA 40065

PRECISION 1.5-KW HEATER CONTROL—Will maintain load temperature within 1 F of set point. Thermistor should be about 1K at set point. Article describes circuit operation. —D. R. Grafham, Using Low Current SCR's, General Electric, Syracuse, N.Y., No. 200.19, 1967, p 34.

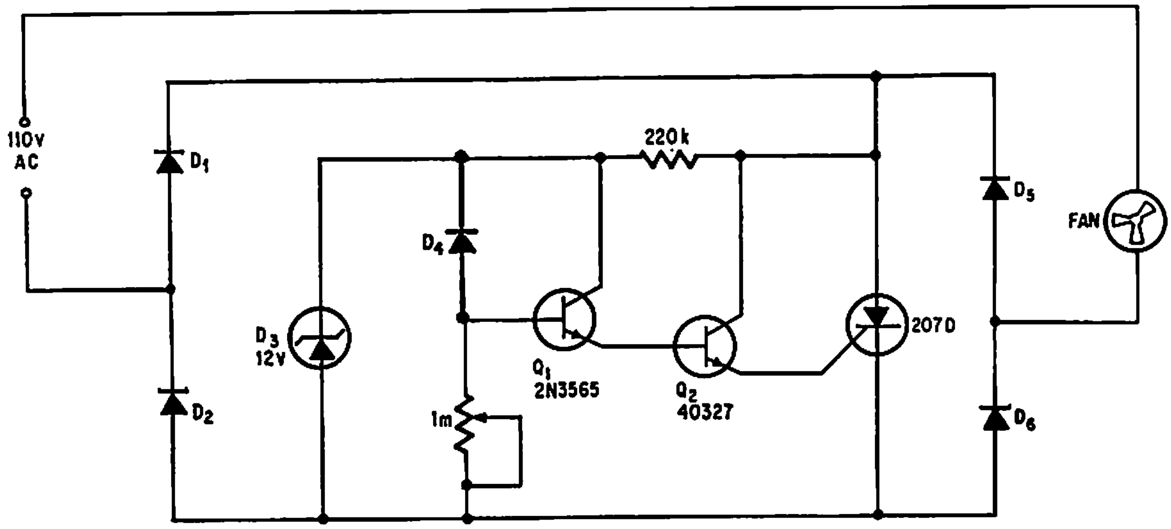
SHADED-POLE BLOWER MOTOR CONTROL—Arrangement shown is for heating applications requiring sophisticated ramp-and-pedestal system having high control gain, for shaded-pole or psc motors, in response to thermistor. When used to control cooling coil temperature of air conditioner to prevent freeze-up, R5 and R6 should be interchanged. Thermistor R6 should be somewhere between 3,000 and 5,000 ohms at temperature desired. R5 should be set to provide full-on control at desired upper temperature limit, and R3 then set for full-off or zero-speed condition at desired lower-temperature limit of R6. Circuit includes r-f noise suppression.—"SCR Manual," 4th Edition, General Electric, 1967, p 220–221.


120V 60Hz
C4
C3
R7
TRIAC
T1
L
D1
D2
D3
D4
R2
R8
R4
"GAIN" R3
C1
Q1
D5
T1
C2
"TEMP" R5
R6 T
D6
R1

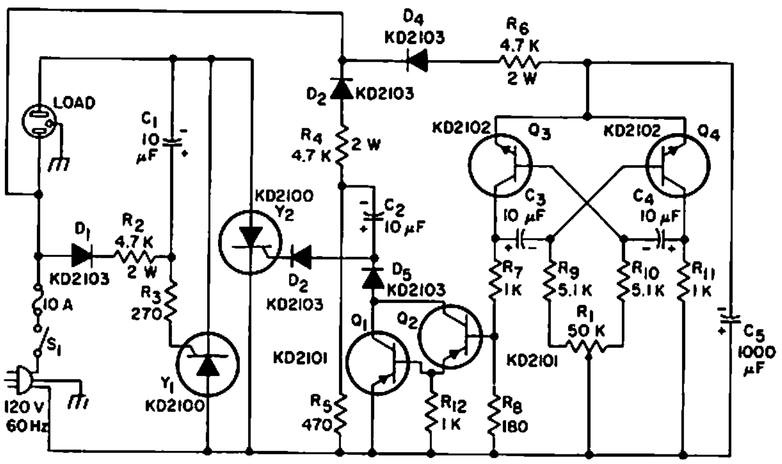
D1→D4 : GE A14B
D5 : GE A14 A
D6 : GE IN1776
Q1 : GE 2N2646
C1 & C2 : 0.1μf, 50V

R1 : 6800Ω 2W
R2 : 470KΩ 1/2W
R3 : 5 MEG 1/2W
R4 : 1KΩ 1/2W
R5 : 10KΩ 1W
R6 : SEE NOTE

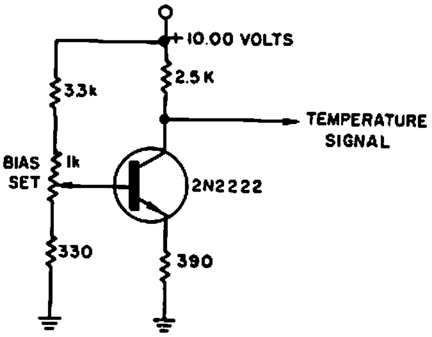
R7 : 33Ω 1/2W
C3 : 0.02μf, 200V
T1 : XFMR 1:1
: SPRAGUE 11Z12 OR EQUIV.
C4 : 0.1μf 400V
R8 : 470KΩ 1/2W


110V AC
D1
D2
D3 12V
D4
220k
1m
Q1 2N3565
Q2 40327
2N3565
2070
D5
D6
FAN

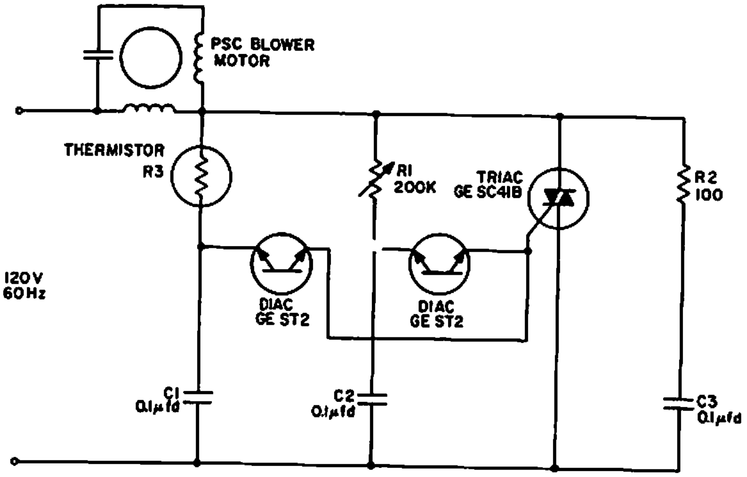
COOLING FAN CONTROL—Ordinary series-connected a-c fan in simple speed-control circuit holds temperature of condensed mercury in high-voltage thyratron within 0.5 C of constant temperature. Germanium diode D4, glued to outside of tube in condensed mercury region, serves as sensor. Temperature-dependent reverse current of diode, regulated by 1-meg pot, is amplified by Q1-Q2 to vary firing angle of scr and change speed of fan.—Y. Alon and M. Jonas, Diode Controls Speed of Fan That Cools a Thyratron, *Electronics*, Jan. 6, 1969, p 95.


LOAD
C1 10 μF
D4 KD2103
R6 4.7 K 2 W
D2 KD2103
R4 4.7 K 2 W
KD2102 Q3
KD2102 Q4
KD2100 Y2
C2 10 μF
C3 10 μF
C4 10 μF
D1 KD2103
R2 4.7 K 2 W
R3 270
D2 KD2103
D5 KD2103
R7 1K
R9 5.1 K
R10 5.1 K
R11 1K
10 A
S1
Q1
Q2
KD2101
R1 50 K
KD2101
C5 1000 μF
120 V 60 Hz
Y1 KD2100
R5 470
R12 1 K
R8 180

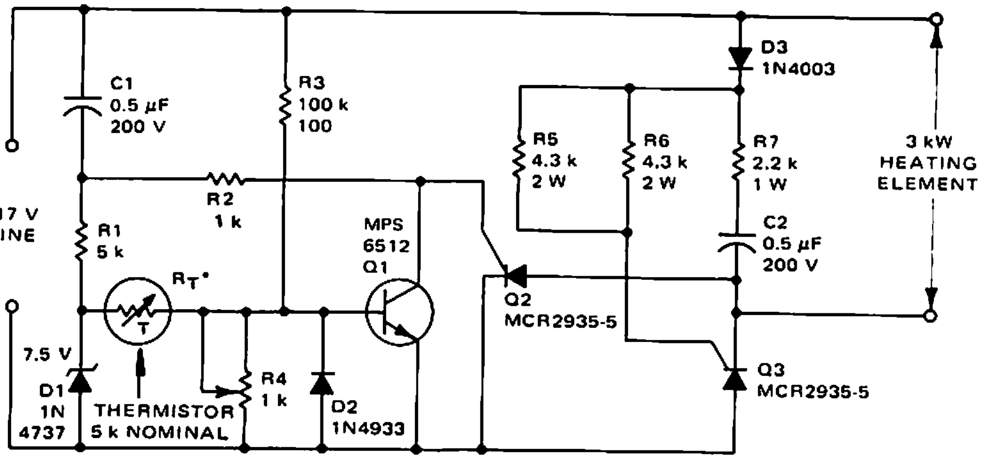
COFFEE WARMER—R1 is adjusted manually to give desired ratio of conducting to nonconducting time of load, over conduction range of 5 to 95%, with switching occurring only when input a-c voltage passes through zero point. Circuit is excellent for electric coffee pots, electric blankets, soldering irons, and other heater loads up to 1 kW. Does not produce rfi.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 130.


+10.00 VOLTS
33k
2.5 K
TEMPERATURE SIGNAL
BIAS SET
1k
2N2222
330
390

TRANSISTOR SENSOR—Single transistor, with collector connected to case for fast response to thermal changes, provides high-level output with linearity of 1% from −40 to +125 C.—J. M. Lee, Linear Temperature Sensor Uses Only a Single Transistor, *Electronic Design*, Feb. 15, 1970, p 86 and 88.

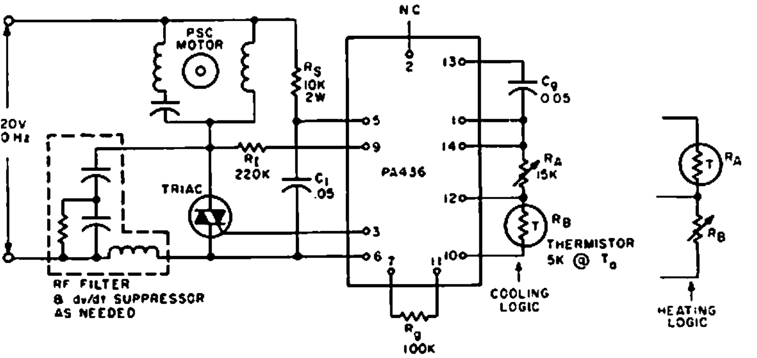

PSC BLOWER MOTOR
THERMISTOR R3
R1 200K
TRIAC GE SC41B
R2 100
120V 60Hz
DIAC GE ST2
DIAC GE ST2
C1 0.1μfd
C2 0.1μfd
C3 0.1μfd

FURNACE BLOWER CONTROL—Thermistor R3 responds to changes in air temperature to control a-c power supplied to blower induction motor. R1 and its phase control network set minimum blower speed, to provide continuous air circulation and maintain lubrication of motor bearings.—"SCR Manual," 4th Edition, General Electric, 1967, p 219–220.

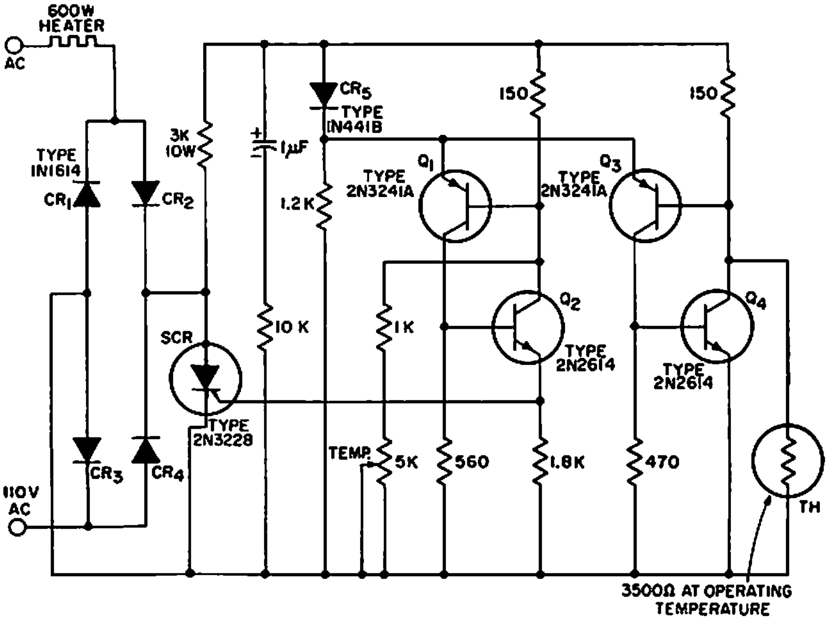

C1 0.5 μF 200 V
R3 100 k 100
D3 1N4003
R5 4.3 k 2 W
R6 4.3 k 2 W
R7 2.2 k 1 W
3 kW HEATING ELEMENT
117 V LINE
R1 5 k
R2 1 k
MPS 6512 Q1
C2 0.5 μF 200 V
RT*
Q2 MCR2935-5
7.5 V
D1 1N 4737
THERMISTOR 5 k NOMINAL
R4 1 k
D2 1N4933
Q3 MCR2935-5

*Thermistor, 5 k nominal. Mount in proximity of heated area.

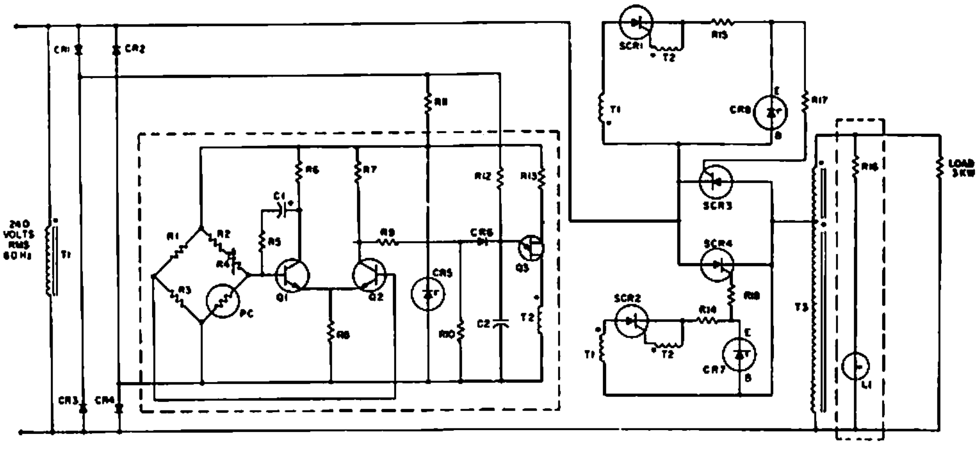
3-KW CONTROL WITH ZERO-POINT SWITCHING—Load switching is done only at zero point of a-c line voltage, to prevent electromagnetic interference. Power is applied to load in full cycles.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–6.


120V
60 Hz
PSC MOTOR
R_S 10K 2W
NC
2
13
5
10
9
14
R_f 220K
PA436
R_A 15K
C_1 .05
12
TRIAC
3
R_B
THERMISTOR 5K @ T_0
6
7
11
10
C_g 0.05
RF FILTER
& dv/dt SUPPRESSOR
AS NEEDED
R_g 100K
COOLING LOGIC
R_A
R_B
HEATING LOGIC

IC BLOWER CONTROL—Uses PA436 phase-control IC with triac to drive psc blower or fan motor. Cooling application is shown. For room-heating fan, thermistor and RA are reversed as at right so increase in temperature will reduce fan speed. Triac should match motor rating.—E. K. Howell, Applications of the PA436 Monolithic Integrated Phase-Control Trigger Circuit, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 12.


600W HEATER
AC
TYPE 1N1614
CR_1
CR_2
3K 10W
1μF
CR_5 TYPE 1N441B
150
150
1.2K
TYPE 2N3241A
Q_1
TYPE 2N3241A
Q_3
Q_2
Q_4
SCR
10 K
1K
TYPE 2N2614
TYPE 2N2614
TYPE 2N3228
CR_3
CR_4
110V AC
TEMP.
5K
560
1.8K
470
TH
3500Ω AT OPERATING TEMPERATURE

HALF-WAVE SCR 600-W HEATER CONTROL—Regulates temperature within 0.2 C, using single scr in rectifier bridge.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 254.


CR1
CR2
240 VOLTS RMS 60 Hz
T1
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
C1
C2
CR5
CR6
CR7
CR8
Q1
Q2
Q3
T2
PC
SCR1
SCR2
SCR3
SCR4
T3
L1
LOAD 3KW
CR3
CR4

CR1 THRU CR4 - GE A130
CR5 - GE Z4XL22
CR6 - GE A13F
CR7, CR8 - GE 1GLM23
C1 - 10μf, 25 VDC GE 62F204
MINIATURE TUBULAR WET SLUG CAP
C2 - 0.22μf, 50VDC
±10% GE 75F3R5-244A
Q1, Q2 - GE 2N2923

Q3 - GE 2N2646
SCR1, SCR2 - GE C6U or C106Y
SCR3, SCR4 - GE C155E or C35E
T1 - 220 V RMS PRIMARY
12 V RMS SECONDARY
100 MA RMS RATED
SECONDARY CURRENT
T2 - PULSE TRANSFORMER (1:1)
ALADDIN PART NO 90-2398

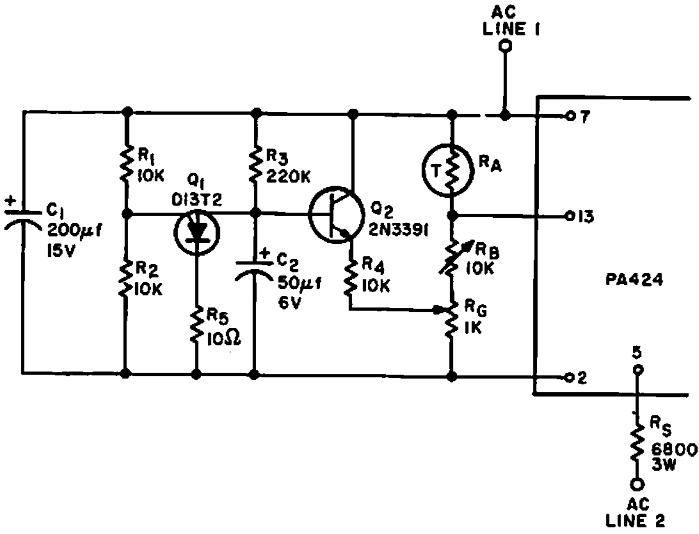
T3 - TURNS RATIO 1:1.62, 4KVA
R1 - 22KΩ
R2 - 2.2KΩ
R3 - 18KΩ
R4 - 10KΩ MULTI-TURN TRIM POT
R5 - 10KΩ
R6 - 2.2KΩ
R7 - 2.2KΩ
R8 - 2.2KΩ

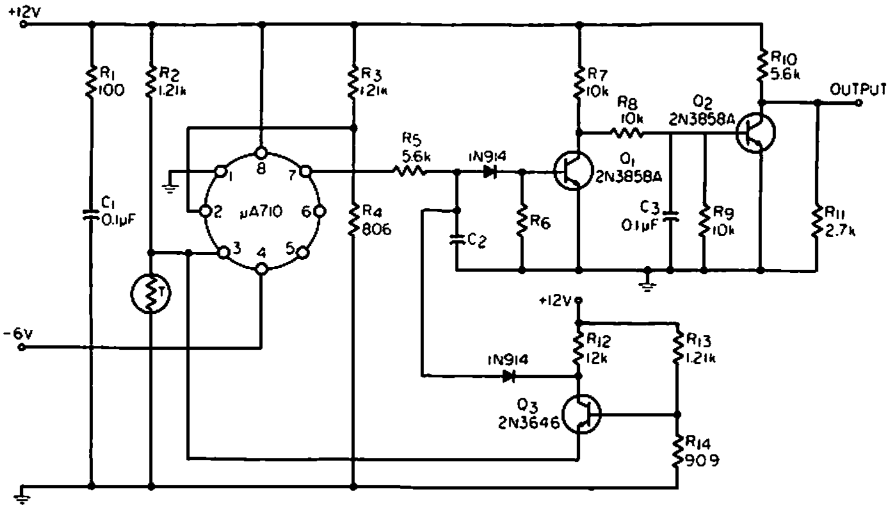
R9 - 56KΩ
R10 - 47KΩ
R11 - 8.2KΩ, 10WATT
R12 - 1.5 MEG Ω
R13 - 1KΩ
R14, R15 - 22Ω 2W
R16 - 9K ± 5%, 1/4 WATTS
R17 - 33Ω, 2W
R18 - 33Ω, 2W

L1 - INCANDESCENT LAMP OF GE PL5B1 (LAMP-PHOTOCELL) INTEGRAL HERMETICALLY SEALED UNIT
PC - CADMIUM SULFIDE PHOTOCELL OF GE PL5B1 (LAMP-PHOTOCELL) INTEGRAL HERMETICALLY SEALED UNIT
ALL RESISTORS ± 10% AND 1/2 WATT EXCEPT WHERE INDICATED

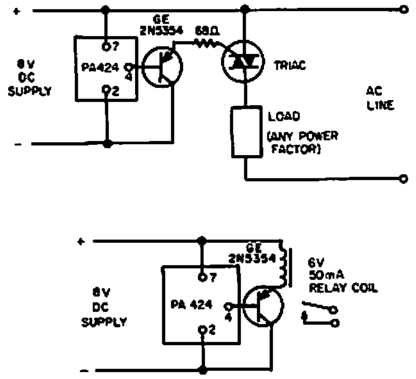
3-KW PHASE-CONTROLLED—Regulates rms value of unfiltered phase-controlled voltage across heater or other resistive load. Lamp in parallel with load, shining on photocell, provides required long averaging time constant. Stability against voltage and temperature variations is achieved with differential amplifier and ujt, ramp-and-pedestal phase-control, and ujt working with scr's.—"SCR Manual," 4th Edition, General Electric, 1967, p 282–283.

HIGH-GAIN IC PROPORTIONAL CONTROL—Uses PA424 IC zero-voltage switching trigger fed by thermistor in external circuit that provides narrow, adjustable proportional band that makes heater power proportional to error of measured temperature from set point. SC50B (triac) and 15-A heater load are connected between a-c lines 1 and 2, with triac gate going to terminal 4 (not shown) of IC. Gives precise and stable control of temperature. Article describes circuit operation in detail.—E. K. Howell, Integrated Circuits for Sophisticated, Low Cost AC Power Control, General Electric, Syracuse, N.Y., No. 671.9, 1968, p 23.

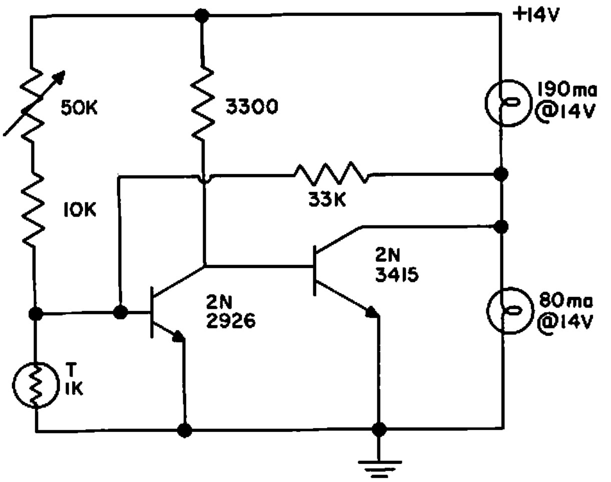

AC LINE 1
7
13
PA424
5
2
C1 200μf 15V
R1 10K
R2 10K
Q1 D13T2
R5 10Ω
R3 220K
C2 50μf 6V
Q2 2N3391
R4 10K
T
RA
RB 10K
RG 1K
RS 6800Ω 3W
AC LINE 2


+12V
-6V
R1 100
R2 1.21k
C1 0.1μF
T
R3 1.21k
R4 806
1
2
3
4
5
6
7
8
μA710
R5 5.6k
1N914
C2
R6
R7 10k
R8 10k
Q1 2N3858A
C3 0.1μF
R9 10k
Q2 2N3858A
R10 5.6k
R11 2.7k
OUTPUT
+12V
R12 12k
R13 1.21k
1N914
Q3 2N3646
R14 909

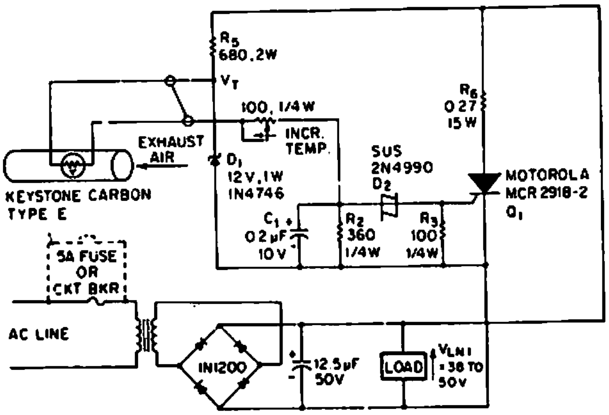
FAIL-SAFE THERMOMETER—Circuit delivers output pulse conventionally when temperature at PTC thermistor T reaches predetermined critical value, and in addition gives output pulse if thermistor opens or shorts. In either case, output pulse shuts down associated industrial control system. Circuit is capable of distinguishing between shorted thermistor and one having 30 ohms resistance. IC operates as differential comparator. —G. J. Granieri, Fail-Safe Temperature Sensor, *EEE*, Sept. 1967, p 132–133.


+
8V DC SUPPLY
-
7
PA424
4
2
GE 2N5354
68Ω
TRIAC
LOAD (ANY POWER FACTOR)
AC LINE
+
8V DC SUPPLY
-
PA 424
7
4
2
GE 2N5354
6V 50mA RELAY COIL

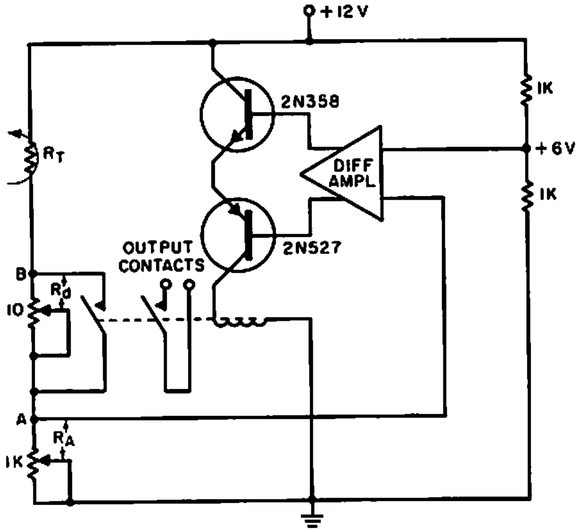
IC ZERO-VOLTAGE SWITCH—Can be used for temperature control, driving relay from 8-V d-c source. For larger loads, transistor can be used to trigger triac. Integrated circuit here acts as combination threshold detector and trigger circuit. Applications include photoelectric and heater control.—Integrated Circuit Zero Voltage Switch PA424, General Electric, Syracuse, N.Y., No. 85.21, 3/69.


+14V
50K
3300
190ma @14V
33K
10K
2N 2926
2N 3415
80ma @14V
T 1K

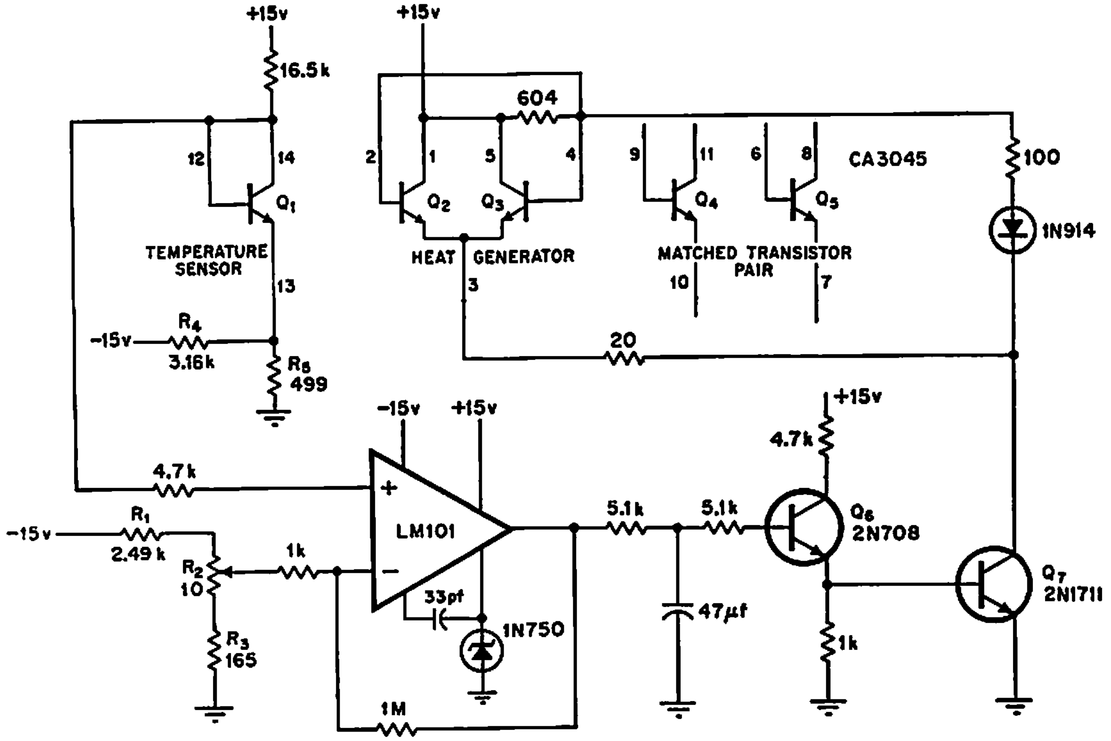
AIR-CONDITIONER MONITOR—Bottom lamp is on at low temperatures, and top lamp when temperature rises above set point. Cost of all parts required is under $1.—R. M. Muth, Digital Circuits with Visual Readouts, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 9.


R5
680.2W
VT
100, 1/4W
INCR. TEMP.
EXHAUST AIR
D1
12V,1W
1N4746
KEYSTONE CARBON
TYPE E
5A FUSE
OR
CKT BKR
AC LINE
1N1200
12.5μF
50V
LOAD
VLN1
=38 TO
50V
C1
0.2μF
10V
R2
360
1/4W
R3
100
1/4W
SUS
2N4990
D2
R6
0.27
15W
MOTOROLA
MCR2918-2
Q1

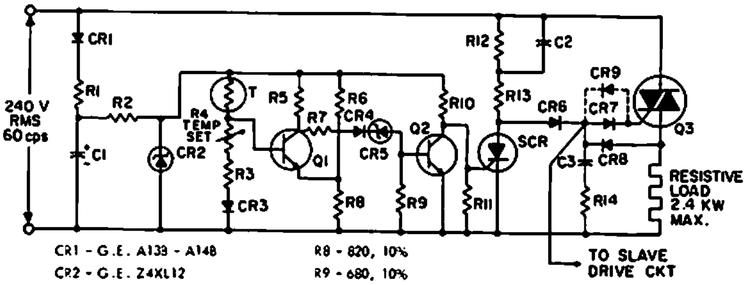
AIR TEMPERATURE AND VELOCITY—Used to sense overheating of power supply. If ambient temperature exceeds predetermined limit for combination of exhaust air or if forced air cooling supply fails, scr fires and blows fuse or opens circuit breaker.—H. Green, Thermistor Circuit Senses Air Temperature and Velocity, *EEE*, March 1969, p 124 and 126.


+12V
2N358
1K
+6V
DIFF AMPL
1K
RT
OUTPUT CONTACTS
2N527
B
Rd
10
A
RA
1K

ADJUSTABLE DEAD ZONE—Uses IC differential amplifier in bridge with two transistors for on-off temperature control having excellent stability at set value. Voltage gain of IC should be above 20,000, and output impedance about 1K. Stability can be improved still more by using platinum resistance thermometer in place of temperature-sensitive resistor RT. Rd sets dead zone.—L. R. Long, Adjustable Dead Zone Improves Temperature-Controller Stability, *Electronic Design*, July 6, 1964, p 52.


+15v
16.5k
12
14
Q1
TEMPERATURE SENSOR
13
R4
-15v
3.16k
R5
499
+15v
604
2
1
5
4
Q2
Q3
HEAT GENERATOR
3
9
11
6
8
Q4
Q5
CA3045
MATCHED TRANSISTOR PAIR
10
7
100
1N914
20
-15v
+15v
4.7k
LM101
R1
-15v
2.49k
R2
10
R3
165
1k
33pf
1N750
1M
5.1k
5.1k
47μf
+15v
4.7k
Q6
2N708
1k
Q7
2N1711

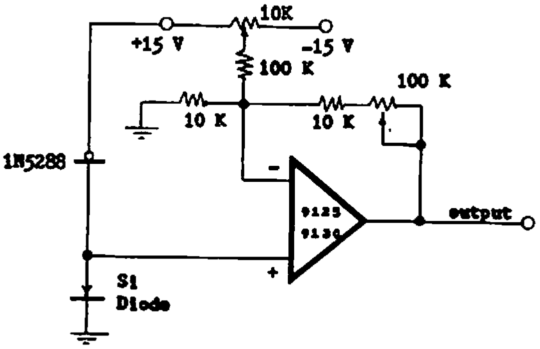
SUBSTRATE TEMPERATURE CONTROL—Q1 serves as temperature sensor and Q2-Q3 as heater for holding Q4-Q5 at desired ambient temperature to hold input offset voltage of matched pair below 5 mV over 300-MHz bandwidth.—D. P. DeAngelis and M. Palumbo, Regulator Holds Temperature of Chip's Substrate Constant, *Electronics*, Feb. 2, 1970, p 100.



240 V RMS 60 cps
CR1
R1
R2
C1
CR2
R4 TEMP SET
T
R3
CR3
R5
R6
R7
CR4
Q1
CR5
Q2
R8
R9
R10
R11
R12
C2
R13
CR6
CR9
CR7
Q3
SCR
C3
CR8
R14
RESISTIVE LOAD 2.4 KW MAX.
TO SLAVE DRIVE CKT

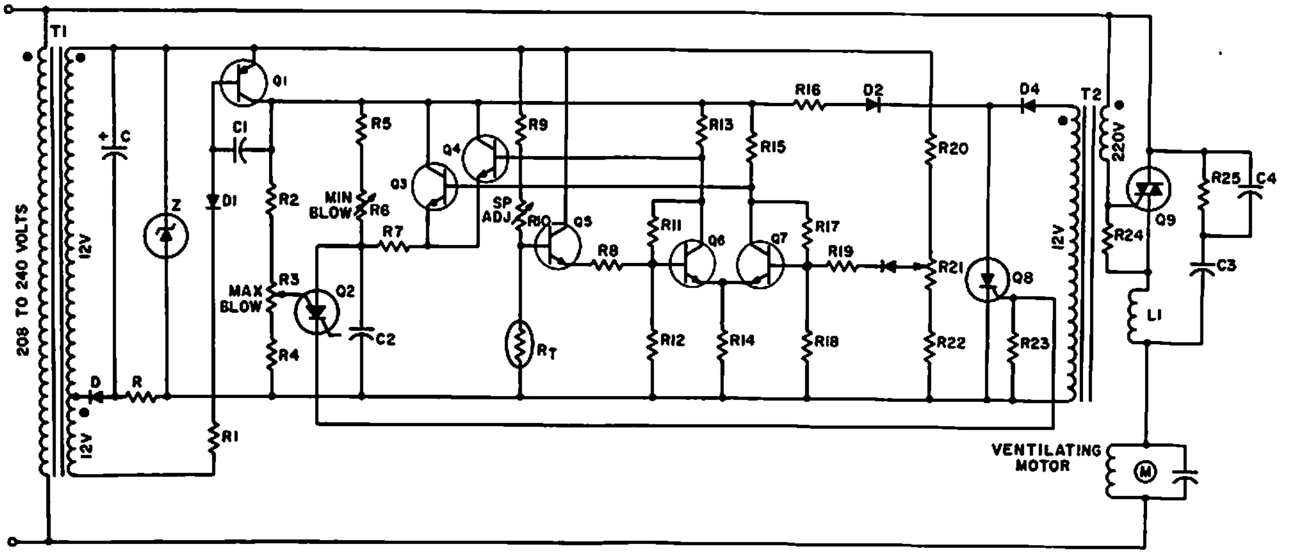
CR1 - G.E. A13B - A14B
CR2 - G.E. Z4XL12
CR3 - G.E. 1N4009
CR4 - G.E. 1N4009
CR5 - G.E. 16L1423 ZENER
CR6 - A13B - A14B
CR7 - A13F - A14F
CR8 - A13F - A14F
CR9 - A13F - A14F
R1 - 10K, 2W
R2 - 330, 10%
R3 - 47K
R4 - 50K POT.
R5 - 1K, 10%
R6 - 3.3K, 10%
R7 - 1.5K, 10%
R8 - 820, 10%
R9 - 680, 10%
R10 - 10K, 10%
R11 - 1K
R12 - 3K, 10W
R13 - 56, 1W
R14 - 470, 1W
C1 - 100 UF, 20W VDC
C2 - 0.82 UF, 20%, 400 VDC
C3 - 0.47 UF, 20%, 400 VDC
Q1 - Q2 - G.E. 2N3390 - MAY SUBSTITUTE 2N3391
Q3 - 400 VOLT, 10 AMP TRIAC - G.E. SC45D - 10 AMP
G.E. SC40D - 6 AMP
SCR - G.E. C5DX280
T - GLASS COATED BEAD, 100K AT SENSING TEMP.
G.E. TYPE 81810401 - 100K AT 25°C

HIGH-PRECISION FULL-WAVE SEMIPROPORTIONAL—Provides zero-voltage switching. May be used to slave-drive additional triac-load combinations each having all components at right of R11. CR9 may be omitted if only one triac is being driven. Differential is 0.1 F above and below set temperature. Article gives changes required for 120-V operation, at which differential is better than twice as good.—J. L. Brookmire, Temperature Controls Incorporating Zero Voltage Switching, General Electric, Syracuse, N.Y., No. 200.45, 1966, p 6.



+15 V
10K
-15 V
100 K
100 K
10 K
10 K
1N5288
9125
9136
output
Si Diode

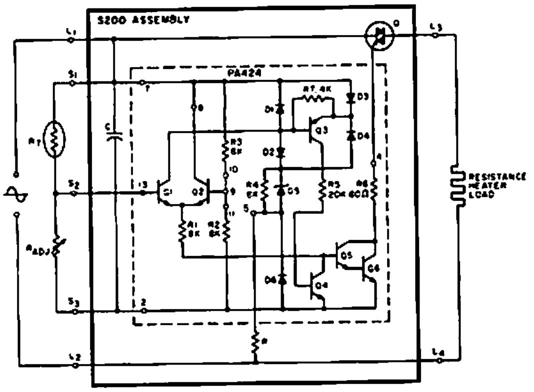
INDUSTRIAL THERMOMETER—Temperature-sensing silicon junction diode, driven by 1N5288 current-limiting diode giving true constant-current operation, drives panel meter through OEI Model 9125 opamp. Sensing diode should be on probe using shielded cable. Temperature coefficient of diode is −1.5 to −2 mV per deg C, which remains constant over wide range of temperatures. Can be calibrated in water-ice slurry and in boiling water.—Two Electronic Thermometers for Medical/Industrial Use, Optical Electronics, Tucson, Ariz., No. 10075.



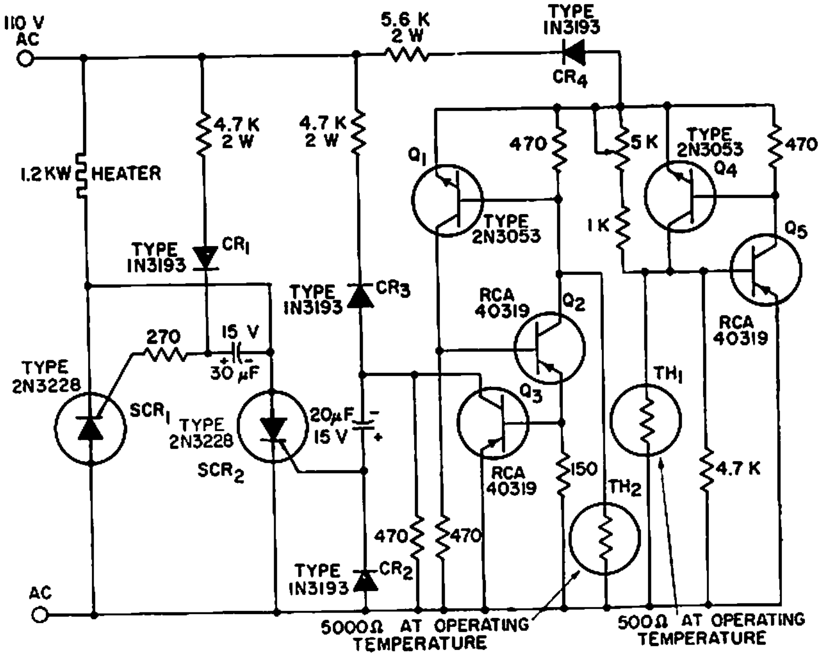
208 TO 240 VOLTS
T1
12V
12V
C
Z
D
R
R1
D1
C1
Q1
R2
R3
MAX BLOW
R4
Q2
R5
MIN BLOW
R6
R7
C2
Q3
Q4
R9
SP ADJ
R10
Q5
R8
RT
R11
R12
R13
R14
Q6
R15
Q7
R17
R18
R19
R16
D2
R20
R21
R22
Q8
R23
D4
T2
220V
12V
Q9
R24
R25
C4
C3
L1
VENTILATING MOTOR
M

R_1, R_{21}, R_{23} - 1K ohm
R_2, R_4 - 4.7K ohm
R_3 - 2.5K ohm
R_5 - 100K ohm
R_6 - 50K ohm
R_7 - 1.5K ohm
R_8, R_{19} - 15K ohm
R_9 - 3.3K ohm
R_{10} - 5K ohm
R_{11} - 470K ohm
R_{12}, R_{18} - 33K ohm
R_{13}, R_{15} - 2.2K ohm
R_{14} - 680 ohm
R_{16} - 10K ohm
R_{17} - 220K ohm
R_{20}, R_{22} - 3.9K ohm
R_{24}, R_{25} - 47 ohm
R - 120 ohm
R_T - GE 2R114
C - GE 43F9723AA9 250 µfd 25V
C_1 - GE 75F1R5A472 .0047 µfd 50V
C_2 - GE AA14A104A .1 µfd 100V
C_3 - GE 75F7R4-224 .22 µfd 400V
C_4 - GE 75F4R4-473 .047 µfd 400V
D, D_1 thru D_4 - GE A14F
Q_1 - GE D29A4
Q_2 - GE 3N86
Q_3 thru Q_7 - GE 2N3393
Q_8 - GE C106Y
Q_9 - GE SC40D
Z - GE Z4XL12
T_2 - Thordarson 23V123
T_1 { 220V PRI, 24V CT SEC, 25 WATT
L_1 - 100 µh

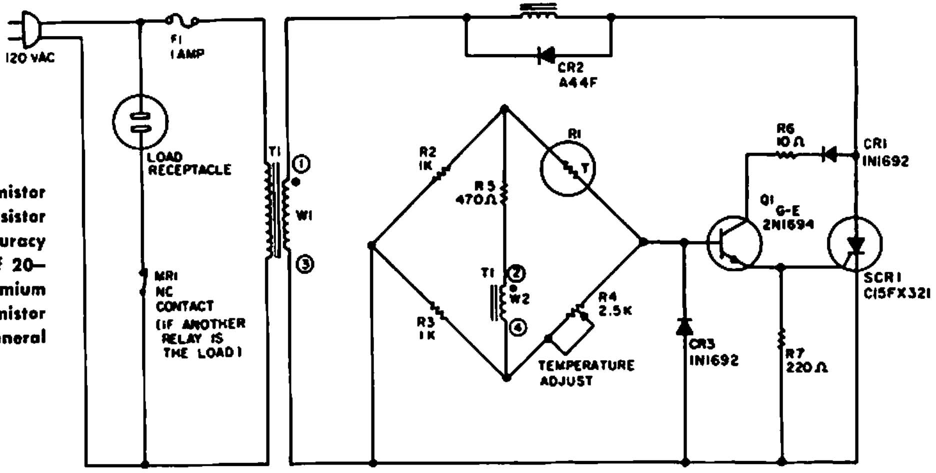
BLOWER CONTROL—Provides proportional motor speed control with rfi suppression circuit. Blower speed is increased for temperature deviations either above or below set point, because central control determines independently whether heater or cooling compressor is operating.—T. A. Penkalski, Better Room Conditioning via Solid State Controls, General Electric, Syracuse, N.Y., No. 200.51, 1967, p 10.


S200 ASSEMBLY
PA424
L1
L2
L3
L4
S1
S2
S3
RT
RADJ
C
Q
Q1
Q2
Q3
Q4
Q5
Q6
R1 8K
R2 8K
R3 6K
R4 6K
R5 20K
R6 60Ω
R7 4K
R
D1
D2
D3
D4
D5
D6
RESISTANCE HEATER LOAD

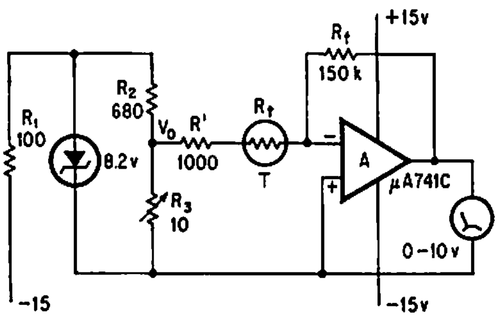
IC ZERO-VOLTAGE SWITCH—Gives on-off control of heater load with only 0.2 F differential when used with solid-state thermostat consisting of thermistor RT and set-point potentiometer in series. Triac Q turns off at end of each half-cycle and removes power from heater, to provide zero-voltage switching of heater. With appropriate triac rating, IC can control heater loads from 500 to 4,150 W on supply voltages up to 277 V a-c.—T. A. Penkalski, Better Room Conditioning via Solid State Controls, General Electric, Syracuse, N.Y., No. 200.51, 1967, p 4.


110 V AC
AC
1.2 KW HEATER
4.7 K 2 W
4.7 K 2 W
5.6 K 2 W
TYPE 1N3193 CR4
TYPE 1N3193 CR1
TYPE 1N3193 CR3
TYPE 1N3193 CR2
TYPE 2N3228 SCR1
TYPE 2N3228 SCR2
270
15 V 30 μF
20μF 15 V
Q1 TYPE 2N3053
470
5 K
1 K
TYPE 2N3053 Q4
470
Q5 RCA 40319
RCA 40319 Q2
Q3 RCA 40319
150
TH1
TH2
4.7 K
470
470
5000Ω AT OPERATING TEMPERATURE
500Ω AT OPERATING TEMPERATURE

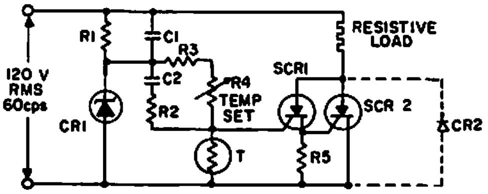
FULL-WAVE 1.2-KW ZERO-SWITCHING—Uses anticipation-type control with two thermistors as sensors. Book describes operation in detail.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 255.


120 VAC
F1 1 AMP
LOAD RECEPTACLE
MR1 NC CONTACT (IF ANOTHER RELAY IS THE LOAD)
T1
①
W1
③
MR1 RELAY OR OTHER 6 VOLT LOAD
CR2 A44F
R2 1K
R5 470Ω
R1
R3 1K
T1 ② W2 ④
R4 2.5K
TEMPERATURE ADJUST
R6 10Ω
CR1 1N1692
Q1 G-E 2N1694
SCR1 C15FX321
CR3 1N1692
R7 220Ω

TEMPERATURE-OPERATED RELAY—Thermistor in bridge energizes relay through transistor and scr when heat is called for. Accuracy is within 1 deg in temperature range of 20–150 F. For illumination control, cadmium sulfide photocell is used in place of thermistor R1.—Precision Temperature Control, General Electric, Auburn, N.Y., No. 630.15.

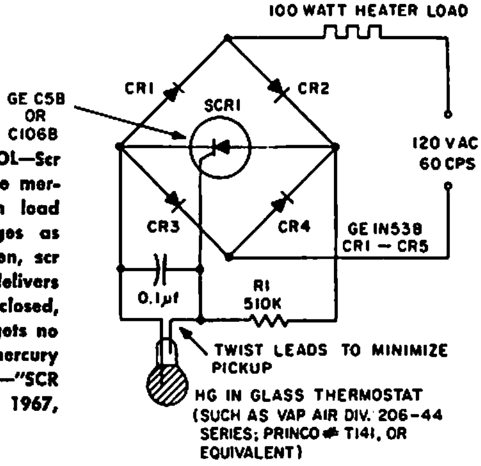

+15v
R_f
150 k
R_2
680
R_1
100
8.2v
V_o
R'
1000
R_t
T
A
µA741C
R_3
10
0-10v
-15
-15v

CORRECTING THERMISTOR LINEARITY—Combining opamp and zener with thermistor boosts output voltage 150 times without exceeding submilliwatt rating of thermistor, and makes output voltage true linear function of temperature over range of −20 C to 70 C if R' is made equal to thermistor resistance at center of desired temperature range. R3 is adjusted so Vo is −0.067 V.—J. M. Nemchik and R. J. Fritsch, Circuit Improves Thermistor's Linearity and Boosts Output, *Electronics*, June 9, 1969, p 99—100.

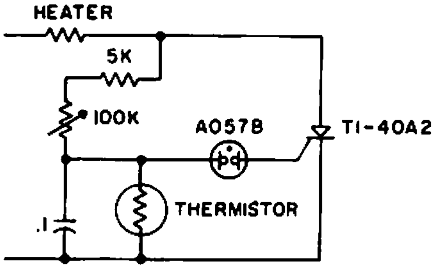

120 V
RMS
60cps
R1
C1
R3
C2
R4
TEMP
SET
R2
CR1
T
SCR1
SCR 2
R5
RESISTIVE
LOAD
CR2

CR1 - G.E. Z4XL6.2 ZENER DIODE
R1 - 6.8K, 2W, 10%
C1 - 0.22 UF, 10%, 200 VDC
C2 - 0.33 UF, 10%, 10 VDC
R2 - 4.7K,
(R3 - R4) - TOTAL RESISTANCE ≈ 1.25K
SCR1 - G.E. C106B OR G.E. C6B
R5 - 100 OHMS
SCR 2 - G.E. C20B
T - 100 OHM THERMISTOR AT SENSING TEMPERATURE. CAN BE GLASS COATED BEAD OR HIGHER DISSIPATION TYPES. MAY USE G.E. TYPE 3D054 (100 OHMS @ 25°C).

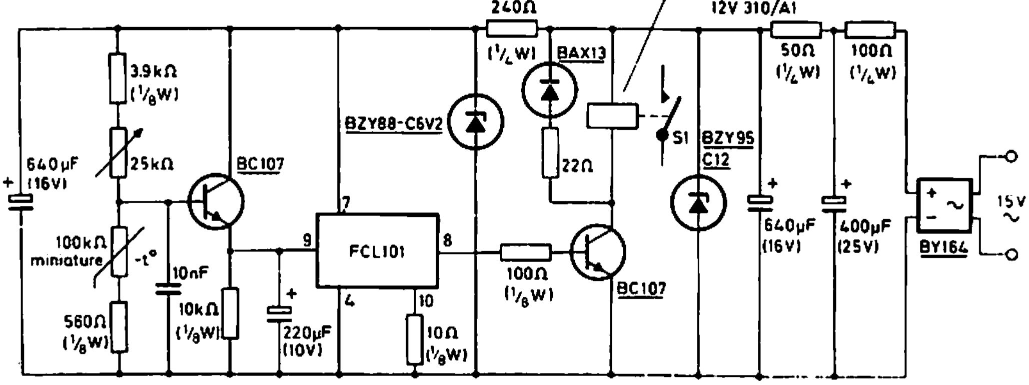
HALF-WAVE CONTROL—Uses pulse and pedestal zero-voltage switching. Voltage is applied to load for all of each negative half-cycle, while positive half-cycles are switched on and off in semiproportional manner as called for by thermistor T. Sensing differential is 0.25 F above and below set point. Zero-voltage switching action eliminates need for rfi filtering.—J. L. Brookmire, Temperature Controls Incorporating Zero Voltage Switching, General Electric, Syracuse, N.Y., No. 200.45, 1966, p 4.


100 WATT HEATER LOAD
GE C5B
OR
C106B
CR1
SCR1
CR2
120 VAC
60 CPS
CR3
CR4
GE IN538
CR1 — CR5
0.1µf
R1
510K
TWIST LEADS TO MINIMIZE PICKUP
HG IN GLASS THERMOSTAT
(SUCH AS VAP AIR DIV. 206-44 SERIES; PRINCO # T141, OR EQUIVALENT)

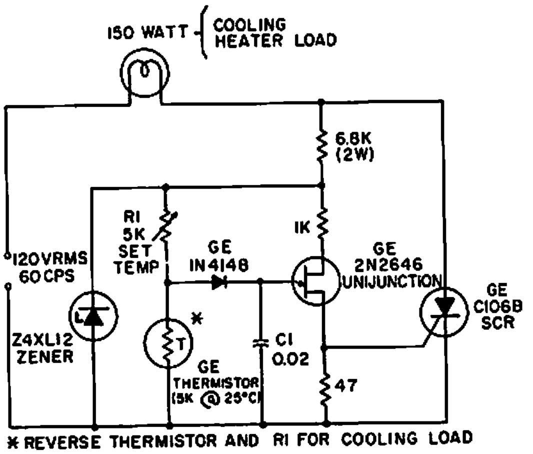
MERCURY THERMOSTAT/SCR CONTROL—Scr serves as current amplifier for sensitive mercury-in-glass thermostat and as main load switching element. Can sense changes as small as 0.1 C. With thermostat open, scr triggers on each half-cycle and delivers power to heater. With thermostat closed, scr can no longer trigger and heater gets no power. Maximum current through mercury of thermostat is below 250 µA rms.—"SCR Manual," 4th Edition, General Electric, 1967, p 168.


HEATER
5K
100K
A057B
TI-40A2
THERMISTOR
.1

NEON-TRIGGERED SCR—High-resistance thermistor determines amount of power delivered to heater. Desired temperature is set with 100K pot.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 124.

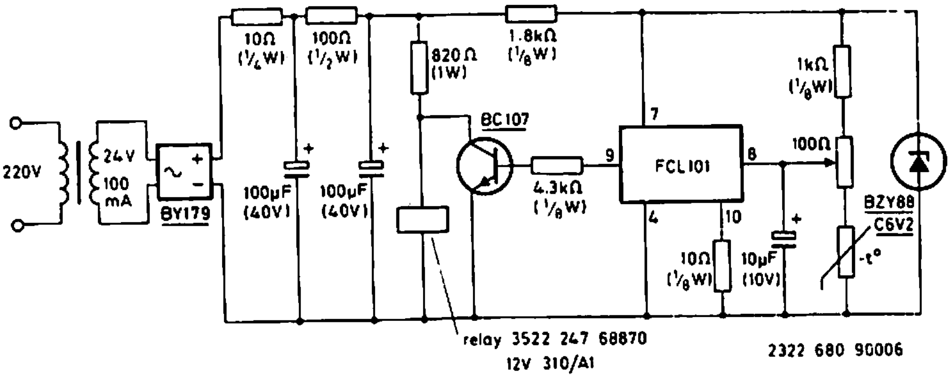

relay 3522 247 68870
12V 310/A1
240Ω
(1/4W)
BAX13
50Ω
(1/4W)
100Ω
(1/4W)
3.9kΩ
(1/8W)
25kΩ
640µF
(16V)
BC107
BZY88-C6V2
22Ω
S1
BZY95
C12
100kΩ
miniature
-t°
10nF
10kΩ
(1/8W)
560Ω
(1/8W)
7
9
FCL101
8
4
10
220µF
(10V)
10Ω
(1/8W)
100Ω
(1/8W)
BC107
640µF
(16V)
400µF
(25V)
BY164
15V
~

100—300 C PRECISION ON-OFF CONTROL—Although electrical precision with thermistor sensor and FCL101 IC level detector is better than 0.5 deg C, actual overall precision depends on thermal time constant of object being heated, and is generally about 2 deg C for range covered.—Triacs—Operation and Use, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1969.


150 WATT
COOLING
HEATER LOAD
6.8K
(2W)
R1
5K
SET
TEMP
GE
1N4148
1K
GE
2N2646
UNIJUNCTION
120VRMS
60CPS
GE
C106B
SCR
Z4XL12
ZENER
*
GE
THERMISTOR
(5K @ 25°C)
C1
0.02
47

* REVERSE THERMISTOR AND R1 FOR COOLING LOAD

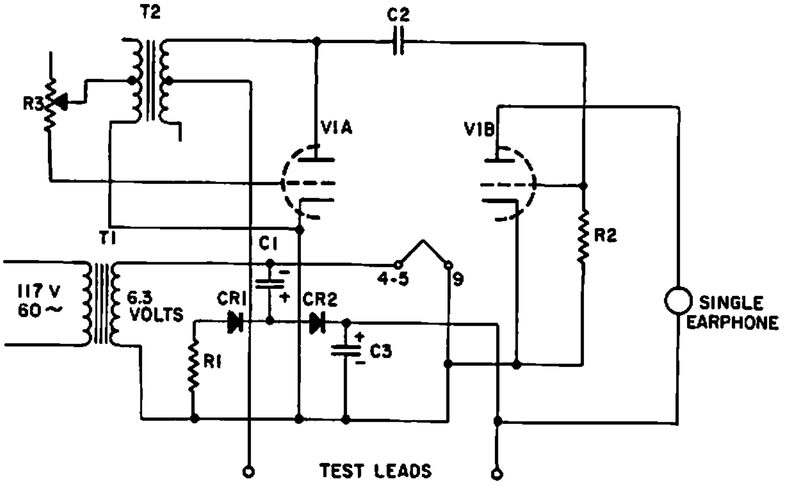
PHOTODEVELOPER HEATER CONTROL—Ujt-scr circuit varies power steplessly to 150-W heater in response to thermistor in liquid bath.—D. R. Grafham, Precision Temperature Controller, General Electric, Syracuse, N.Y., No. 201.9, 1965.


220V
24V
100
mA
BY179
10Ω
($\frac{1}{4}$W)
100Ω
($\frac{1}{2}$W)
100μF
(40V)
100μF
(40V)
820Ω
(1W)
1.8kΩ
($\frac{1}{8}$W)
BC107
4.3kΩ
($\frac{1}{8}$W)
7
9
8
4
10
FCL101
1kΩ
($\frac{1}{8}$W)
100Ω
10Ω
($\frac{1}{8}$W)
10μF
(10V)
BZY88
C6V2
-t°
relay 3522 247 68870
12V 310/A1
2322 680 90006

ON-OFF TRIAC TRIGGERING CONTROL—Suitable for range of 30 to 45 deg C. Uses thermistor with positive temperature coefficient of resistance, to actuate relay through FCL101 level detector and transistor.—Triacs—Operation and Use, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1969.

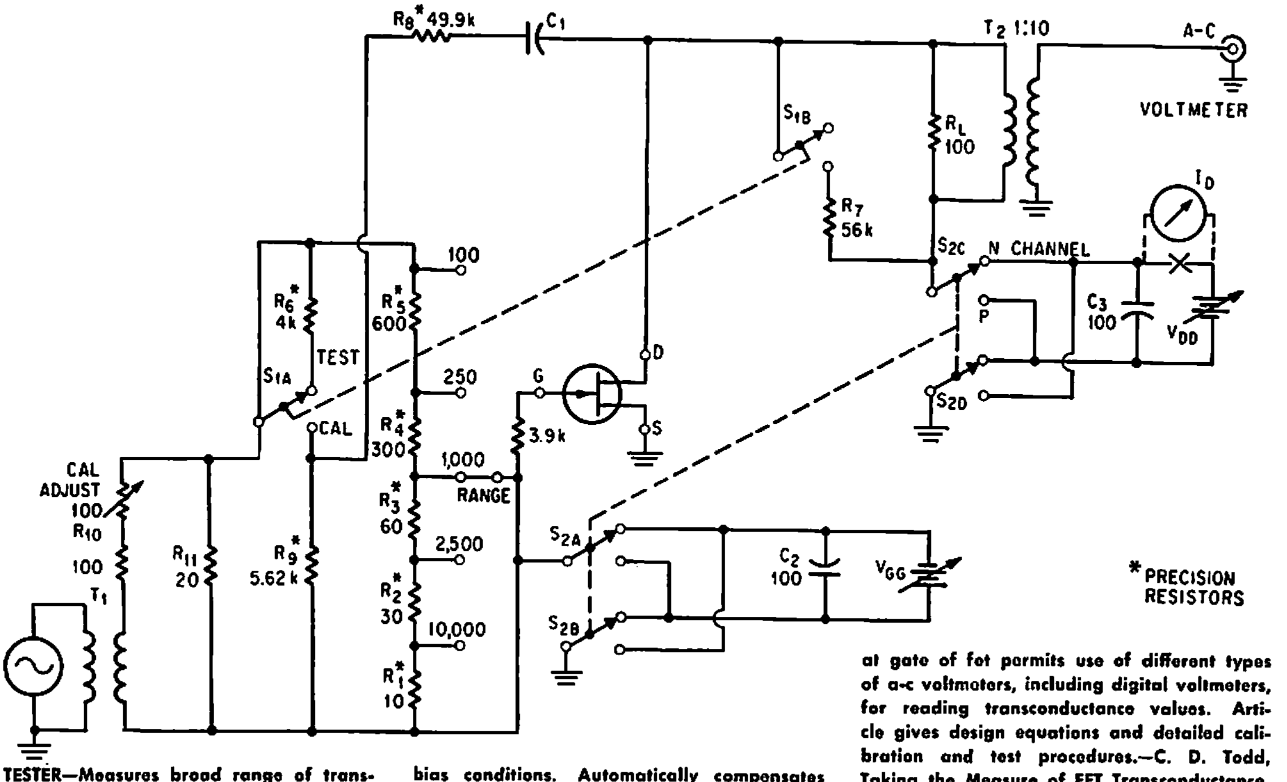
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 88
Test Circuits



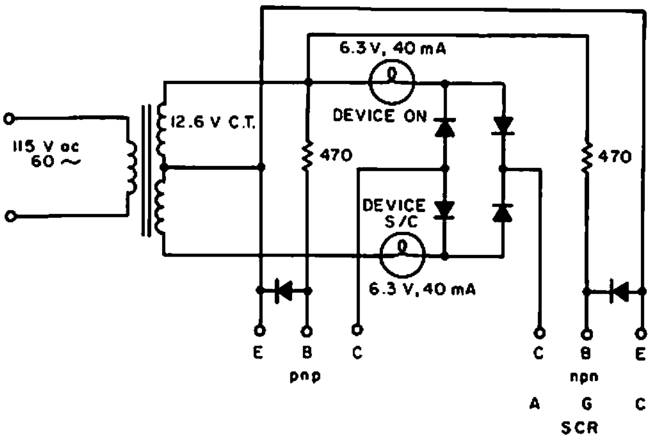
T2
C2
R3
V1A
V1B
T1
C1
117 V
60 ~
6.3
VOLTS
CR1
+
CR2
4-5
9
R2
R1
+
C3
SINGLE
EARPHONE
TEST LEADS

6-V VERSION OF CONTINUITY TESTER—Produces tone in earphone when continuity exists between points in circuit to which test leads are touched. Reversing test leads will tell whether path contains electrolytic, because for one polarity tone will die away in few seconds; for resistive path, tone is same loudness for both polarities. Tone changes with resistance of measured path, giving rough indication of amount of resistance; measuring assortment of known resistance values will show how tone changes. Parts values are not critical: C1 and C3 25 μF; C2 0.005 μF; CR1-CR2 1N34AS; R1 150; R2 470K; R3 250K; T1 6.3 V 0.3 A filament transformer; T2 any audio interstage transformer; V1 almost any twin-triode such as 12AX7, 12AT7, or 12AU7.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 175.

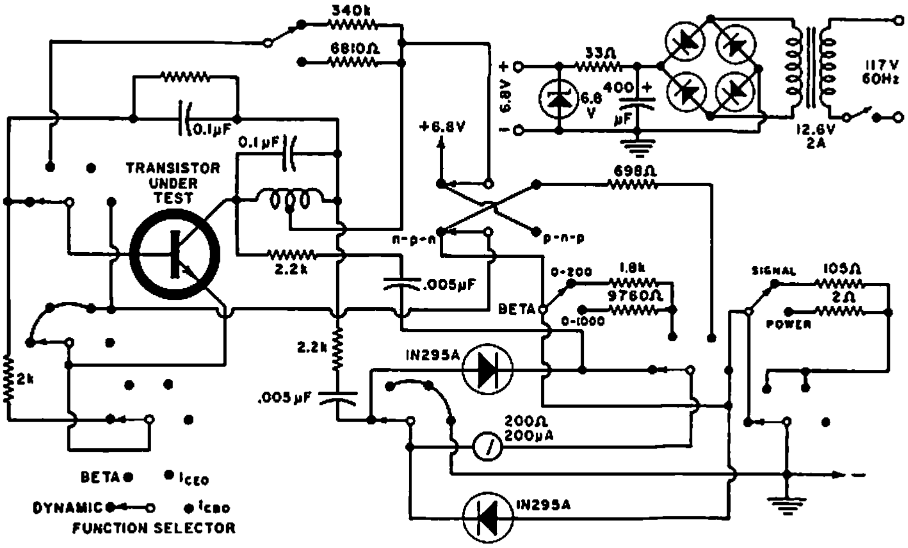


R_8^* 49.9k
C_1
T_2 1:10
A-C
VOLTMETER
S_{1B}
R_L 100
R_7 56k
I_D
S_{2C}
N CHANNEL
P
C_3 100
V_{DD}
S_{2D}
R_6^* 4k
R_5^* 600
100
TEST
S_{1A}
250
G
D
S
CAL
R_4^* 300
1,000
RANGE
3.9k
CAL ADJUST 100 R_{10}
R_3^* 60
2,500
S_{2A}
C_2 100
V_{GG}
*PRECISION RESISTORS
100
T_1
R_{11} 20
R_9^* 5.62k
R_2^* 30
10,000
S_{2B}
R_1^* 10

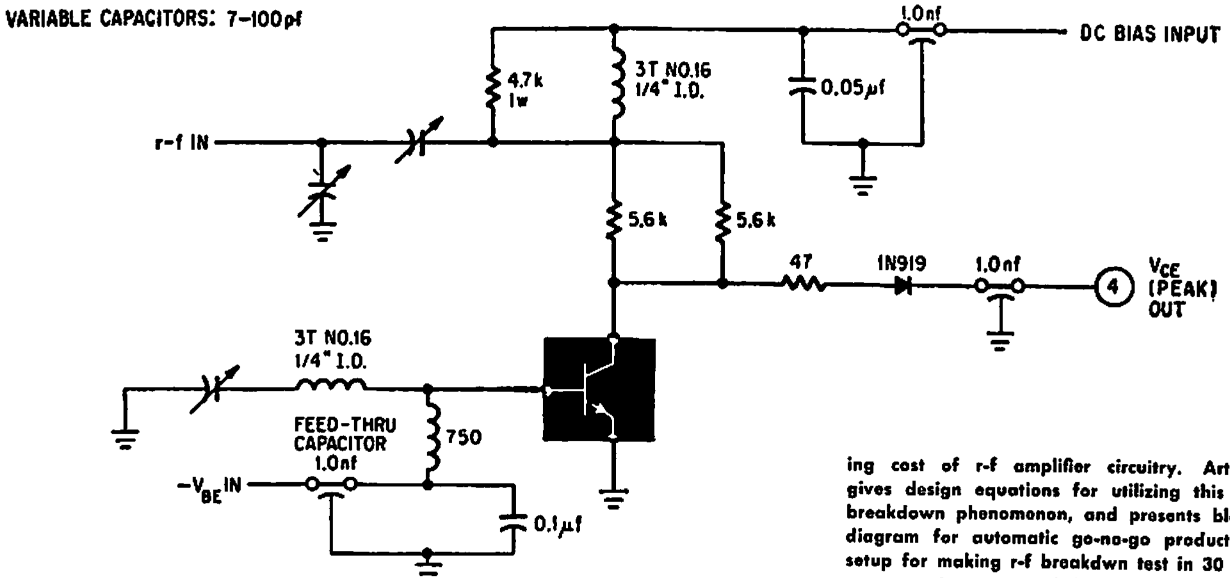
FET TESTER—Measures broad range of transconductance values, even under abnormal bias conditions. Automatically compensates for most sources of errors. Range switch at gate of fet permits use of different types of a-c voltmeters, including digital voltmeters, for reading transconductance values. Article gives design equations and detailed calibration and test procedures.—C. D. Todd, Taking the Measure of FET Transconductance, *Electronics*, April 3, 1967, p 88–92.


6.3 V, 40 mA
DEVICE ON
115 V ac
60 ~
12.6 V C.T.
470
470
DEVICE
S/C
6.3 V, 40 mA
E
B
C
pnp
C
B
E
npn
A
G
C
SCR

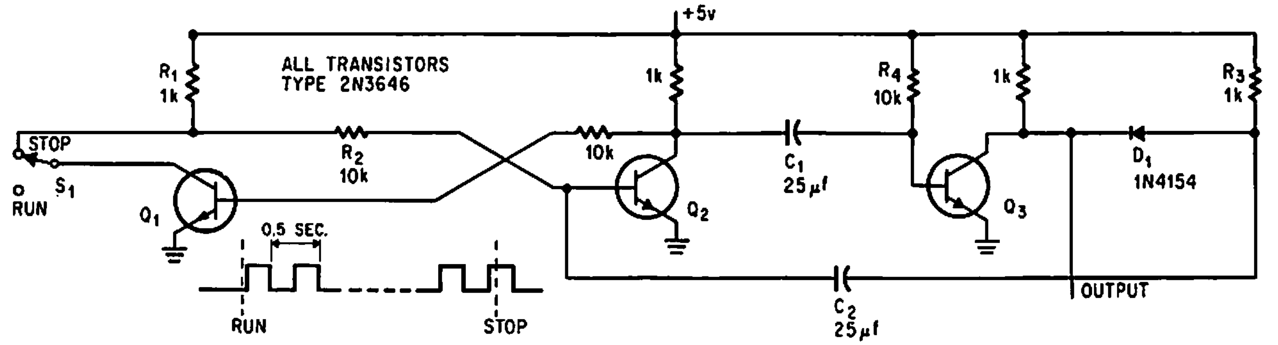
SCR-TRANSISTOR TESTER—Simple circuit turns on lower DEVICE S/C lamp to indicate that solid-state device under test is short-circuited. Good device turns on only upper lamp. Other fault conditions turn both lamps on or leave both off. Practically any junction diodes can be used in test circuit. Not recommended for devices having less than 12 V collector-base voltage, peak collector current less than 100 mA, or dissipation below 50 mW.—D. Wadsworth, Go/No-Go Tester Checks SCRs, NPN and PNP Transistors, *Electronic Design*, June 6, 1968, p 112.


340k
6810Ω
0.1μF
0.1μF
TRANSISTOR
UNDER
TEST
2.2k
.005μF
2.2k
.005μF
2k
33Ω
6.8V
6.8 V
400 μF
117 V
60Hz
12.6V
2A
+6.8V
698Ω
n-p-n
p-n-p
0-200
1.8k
9760Ω
BETA
0-1000
SIGNAL
105Ω
2Ω
POWER
1N295A
200Ω
200μA
1N295A
BETA
I_{CEO}
DYNAMIC
I_{CBO}
FUNCTION SELECTOR

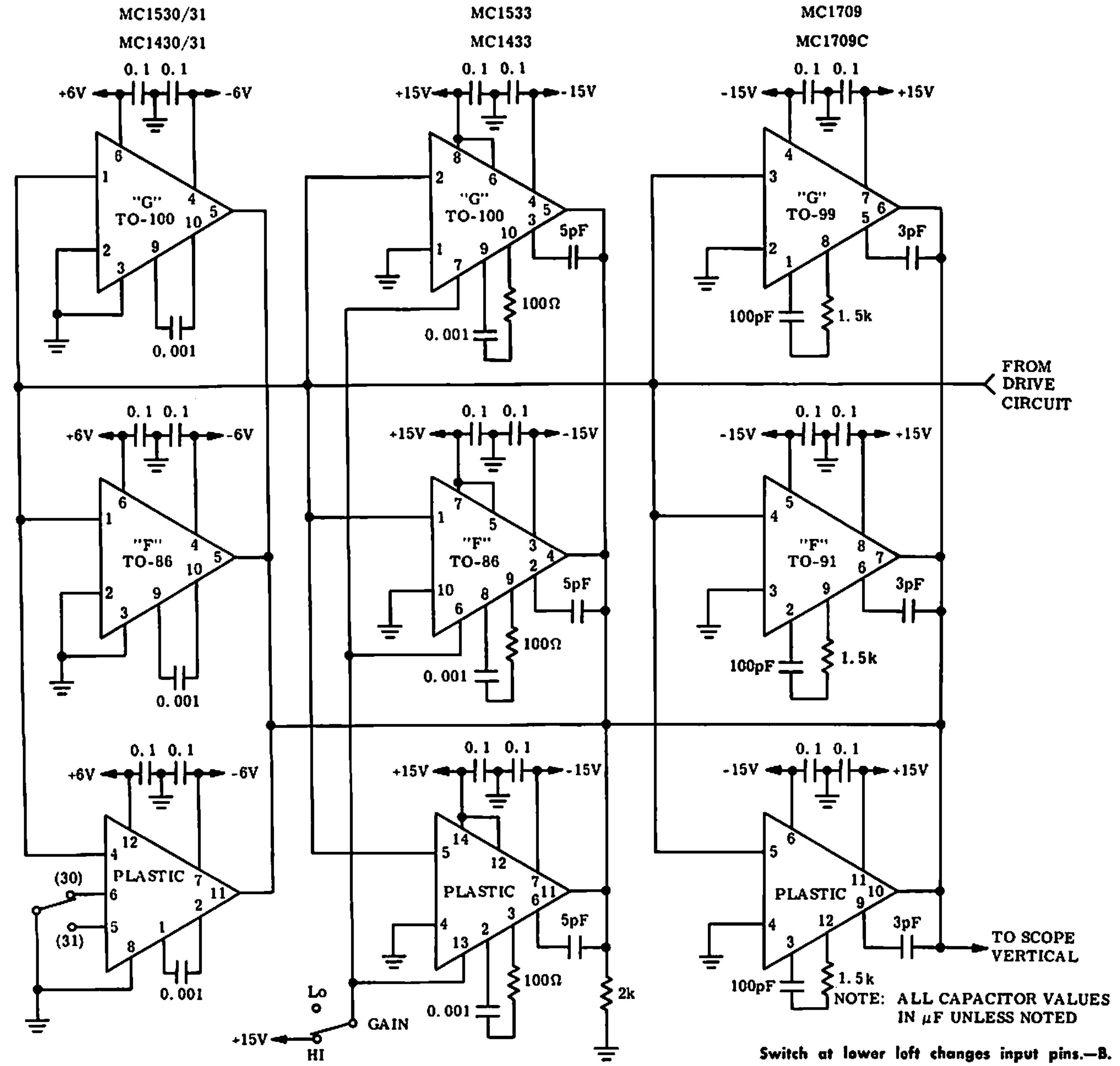
TRANSISTOR ANALYZER—Checks both power and signal transistors without removal from circuits. Identifies npn or pnp, as well as lead connections. Reads d-c gain directly. Measures collector-emitter and collector-base leakage currents.—Seco Model 260 Transistor Analyzer, *Electronics World*, Oct. 1967, p 76–77.


VARIABLE CAPACITORS: 7-100pf
1.0nf
DC BIAS INPUT
4.7k
1w
3T NO.16
1/4" I.D.
0.05μf
r-f IN
5.6k
5.6k
47
1N919
1.0nf
4
V_{CE}
(PEAK)
OUT
3T NO.16
1/4" I.D.
FEED-THRU
CAPACITOR
1.0nf
750
$-V_{BE}$ IN
0.1μf

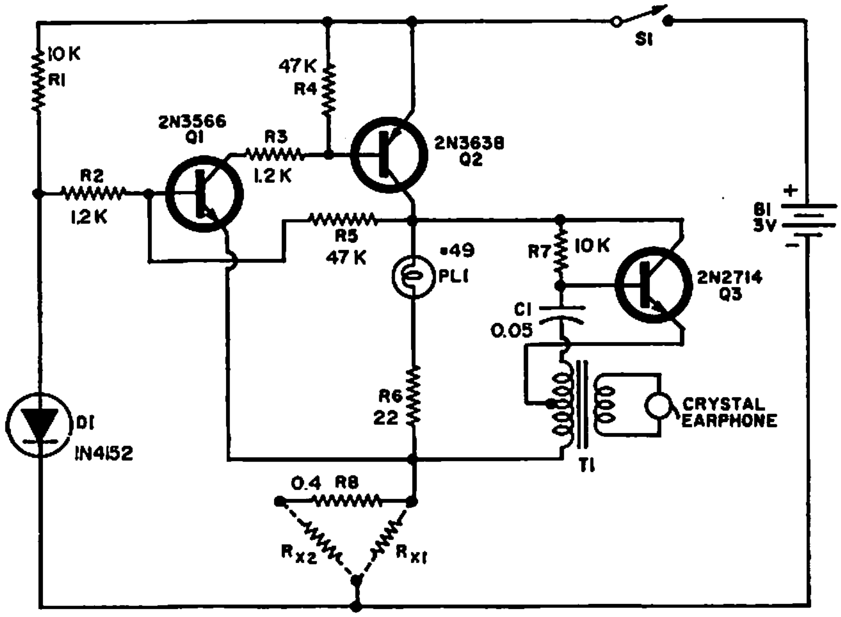
TRANSISTOR R-F BREAKDOWN TEST—Measures r-f breakdown voltage while transistor is operated above its specified alpha-cutoff frequency, using sine-wave r-f input. Once limit of transistor is determined, it can be operated at much higher frequencies, lowering cost of r-f amplifier circuitry. Article gives design equations for utilizing this r-f breakdown phenomenon, and presents block diagram for automatic go-no-go production setup for making r-f breakdwn test in 30 ms per transistor.—P. Schiff, R-F Breakdown Phenomenon Improves the Voltage Capability of a Transistor, *Electronics*, June 12, 1967, p 97–101.


+5v
R1 1k
ALL TRANSISTORS TYPE 2N3646
1k
R4 10k
1k
R3 1k
STOP
S1
RUN
R2 10k
10k
C1 25μf
D1 1N4154
Q1
Q2
Q3
0.5 SEC.
RUN
STOP
C2 25μf
OUTPUT

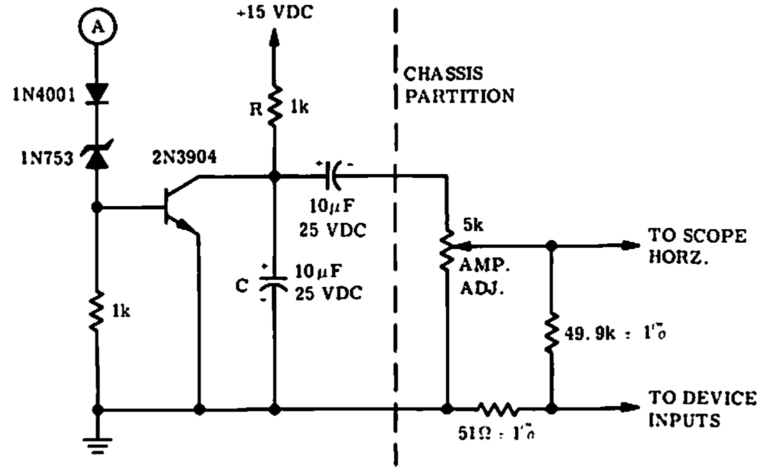
2-HZ CHECKOUT—Extra transistor Q2 in low-speed oscillator permits checking of digital circuits at 2 Hz, slow enough so operator can watch logic operate visual indicator, with no risk of false output because of contact bounce in switch or because oscillator is switched off in middle of cycle. Q1 keeps oscillator running until cycle is ended.—P. T. Rux, Oscillator Waits for Switch to Quiet Down, *Electronics*, Nov. 13, 1967, p 103.


MC1530/31
MC1430/31
MC1533
MC1433
MC1709
MC1709C
0.1 0.1
+6V
-6V
+15V
-15V
"G" TO-100
"G" TO-99
"F" TO-86
"F" TO-91
PLASTIC
5pF
3pF
100Ω
0.001
100pF
1.5k
FROM DRIVE CIRCUIT
(30)
(31)
Lo
HI
GAIN
2k
TO SCOPE VERTICAL
NOTE: ALL CAPACITOR VALUES IN μF UNLESS NOTED

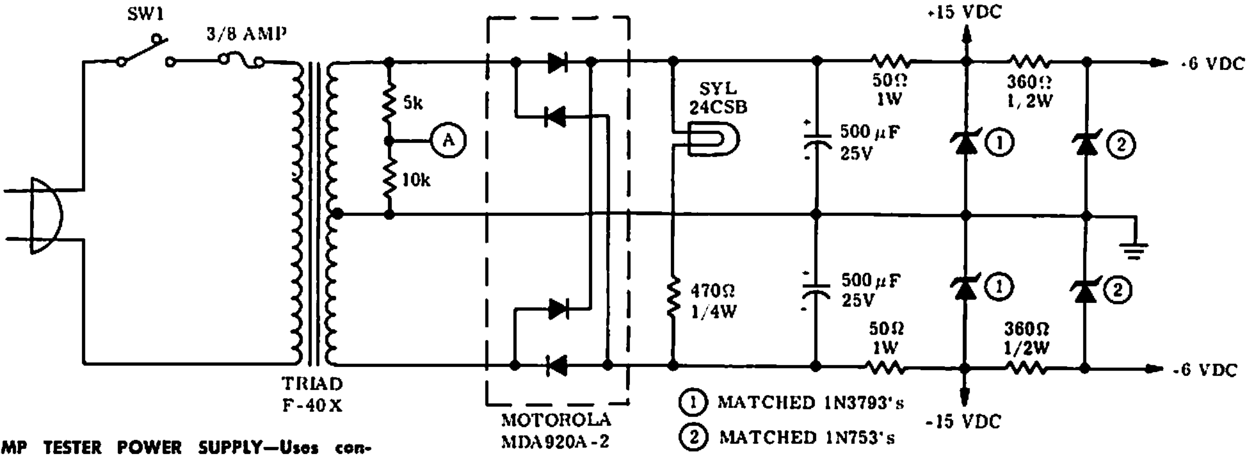
OPAMP TESTER SOCKETS—Provides nine different sockets for testing commonest types of IC opamps during incoming inspection. Requires power supply and drive circuit. Switch at lower left changes input pins.—B. Botos, An Operational Amplifier Tester, Motorola, Phoenix, Ariz., No. AN-400, 1967.


10K
R1
47K
R4
2N3566
Q1
R3
1.2K
2N3638
Q2
R2
1.2K
R5
47K
#49
PL1
R7
10K
C1
0.05
2N2714
Q3
S1
+
B1
3V
−
D1
1N4152
R6
22
CRYSTAL EARPHONE
T1
0.4 R8
Rx2
Rx1

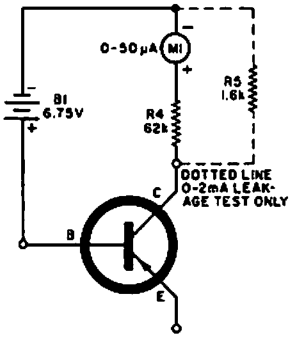
CONTINUITY TESTER—Gives reliable indication of continuity down to 0.1 ohm on go/no-go lamp or by tone in earphone, with no risk of damage to sensitive transistors and integrated circuits. R8 should be about 0.1 ohm less than maximum value for which continuity indication is desired. Use RX2 terminals for checking down to 0.1 ohm.—C. D. Todd, A Sub-Ohm Continuity Tester, *Electronics World*, Feb. 1969, p 78–80.


A
1N4001
1N753
2N3904
+15 VDC
R
1k
+
10μF
25 VDC
C
10μF
25 VDC
1k
CHASSIS
PARTITION
5k
AMP.
ADJ.
TO SCOPE
HORZ.
49.9k ± 1%
TO DEVICE
INPUTS
51Ω ± 1%

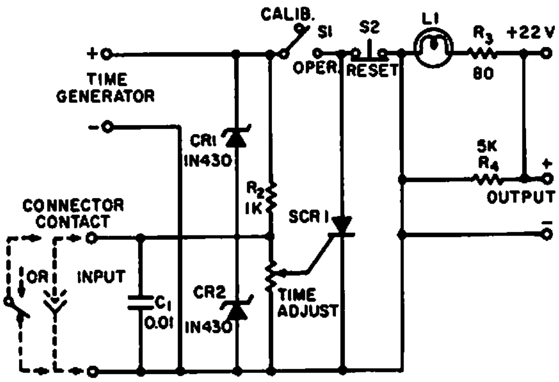
OPAMP TESTER—Includes drive circuit shown, providing horizontal sweep drive for standard X-Y scope, feed to input terminals of all nine opamp test sockets, and 60-Hz voltage at point A, obtained from secondary of power supply transformer. Developed as simple and inexpensive tester for use by customers in checking shipments of opamps. Cro display shows transfer function of opamp.—B. Botos, An Operational Amplifier Tester, Motorola, Phoenix, Ariz., No. AN-400, 1967.


SW1
3/8 AMP
TRIAD
F-40X
5k
A
10k
MOTOROLA
MDA920A-2
SYL
24CSB
470Ω
1/4W
500μF
25V
500μF
25V
+15 VDC
50Ω
1W
50Ω
1W
360Ω
1/2W
360Ω
1/2W
①
②
+6 VDC
-6 VDC
-15 VDC
① MATCHED 1N3793's
② MATCHED 1N753's

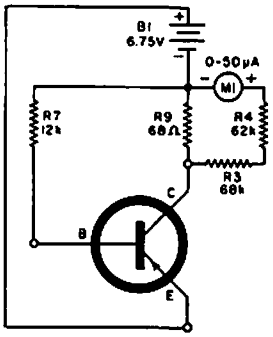
OPAMP TESTER POWER SUPPLY—Uses conventional shunt zener regulator, with pilot lamp bridged across filter capacitors as on-off indicator and as bleeder for capacitor charge after power is turned off.—B. Botos, An Operational Amplifier Tester, Motorola, Phoenix, Ariz., No. AN-400, 1967.


0-50μA
M1
R5
1.6k
B1
6.75V
R4
62k
DOTTED LINE
0-2mA LEAK-
AGE TEST ONLY
C
B
E

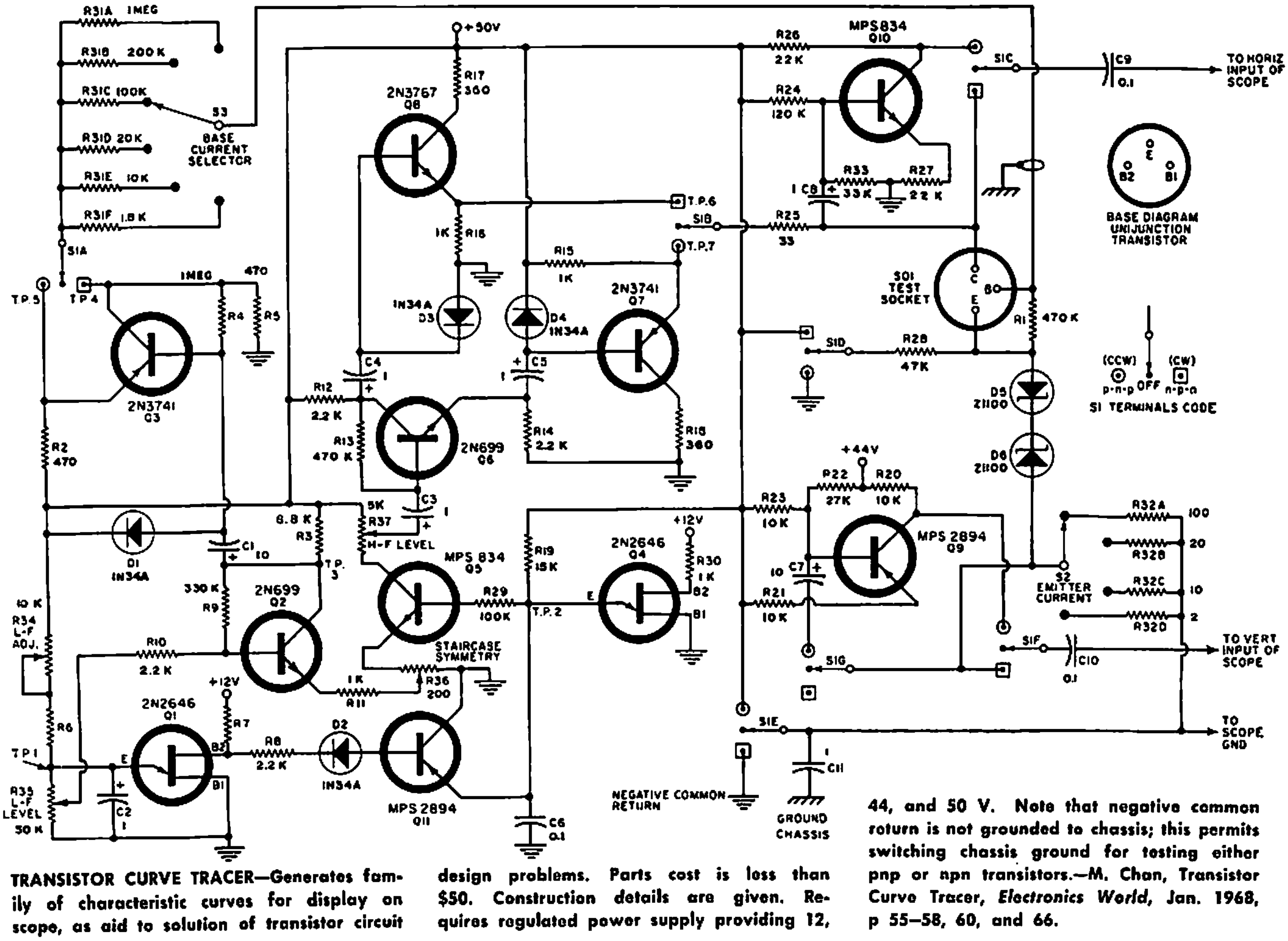
TRANSISTOR LEAKAGE—Basic circuit measures reverse-biased collector-to-base current. R4 limits meter current to 100 μA if transistor under test is shorted. Used in battery-powered tester that checks gain, leakage, and breakdown voltage of small-signal and power transistors. Also checks diodes.—M. J. Moss, Versatile Transistor Tester, *Electronics World*, Aug. 1967, p 56–58.


CALIB.
S1
S2
L1
R_3
+22V
OPER
RESET
80
+
TIME
GENERATOR
-
CR1
1N430
5K
R_4
+
OUTPUT
-
CONNECTOR
CONTACT
R_2
1K
SCR1
OR
INPUT
C_1
0.01
CR2
1N430
TIME
ADJUST

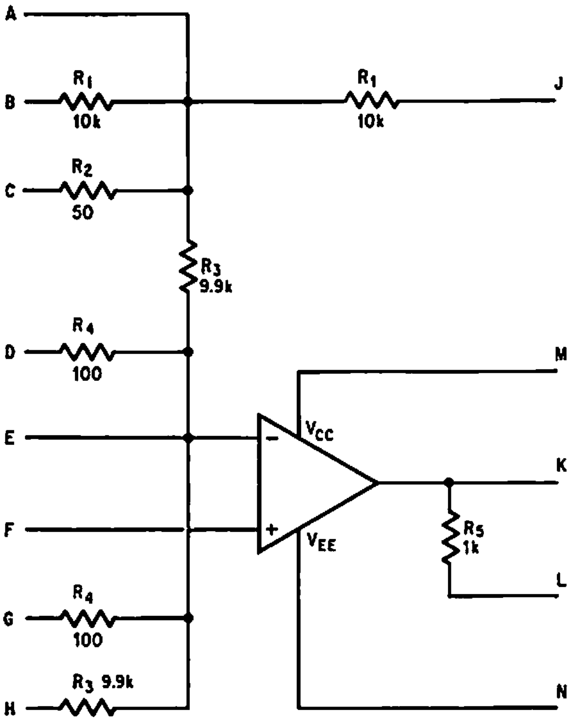
CONTACT-CHATTER TESTER—Immunity of scr to noise excitation makes it far superior to conventional thyratron in discontinuity tester used for monitoring circuit interruptions in 10-μs range. Once scr conducts and turns on indicator lamp, S2 must be opened momentarily to reset circuit.—J. A. Ray, Discontinuity Tester is Insensitive to Noise, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 152.


B1
6.75V
0-50μA
M1
R7
12k
R9
68Ω
R4
62k
R3
68k
C
B
E

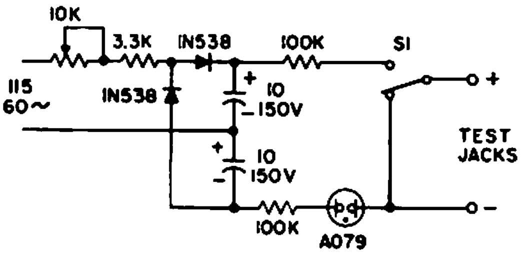
POWER TRANSISTOR GAIN—Basic test circuit for measuring beta or gain, using higher collector current than for checking small-signal transistors so higher leakage currents of power transistors do not mask true measurement. Collector current is set at 50 mA, corresponding to beta of 100.—M. J. Moss, Versatile Transistor Tester, *Electronics World*, Aug. 1967, p 56–58.


R31A 1MEG
R31B 200K
R31C 100K
R31D 20K
R31E 10K
R31F 1.8K
S3
BASE CURRENT SELECTOR
S1A
+50V
R17 360
2N3767 Q8
R26 22K
MPS834 Q10
R24 120K
S1C
C9 0.1
TO HORIZ INPUT OF SCOPE
BASE DIAGRAM UNIJUNCTION TRANSISTOR
E
B2
B1
R33 33K
R27 22K
C8 1
T.P.6
S1B
R25 33
T.P.7
1K R16
R15 1K
1N34A D3
D4 1N34A
2N3741 Q7
S01 TEST SOCKET
C
B
E
R1 470K
T.P.5
T.P.4
1MEG
470
R4
R5
2N3741 Q3
C4 1
C5 1
R12 2.2K
R13 470K
2N699 Q6
R14 2.2K
R18 360
S1D
R28 47K
D5 Z1100
D6 Z1100
(CCW)
(CW)
p-n-p OFF n-p-n
S1 TERMINALS CODE
R2 470
+44V
R22 27K
R20 10K
R23 10K
MPS 2894 Q9
5K R37
H-F LEVEL
C3 1
8.8K R3
T.P.3
C1 10
D1 1N34A
330K R9
2N699 Q2
MPS 834 Q5
R19 15K
2N2646 Q4
+12V
R30 1K
B2
B1
R29 100K
T.P.2
C7 10
R21 10K
S2 EMITTER CURRENT
R32A 100
R32B 20
R32C 10
R32D 2
10K R34 L-F ADJ.
R10 2.2K
STAIRCASE SYMMETRY
R36 200
R11 1K
S1F
C10 0.1
TO VERT INPUT OF SCOPE
S1G
+12V
2N2646 Q1
R7
R6
T.P.1
R35 L-F LEVEL 50K
C2 1
R8 2.2K
D2 1N34A
MPS 2894 Q11
C6 0.1
S1E
C11 1
NEGATIVE COMMON RETURN
GROUND CHASSIS
TO SCOPE GND

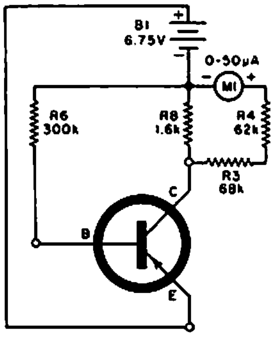
TRANSISTOR CURVE TRACER—Generates family of characteristic curves for display on scope, as aid to solution of transistor circuit design problems. Parts cost is less than $50. Construction details are given. Requires regulated power supply providing 12, 44, and 50 V. Note that negative common return is not grounded to chassis; this permits switching chassis ground for testing either pnp or npn transistors.—M. Chan, Transistor Curve Tracer, *Electronics World*, Jan. 1968, p 55–58, 60, and 66.


A
B
R_1
10k
R_1
10k
J
C
R_2
50
R_3
9.9k
D
R_4
100
M
E
V_{CC}
K
F
V_{EE}
R_5
1k
L
G
R_4
100
R_3 9.9k
H
N

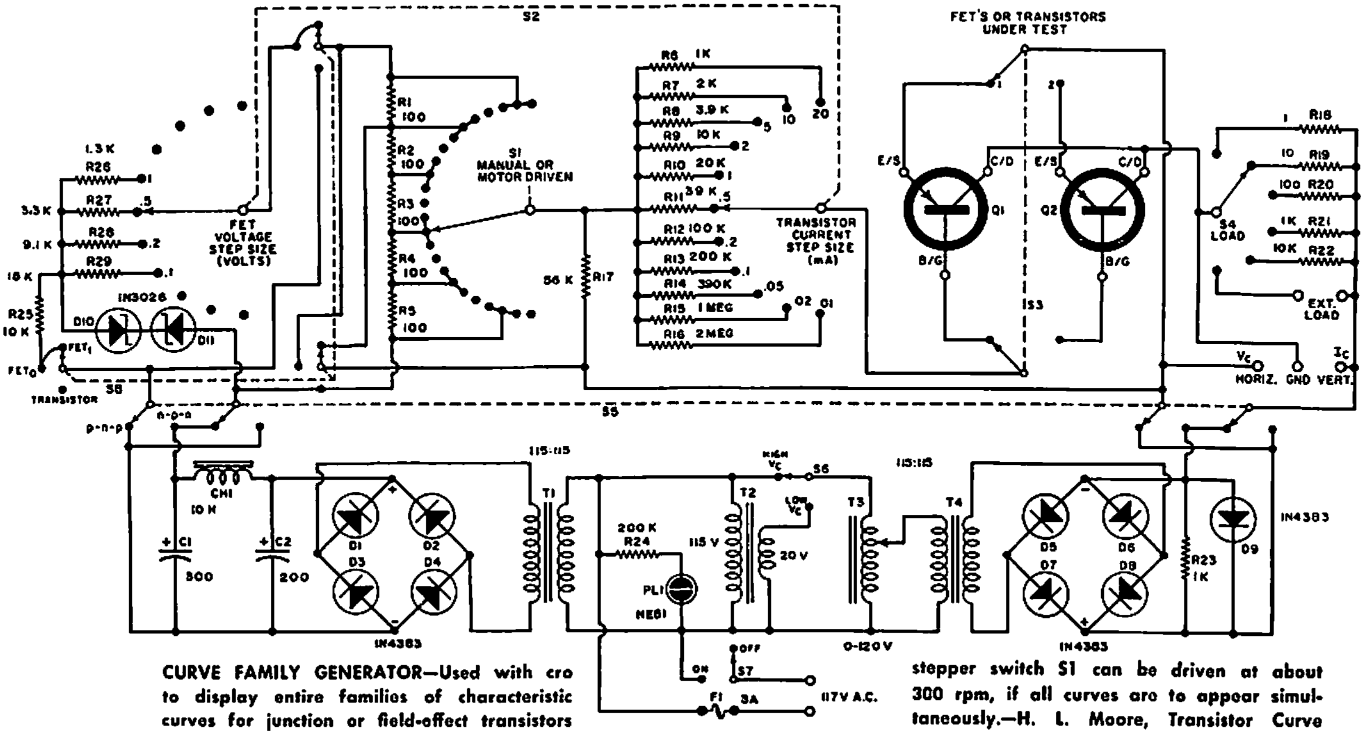
AUTOMATIC OPAMP TESTER—Simple, versatile interface fixture circuit shown permits checking of opamps and other linear circuits with automatic testers designed primarily for digital IC's. Opamp is connected through pins E and F, and receives power from pins M and N, while K and L are output lines. Resistor values must be adjusted for opamp under test; those shown are for Amelco 809. Article gives setup and measurement procedures.—R. McIntyre, Adapter Lets Digital IC Tester Check on Operational Amplifiers, *Electronics*, July 21, 1969, p 94–96.


10K
3.3K
IN538
100K
S1
115
60~
IN538
+ 10
150V
+
TEST
JACKS
+ 10
150V
100K
A079
−

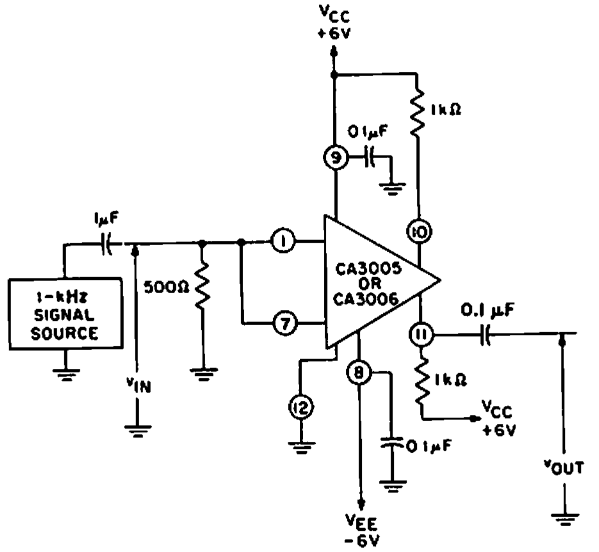
CAPACITOR LEAKAGE—Blinking neon lamp with S1 closed indicates capacitor connected to test jacks is leaking.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 150.


B1
6.75V
0-50µA
M1
R6
300k
R8
1.6k
R4
62k
R3
68k
C
B
E

SMALL-SIGNAL TRANSISTOR CURRENT GAIN—Basic circuit for measuring current gain of pnp transistor uses base current of about 20 µA. Used in battery-powered tester that checks gain, leakage, and breakdown voltage of small-signal and power transistors. Also checks diodes.—M. J. Moss, Versatile Transistor Tester, *Electronics World*, Aug. 1967, p 56–58.

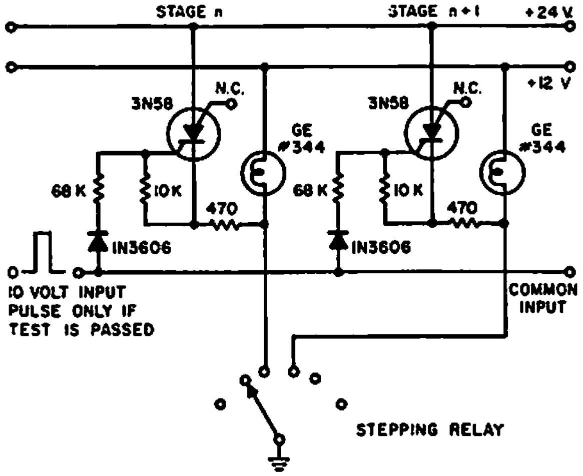

S2
1.3 K
R26
1
3.3 K
R27
.5
9.1 K
R28
.2
18 K
R29
.1
R25
10 K
FET VOLTAGE STEP SIZE (VOLTS)
IN3026
D10
D11
FET₁
FET₀
TRANSISTOR
S8
p-n-p
n-p-n
R1 100
R2 100
R3 100
R4 100
R5 100
S1 MANUAL OR MOTOR DRIVEN
56 K
R17
R6 1K
R7 2K
R8 3.9 K
R9 10 K
R10 20 K
R11 39 K
R12 100 K
R13 200 K
R14 390K
R15 1 MEG
R16 2 MEG
20
10
5
2
1
.5
.2
.1
.05
.02
.01
TRANSISTOR CURRENT STEP SIZE (mA)
FET'S OR TRANSISTORS UNDER TEST
1
2
E/S
C/D
E/S
C/D
Q1
Q2
B/G
B/G
S3
R18
10 R19
100 R20
1K R21
10K R22
S4 LOAD
EXT. LOAD
V_C
HORIZ.
GND
I_C
VERT.
S5
CH1
10 H
C1
300
C2
200
D1
D2
D3
D4
IN4383
115:115
T1
200 K
R24
PL1
NE81
115 V
T2
HIGH V_C
S6
LOW V_C
20 V
T3
0-120 V
115:115
T4
D5
D6
D7
D8
IN4383
R23
1K
D9
IN4383
OFF
ON
S7
F1 3A
117V A.C.

CURVE FAMILY GENERATOR—Used with cro to display entire families of characteristic curves for junction or field-effect transistors on cro. Article gives construction details. For generating five curves and base line, stepper switch S1 can be driven at about 300 rpm, if all curves are to appear simultaneously.—H. L. Moore, Transistor Curve Tracer, *Electronics World*, March 1968, p 53–56 and 84.

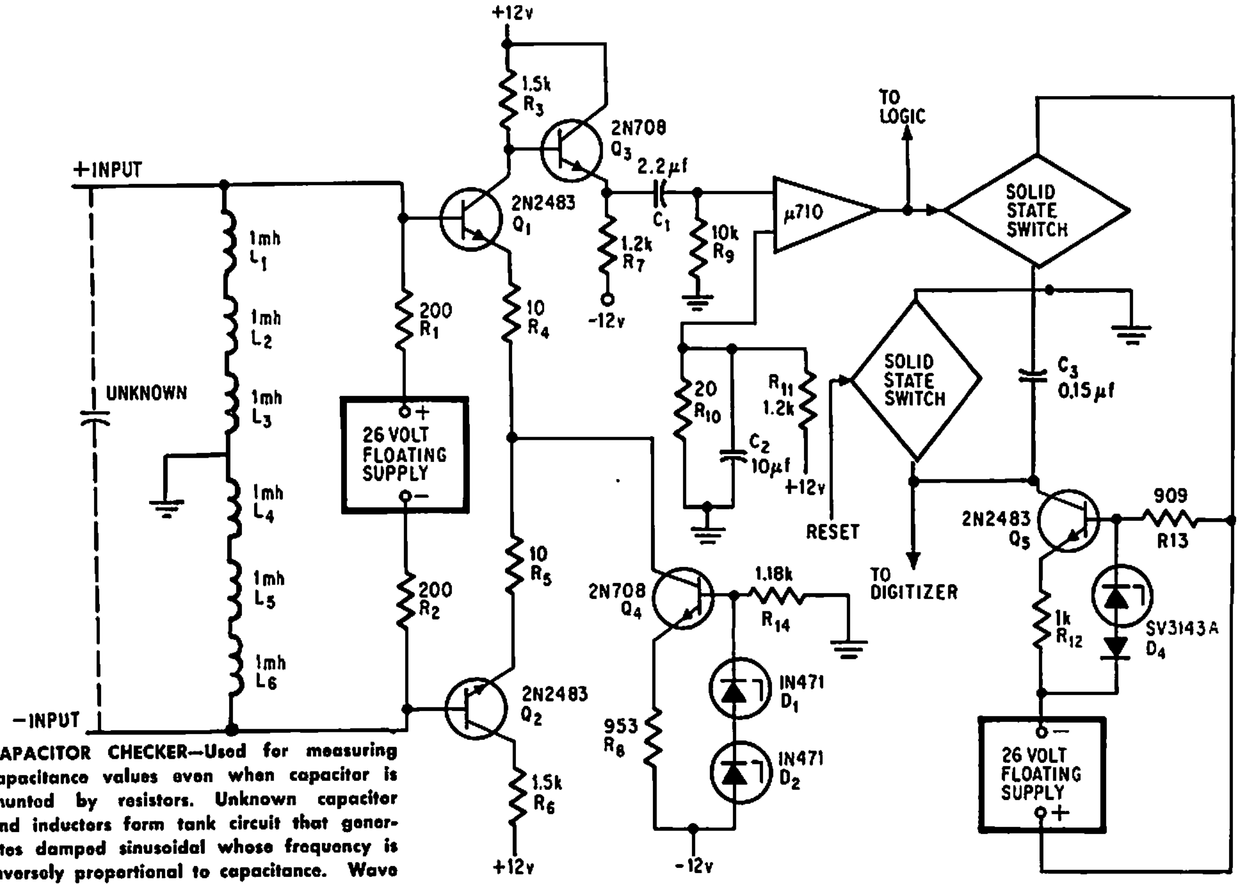

VCC +6V
1kΩ
0.1μF
9
1μF
1
10
1-kHz SIGNAL SOURCE
500Ω
CA3005 OR CA3006
7
0.1 μF
11
VIN
12
8
1kΩ
VCC +6V
0.1μF
VOUT
VEE -6V

SINGLE-ENDED COMMON-MODE GAIN = $\Delta v_{OUT}/\Delta v_{IN}$

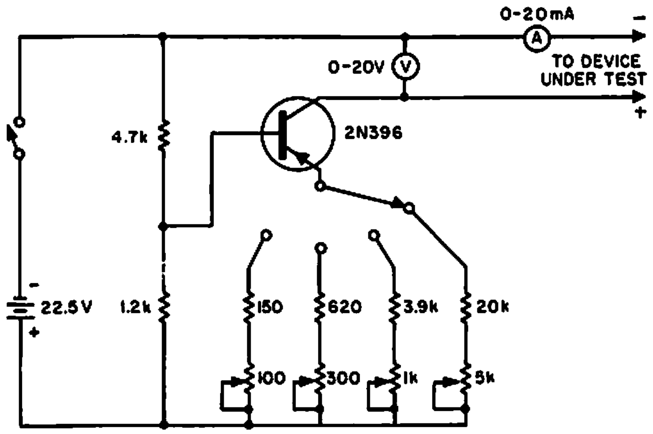
IC R-F AMPLIFIER TESTER—Determines single-ended common-mode gain of IC r-f amplifier at 1 kHz. With variable-frequency signal source, test can be made over entire useful frequency range.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 200.


STAGE n
STAGE n+1
+24 V
+12 V
3N58
N.C.
GE #344
68 K
10K
470
IN3606
10 VOLT INPUT PULSE ONLY IF TEST IS PASSED
COMMON INPUT
STEPPING RELAY

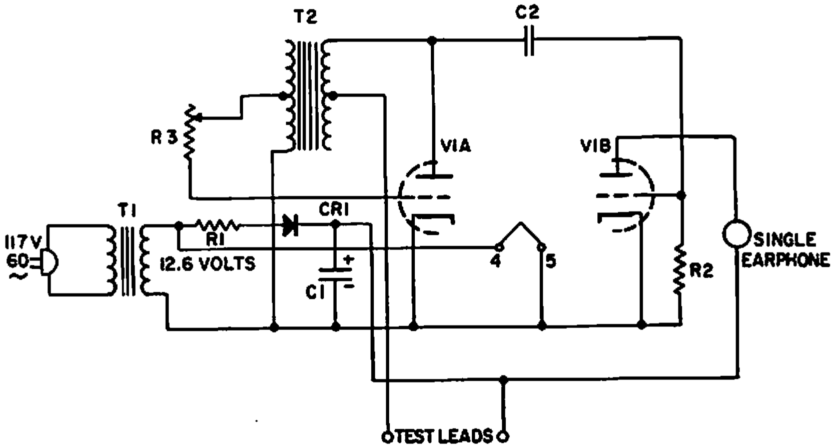
INDICATORS FOR SEQUENCE TESTER—Scr and lamp for each position of stepper relay provide visual indication of passed tests and indicate position of stepper. All lamps are reset by opening 24-V supply for few seconds. Lamp is ON at stepper position, but stays ON only if passed-test pulse arrives and turns on scr before stepper moves to next position.—E. Pacia, Visual Readout for Tester Uses Silicon-Controlled Switch, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 146–147.


+12v
1.5k R3
2N708 Q3
2.2μf C1
TO LOGIC
+INPUT
2N2483 Q1
μ710
SOLID STATE SWITCH
1.2k R7
10k R9
-12v
1mh L1
1mh L2
200 R1
10 R4
UNKNOWN
1mh L3
26 VOLT FLOATING SUPPLY
20 R10
R11 1.2k
C2 10μf
+12v
SOLID STATE SWITCH
C3 0.15μf
1mh L4
RESET
909
2N2483 Q5
R13
10 R5
200 R2
1mh L5
2N708 Q4
1.18k R14
TO DIGITIZER
1k R12
SV3143A D4
1mh L6
-INPUT
2N2483 Q2
IN471 D1
953 R8
IN471 D2
1.5k R6
26 VOLT FLOATING SUPPLY
+12v
-12v

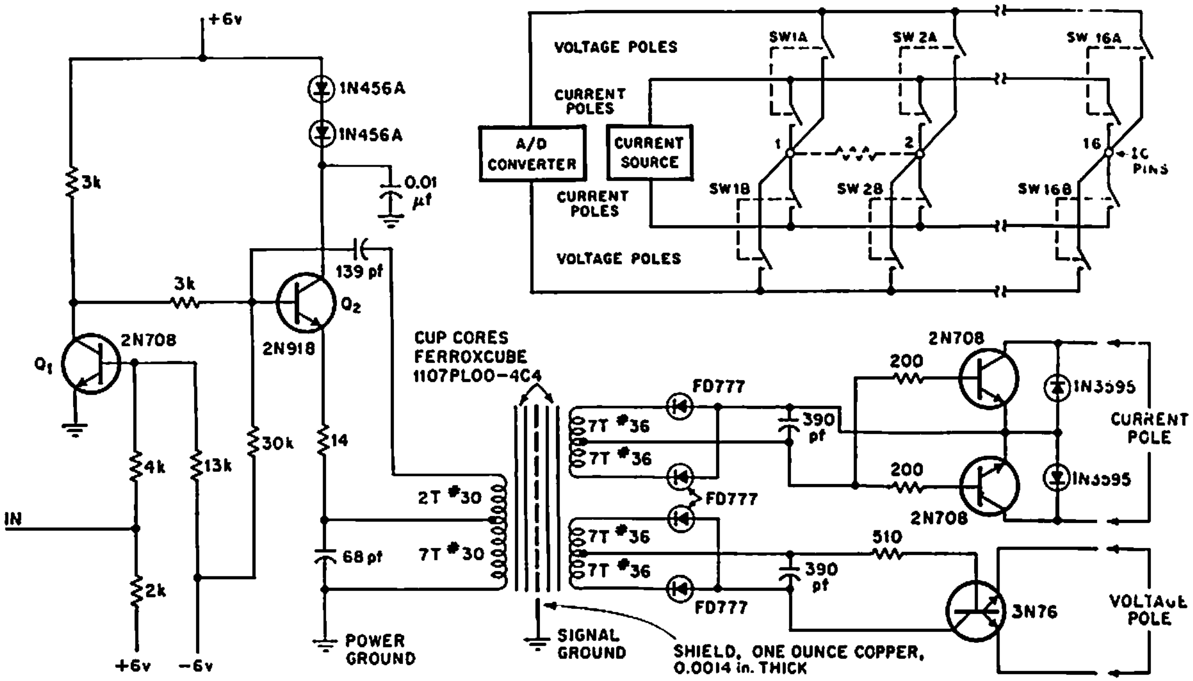
CAPACITOR CHECKER—Used for measuring capacitance values even when capacitor is shunted by resistors. Unknown capacitor and inductors form tank circuit that generates damped sinusoidal whose frequency is inversely proportional to capacitance. Wave is amplified by differential amplifier Q1-Q2 and squared by IC differential comparator whose output turns on solid-state switch for duration of first pulse. This initiates charging of C3 for first quarter-cycle to give voltage proportional to pulse width and to capacitance, for reading with digitizer.—C. H. Ristad, Resonance Effects Yield In-Circuit Capacitance Checks, *Electronics*, Oct. 14, 1968, p 119–120.


0-20mA
A
TO DEVICE UNDER TEST
0-20V
V
2N396
4.7k
22.5V
1.2k
150
620
3.9k
20k
100
300
1k
5k

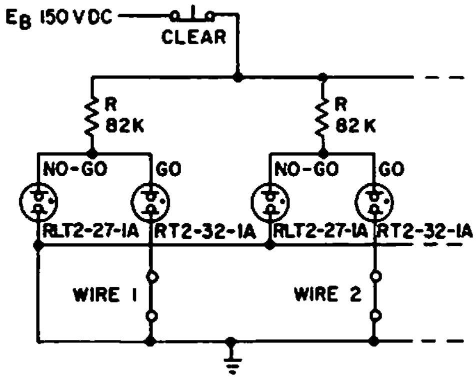
ZENER TESTER—Permits quick check of zener voltage and current characteristics of unmarked zener diodes. Can also be used to check forward voltage drop across diodes. Adjust variable resistors until desired values of current (0.2, 1, 5, and 20 mA) flow through milliammeter. Use heat sink with transistor.—G. V. Pallottino, Simple Zener-Diode Tester Uses Single Transistor, *Electronic Design*, Oct. 25, 1967, p 140.


T2
C2
R3
VIA
VIB
T1
CRI
RI
117V 60~
12.6 VOLTS
CI
4
5
R2
SINGLE EARPHONE
TEST LEADS

AURAL CONTINUITY TESTER—Continuity is indicated by tone in earphone, eliminating need for watching meter. Sends only very small current through circuit under test, minimizing damage to components under test. None of parts are critical; V1 can be almost any twin-triode having 12.6-V filament, such as 12AX7, 12 AT7, or 12AU7. T2 is any interstage audio transformer. Values are: C1 25 μF; C2 0.005 μF; CR1 1N34AS; R1 150; R2 470K; R3 250K. R3 adjusts tone; if not heard, reverse connections to one winding of T2.—"Hobby Manual," General Electric, Owensboro, Ky., Second Edition, 1965, p 174.

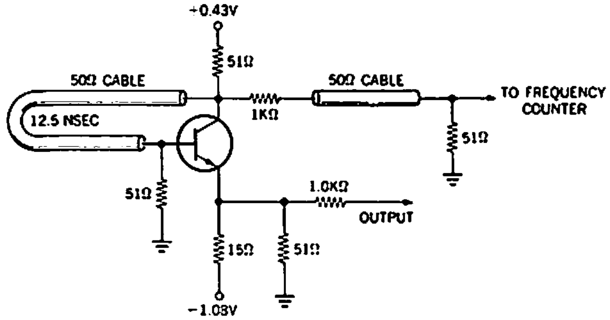

+6v
1N456A
1N456A
0.01 μf
3k
3k
139 pf
Q2
2N918
2N708
Q1
4k
13k
30k
14
IN
2k
+6v
-6v
68 pf
POWER GROUND
2T #30
7T #30
CUP CORES FERROXCUBE 1107PLOO-4C4
SIGNAL GROUND
SHIELD, ONE OUNCE COPPER, 0.0014 in. THICK
7T #36
7T #36
7T #36
7T #36
FD777
FD777
FD777
390 pf
390 pf
200
200
510
2N708
2N708
1N3595
1N3595
3N76
CURRENT POLE
VOLTAGE POLE
VOLTAGE POLES
CURRENT POLES
A/D CONVERTER
CURRENT SOURCE
CURRENT POLES
VOLTAGE POLES
SW1A
SW 2A
SW 16A
SW1B
SW 2B
SW 16B
1
2
16
IC PINS

FOUR-WIRE RESISTANCE CHECKER—Used in computer-controlled component testing in which voltage or current drive is applied to component under test and appropriate meter is connected. 14-MHz Hartley Q2 turns on current and voltage switches in about 2 μs. Transformer provides isolation between switch control and measurement circuit grounds for four-wire resistance measurements.—C. H. Ristad, Switched Oscillator Controls Four-Wire Resistance Checks, *Electronics*, July 6, 1970, p 78.



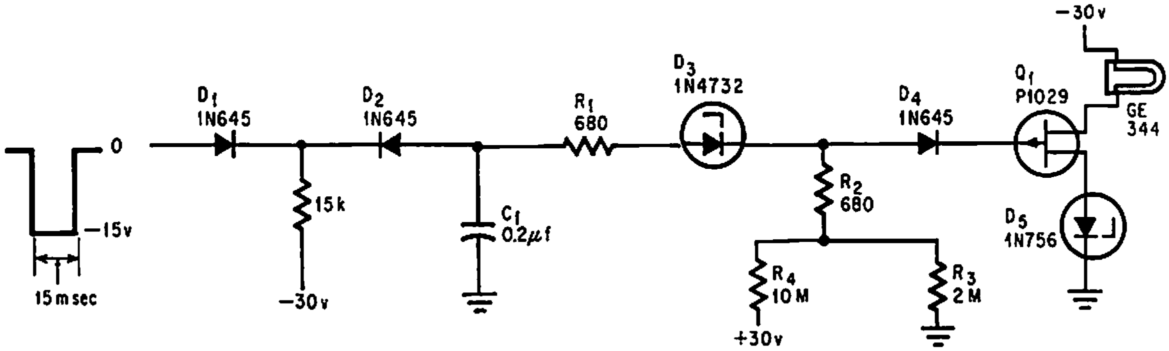
E_B 150 VDC
CLEAR
R 82K
R 82 K
NO-GO
GO
NO-GO
GO
RLT2-27-IA
RT2-32-IA
RLT2-27-IA
RT2-32-IA
WIRE I
WIRE 2

NEON CABLE TESTER—Simple and economical tester for one or more wires uses neon lamps with different firing potentials. NO-GO lamp glows only when cable under test is open.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 142.



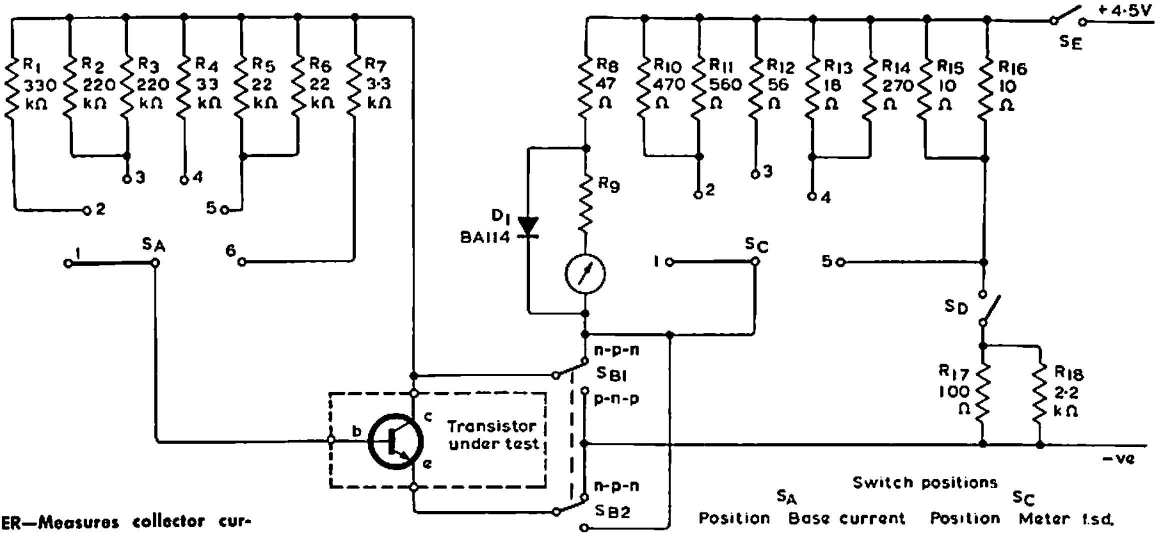
+0.43V
51Ω
50Ω CABLE
12.5 NSEC
1KΩ
50Ω CABLE
TO FREQUENCY COUNTER
51Ω
51Ω
1.0KΩ
OUTPUT
15Ω
51Ω
−1.03V

TRANSISTOR CHIP TESTER—Variation of circulating loop test is used to check switching speed of transistor chips before committing them to ASLT module for IBM 360/91 computer. Transistor drives itself on and off at rate determined by sum of its turn-on and turn-off delays and electrical length of cable in ns, according to equation given in article. Frequency counter is used to count number of switching operations and thereby determine switching speed.—R. F. Sechler, A. R. Strube, and J. R. Turnbull, ASLT Circuit Design, *IBM Journal*, Jan. 1967, p 74–85.



0
−15v
15 msec
D_1 1N645
15k
−30v
D_2 1N645
C_1 0.2μf
R_1 680
D_3 1N4732
R_2 680
R_4 10 M
+30v
R_3 2 M
D_4 1N645
Q_1 P1029
−30v
GE 344
D_5 1N756

LAMP SHOWS NARROW PULSES—Uses fet, gated into conduction while 15-ms pulse at test point in radar receiver is slowly discharged, to hold indicator lamp on for 180 ms. Lamp system is equally as effective for troubleshooting pulse circuits as more expensive oscilloscope systems. Can also be used for testing color tv and f-m multiplex circuits.—W. A. Magee, Stretching Video Pulse Keeps Indicator On, *Electronics*, March 4, 1968, p 90.

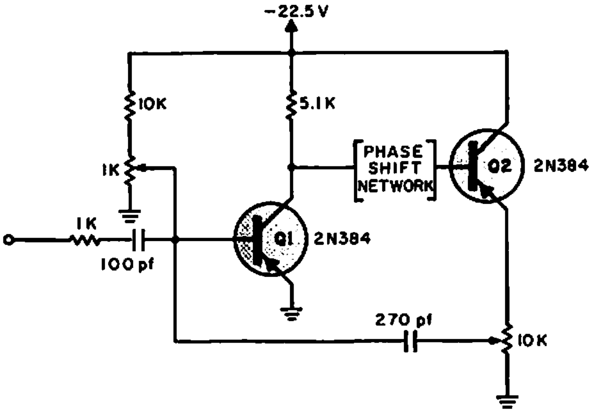


R_1 330 kΩ
R_2 220 kΩ
R_3 220 kΩ
R_4 33 kΩ
R_5 22 kΩ
R_6 22 kΩ
R_7 3·3 kΩ
2
3
4
5
6
1
S_A
R_8 47 Ω
R_{10} 470 Ω
R_{11} 560 Ω
R_{12} 56 Ω
R_{13} 18 Ω
R_{14} 270 Ω
R_{15} 10 Ω
R_{16} 10 Ω
+4·5V
S_E
R_9
D_1 BA114
2
3
4
1
S_C
5
S_D
R_{17} 100 Ω
R_{18} 2·2 kΩ
n-p-n
S_{B1}
p-n-p
c
b
e
Transistor under test
n-p-n
S_{B2}
p-n-p
−ve

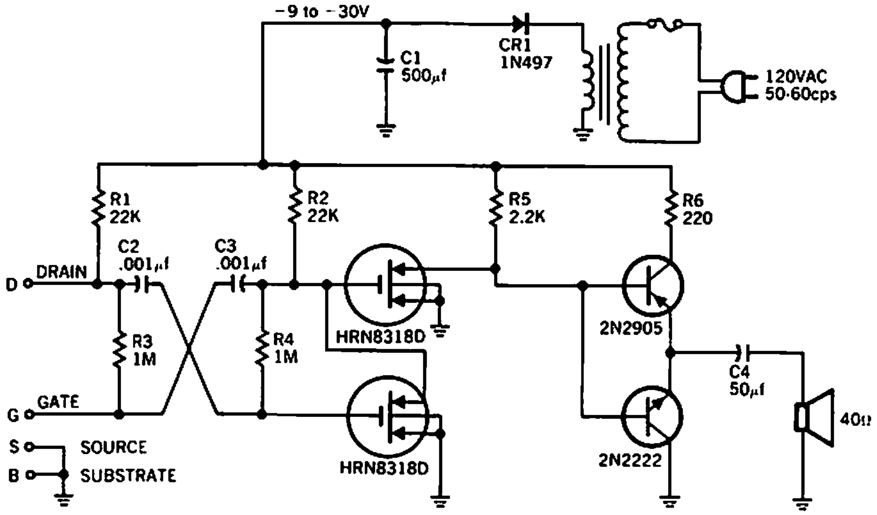
TRANSISTOR TESTER—Measures collector current of transistor under test, using 1-mA meter with suitable shunts. Switch permits measurement of collector-emitter reverse leakage current while base current of transistor is zero. Switch SA gives choice of five ranges for measuring static forward current transfer ratio.—"Transistor Audio and Radio Circuits," Mullard Ltd., London, 1969, p 180.

Switch positions

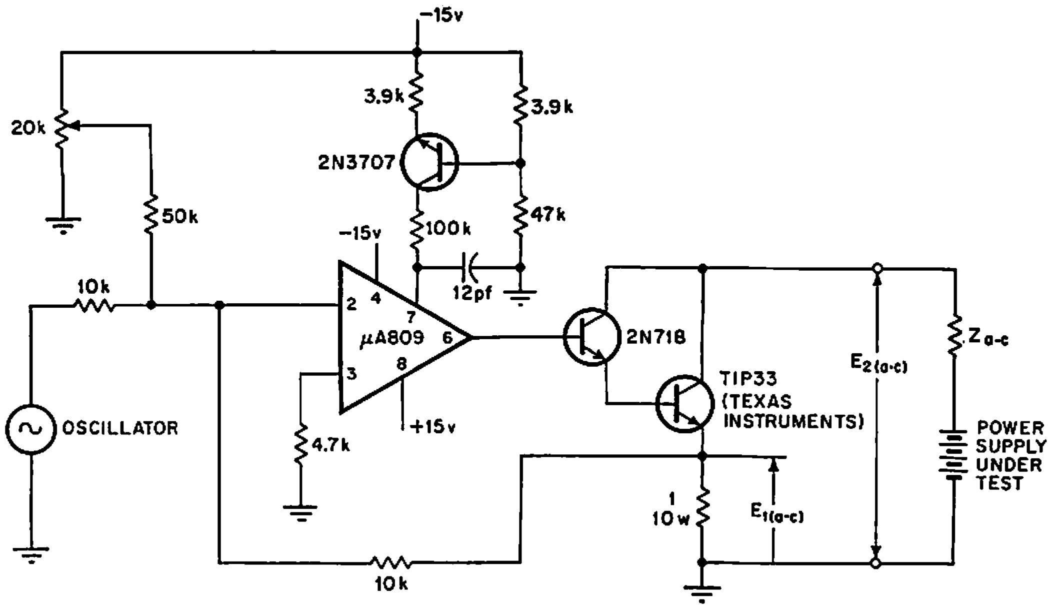
S_A Position	S_A Base current	S_C Position	S_C Meter f.s.d.
1	0	1	1mA
2	10μA	2	3mA
3	30μA	3	10mA
4	100uA	4	30mA
5	300μA	5	100mA
6	1mA		


−22.5V
10K
5.1K
1K
PHASE SHIFT NETWORK
Q2
2N384
1K
100 pf
Q1
2N384
270 pf
10K

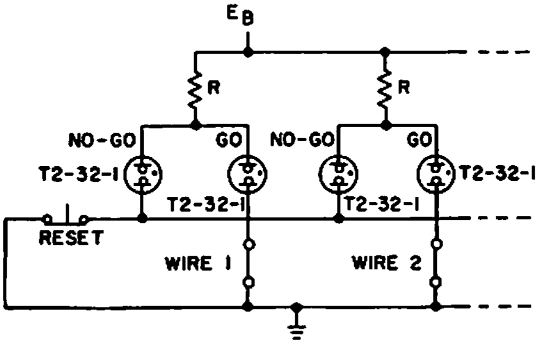
PHASE-SHIFT NETWORK TESTER—Simple amplifier serves for evaluation of distributed-parameter networks for i-f tuned amplifiers. —I. F. Barditch, Adapting Conventional VHF Equipment to Molecular Electronics, *Electronic Design*, Feb. 17, 1964, p 44–51.


−9 to −30V
C1
500μf
CR1
1N497
120VAC
50-60cps
R1
22K
R2
22K
R5
2.2K
R6
220
C2
.001μf
C3
.001μf
D
DRAIN
R3
1M
R4
1M
HRN8318D
2N2905
C4
50μf
40Ω
G
GATE
S
SOURCE
B
SUBSTRATE
HRN8318D
2N2222

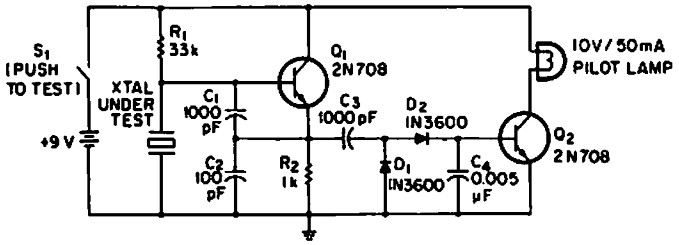
GO-NO-GO FET TESTER—Produces audible tone when good fet is properly inserted in test terminals at left. Fet under test serves as half of low-frequency mvbr, with lower fet of tester as other half. Upper fet serves as buffer for complementary-transistor output stage. May be used on fet production line to verify connections and operation before final encapsulation.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 2.


−15v
3.9k
3.9k
20k
2N3707
50k
47k
−15v
100k
12pf
10k
2
4
7
μA809
6
3
8
2N718
TIP33
(TEXAS
INSTRUMENTS)
E2(a-c)
Za-c
OSCILLATOR
4.7k
+15v
POWER
SUPPLY
UNDER
TEST
1
10w
E1(a-c)
10k

REGULATOR TESTER—Measures dynamic output impedance of regulated power supply, using high-gain feedback amplifier that accurately sets a-c load current at frequencies up to 500 kHz. A-c component from oscillator and d-c component from pot are fed into opamp. Transistor circuit connected to pin 7 improves high-frequency large-signal response without lowering gain appreciably.—R. D. Guyton, A Dynamic Load Tester for Regulated Power Supplies, *Electronics*, Feb. 2, 1970, p 98.

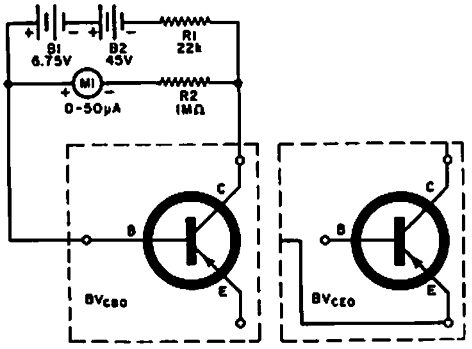

E_B
R
R
NO-GO
GO
NO-GO
GO
T2-32-1
T2-32-1
T2-32-1
T2-32-1
RESET
WIRE 1
WIRE 2

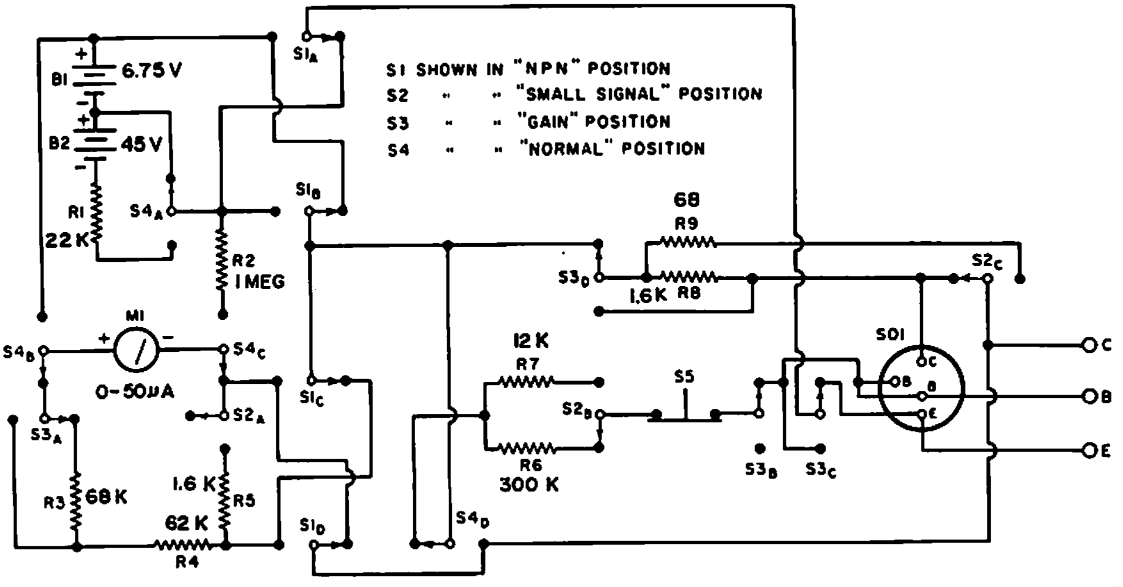
NEON HARNESS TESTER—Compact and inexpensive neon flip-flop circuit continuously monitors each individual wire in cable harness. Resistor values depend on E; for 250 V, R is 220K.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 142.


S1
(PUSH TO TEST)
+9 V
XTAL UNDER TEST
R1 33k
C1 1000 pF
C2 100 pF
Q1 2N708
C3 1000 pF
R2 1k
D2 1N3600
D1 1N3600
C4 0.005 μF
Q2 2N708
10V/50mA PILOT LAMP

CRYSTAL TESTER—Will check any crystal in range of 3.5 to 90 MHz almost instantly. Crystal is inserted in test socket and switch S1 pushed. If crystal is good, untuned Colpitts oscillator goes into oscillation, and its output signal is rectified to turn on Q2 and pilot lamp.—M. Kaufman, Self-Contained Crystal Tester, *EEE*, July 1970, p 84.

TRANSISTOR BREAKDOWN—Same circuit can be used to measure collector breakdown to emitter with base open and collector breakdown to base with emitter open, for up to 50 V breakdown. This test provides data for deciding if given transistor should be used in high-voltage circuit. Can also be used to measure breakdown voltage of zener diode, and for determining whether given transistor is germanium or silicon.—M. J. Moss, Versatile Transistor Tester, *Electronics World*, Aug. 1967, p 56–58.

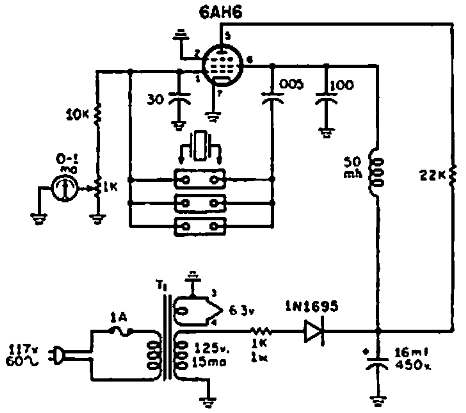

B1 6.75V
B2 45V
R1 22k
M1 0-50μA
R2 1MΩ
C
B
E
BV_CBO
C
B
E
BV_CEO

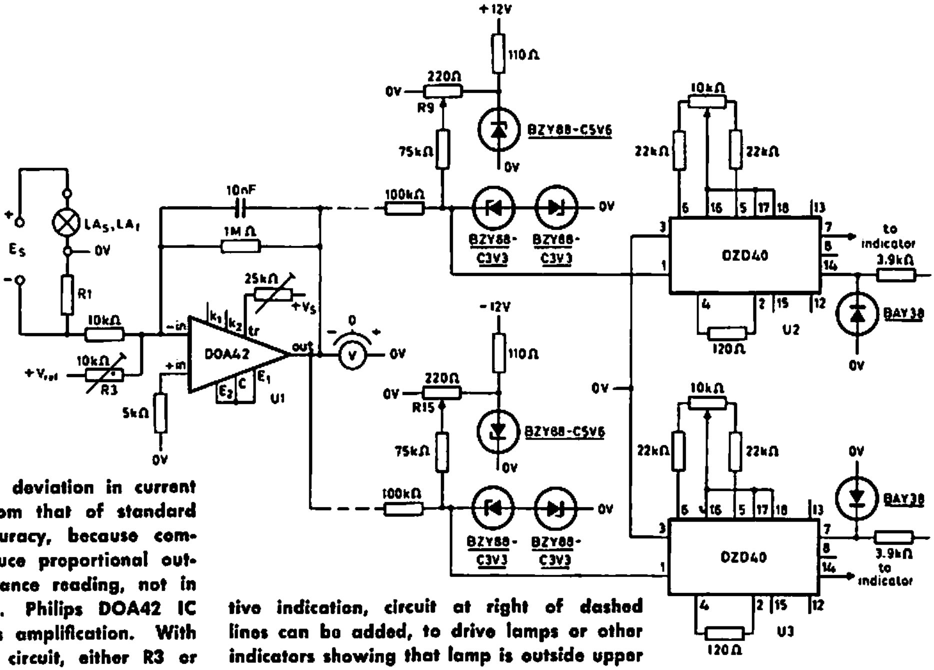

B1 6.75V
B2 45V
R1 22K
S4A
R2 1MEG
S1A
S1B
S1C
S1D
M1 0-50μA
S4B
S4C
S2A
S3A
R3 68K
1.6K R5
62K R4
68 R9
1.6K R8
S3D
S2C
12K R7
R6 300K
S2B
S5
S3B
S3C
S4D
SO1
C
B
E

S1 SHOWN IN "NPN" POSITION
S2 " " "SMALL SIGNAL" POSITION
S3 " " "GAIN" POSITION
S4 " " "NORMAL" POSITION

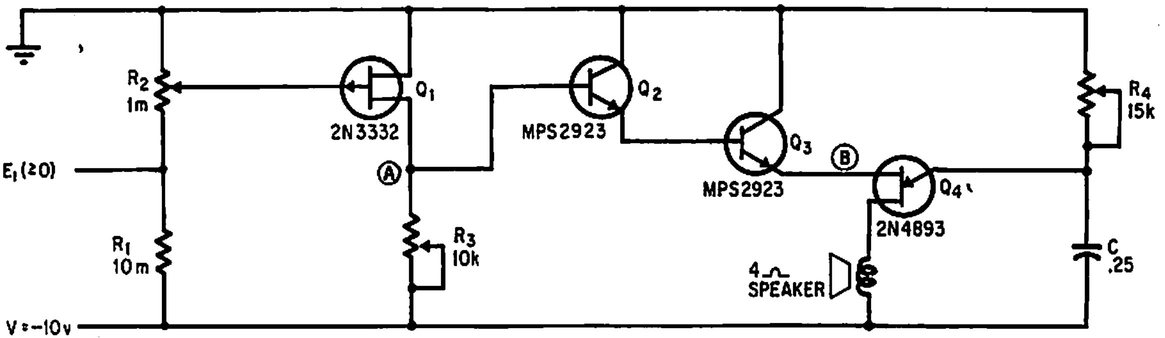
TRANSISTOR/DIODE TESTER—Circuit features simplicity of operation and lack of critical adjustments, for checking gain, leakage, and breakdown voltage of small-signal and power transistors. No on-off switch is needed for battery supply, so tester is ready for instant use. Circuit design makes it virtually impossible to damage either meter or transistor under test even if switches are set wrong. Also makes zener breakdown tests. Article gives operating instructions, along with changes needed to use 100-μA meter.—M. J. Moss, Versatile Transistor Tester, *Electronics World*, Aug. 1967, p 56–58.

SURPLUS-CRYSTAL CHECKER—Provides quick performance check of used or surplus crystals often available for as little as 10 cents each. Tube circuit operating from a-c line will oscillate for crystals throughout 2–30 MHz range and for fundamental crystals in 200–500 kHz range. (Transistor equivalent was extremely critical as to frequency.) Good crystal gives meter reading of 0.3 to 1 mA, while bad crystals read below 0.2 mA. Checker is easily calibrated with a few good crystals.—E. H. Marriner, The Crystal Checker, CQ, July 1964, p 30–31.


6AH6
10K
30
.005
100
0-1 ma
1K
50 mh
22K
T₁
1A
6.3v
1N1695
117v 60~
125v. 15ma
1K 1w
16mf 450v.

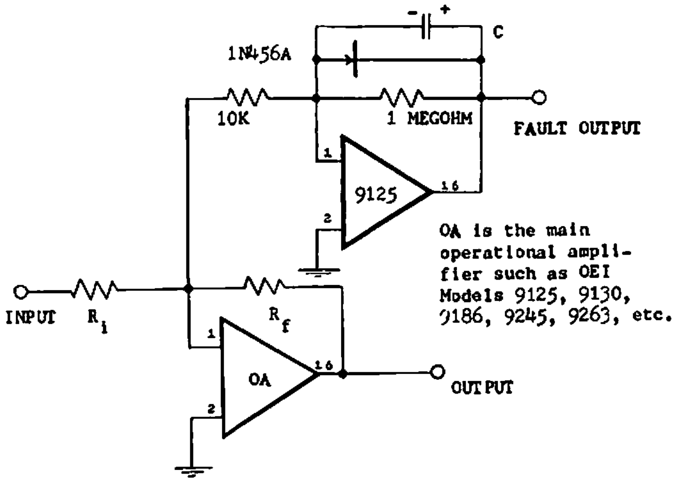

+12V
110Ω
220Ω
0V
R9
75kΩ
BZY88-C5V6
0V
10kΩ
22kΩ
22kΩ
10nF
1MΩ
100kΩ
BZY88-C3V3
BZY88-C3V3
+
-
Es
LAs, LA₁
0V
R1
10kΩ
10kΩ
+Vref
R3
25kΩ
+Vs
5kΩ
-in
+in
k₁
k₂
tr
DOA42
out
E₁
E₂
C
U1
V
0
DZD40
to indicator
3.9kΩ
+12V
BAY38
120Ω
U2
-12V
R15
U3

LAMP TESTER—Measures deviation in current of lamp under test from that of standard lamp. Gives high accuracy, because component variations produce proportional output error only in tolerance reading, not in total measured current. Philips DOA42 IC opamp gives 100 times amplification. With standard lamp LAs in circuit, either R3 or Vref is adjusted for zero output of opamp as indicated by zero-center voltmeter. Lamp testing can now be carried out. For positive indication, circuit at right of dashed lines can be added, to drive lamps or other indicators showing that lamp is outside upper or lower tolerance limits determined by 10K pots connected to DZD40 Philips IC zero detectors.—P. Havas, Measurement of Deviation from Standard Using A DOA42 Circuit Block, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 83.


R₂ 1m
Q₁
2N3332
E₁(±0)
Ⓐ
R₁ 10m
R₃ 10k
MPS2923
Q₂
Q₃
MPS2923
Ⓑ
Q₄
2N4893
4Ω SPEAKER
R₄ 15k
C .25
V = -10v

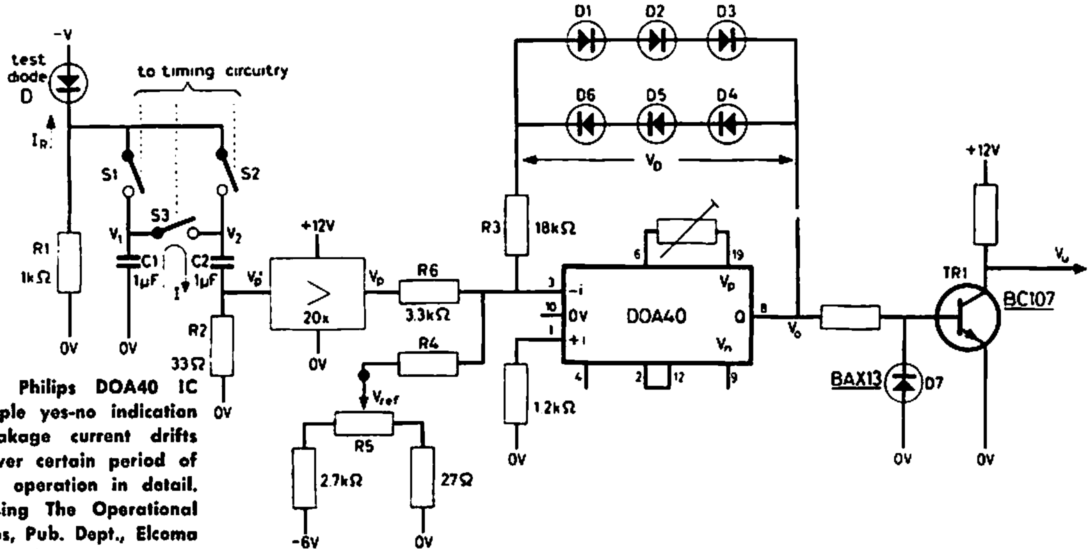
AUDIBLE VOLTMETER FOR IC'S—Circuit produces three different squeals from loudspeaker—250 Hz for open circuit, 300 Hz for 0 V, and 1,000 Hz for +5 V, to speed checking of DTL and TTL IC's when visual readout is inconvenient. Rheostats can be adjusted for wide range of other input voltages and output frequencies.—T. F. Piatkowski, ICs Are Checked Faster With Audible Voltmeter, *Electronics*, Jan. 20, 1969, p 88.

E₁	OUTPUT FREQUENCY
OPEN	250hz
0v	300hz
+5v	1000hz

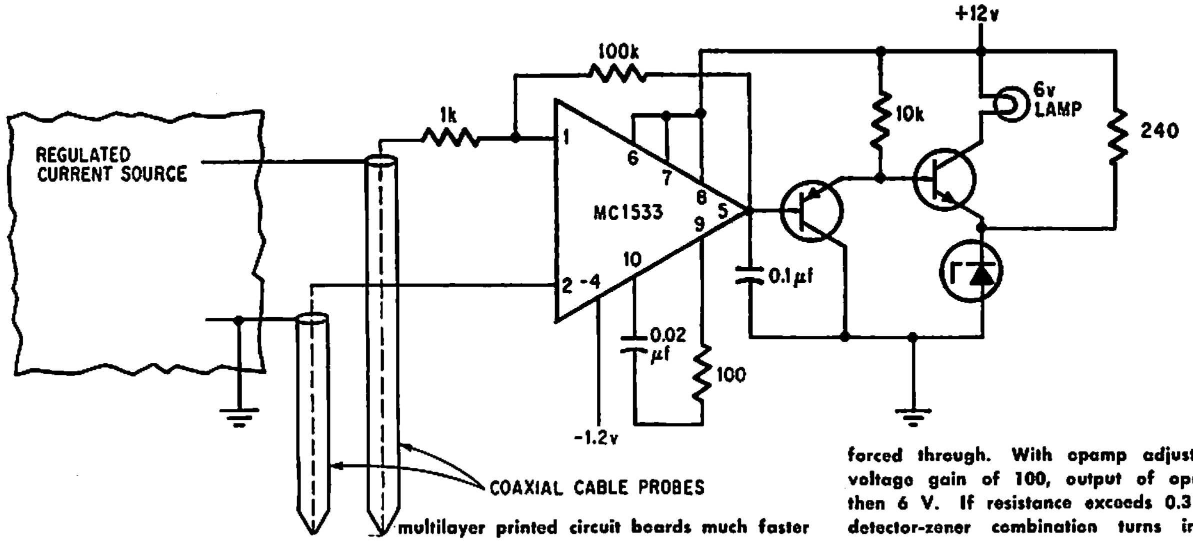

1N456A
C
10K
1 MEGOHM
FAULT OUTPUT
9125
1
2
16
INPUT
R_i
R_f
OA
1
2
16
OUTPUT

OA is the main operational amplifier such as OEI Models 9125, 9130, 9186, 9245, 9263, etc.

OPAMP FAULT DETECTOR—Senses and indicates presence of signal at inverting input of opamp. Detection takes place in another opamp connected in polar integrator circuit, to give positive d-c voltage as indication of fault output. Can be used to drive indicator lamp, reset analog computer, or stop process under control. Choose value of C for desired R-C time constant with 1-meg feedback resistor. 1 μF gives 1 s. Values of Ri and Rf depend on opamp OA under test.—An Operational Amplifier Fault Detector, Optical Electronics, Tucson, Ariz., No. 10168.

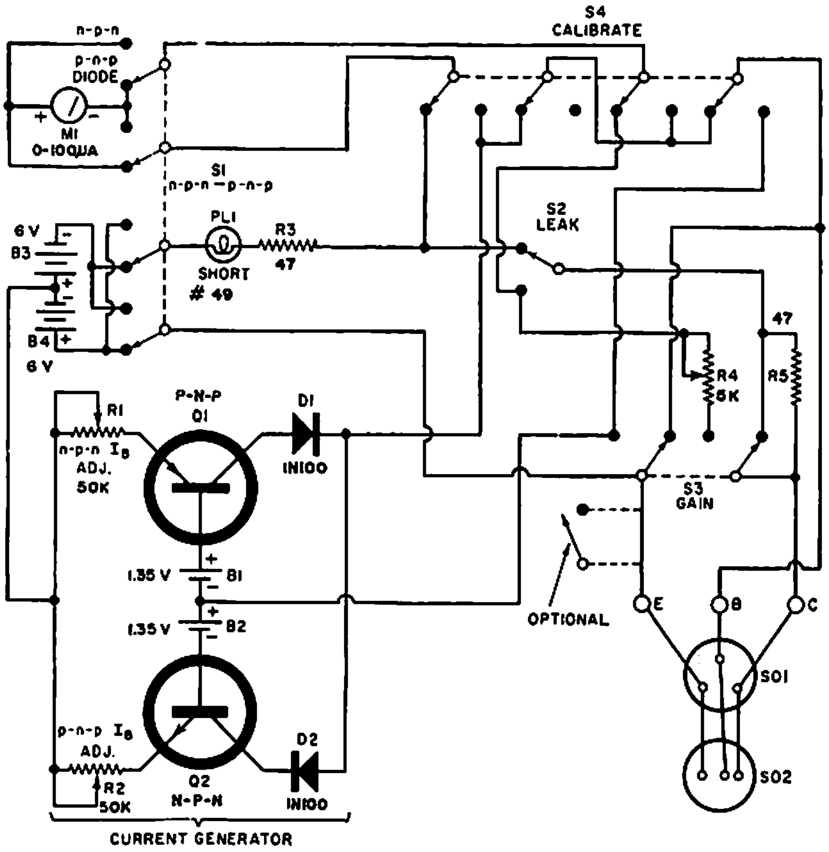

-V
test diode D
I_R
to timing circuitry
S1
S2
S3
V_1
V_2
R1
1kΩ
C1 1μF
C2 1μF
I
0V
0V
R2
33Ω
0V
V_0'
+12V
20x
0V
V_0
R6
3.3kΩ
R4
V_{ref}
R5
2.7kΩ
27Ω
-6V
0V
R3
18kΩ
D1
D2
D3
D6
D5
D4
V_D
DOA40
-i
0V
+i
V_p
0
V_n
1.2kΩ
0V
V_o
+12V
TR1
BC107
BAX13
D7
V_u
0V
0V

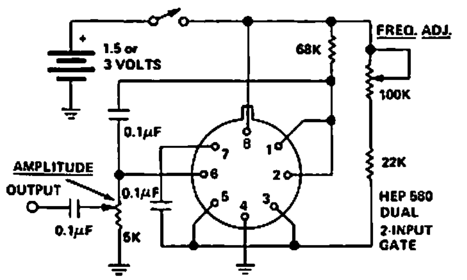
LEVEL DETECTOR—Uses Philips DOA40 IC opamp to provide simple yes-no indication of whether diode leakage current drifts within certain value over certain period of time. Report describes operation in detail. —A Level Detector Using The Operational Amplifier DOA40, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands.


+12v
100k
1k
REGULATED CURRENT SOURCE
MC1533
1
6
7
8
5
9
10
2 -4
10k
6v LAMP
240
0.1μf
0.02 μf
100
-1.2v
COAXIAL CABLE PROBES

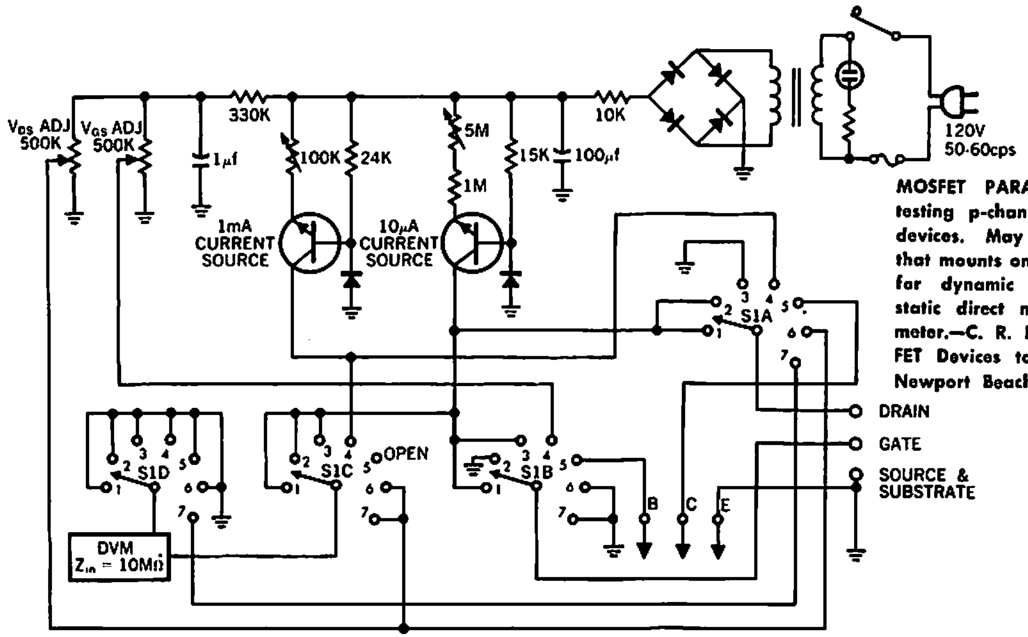
WIRING CHECKER—IC opamp followed by two-transistor detector with indicator lamp checks resistance of critical conductor runs on multilayer printed circuit boards much faster than with digital ohmmeter. Maximum permissible resistance is 0.3 ohm, which gives voltage drop of 0.06 V when 200 mA is forced through. With opamp adjusted for voltage gain of 100, output of opamp is then 6 V. If resistance exceeds 0.31 ohm, detector-zener combination turns indicator lamp off.—D. Haggan, Tester Measures Resistance of Multilayer P-C Boards, *Electronics*, Sept. 16, 1968, p 100–101.

TRANSISTOR-DIODE-SCR TESTER—Measures leakage current and d-c current gain (beta) of transistors, indicates open or shorted junctions via lamp, indicates whether scr will conduct when current is furnished to gate and will turn off when voltage is removed, and checks for opens or shorts in diodes. Q1 and Q2 should have beta over 20. Article gives construction and calibration procedures.—M. Gross, Semiconductor Test Set, *Electronics World*, Nov. 1967, p 74–76.


n-p-n
p-n-p
DIODE
M1
0-100μA
S1
n-p-n — p-n-p
PL1
SHORT
# 49
R3
47
6 V
B3
B4
6 V
S4
CALIBRATE
S2
LEAK
47
R4
5K
R5
S3
GAIN
OPTIONAL
E
B
C
SO1
SO2
R1
n-p-n I_B
ADJ.
50K
P-N-P
Q1
D1
IN100
1.35 V
B1
1.35 V
B2
p-n-p I_B
ADJ.
R2
50K
Q2
N-P-N
D2
IN100
CURRENT GENERATOR


1.5 or
3 VOLTS
68K
FREQ. ADJ.
100K
0.1μF
22K
AMPLITUDE
OUTPUT
0.1μF
0.1μF
5K
HEP 580
DUAL
2-INPUT
GATE
1
2
3
4
5
6
7
8

SIGNAL INJECTOR—Helps locate defective r-f or audio stage in radio or tv testing. Square-wave output is variable from 200 to 2,000 Hz, with amplitude adjustable from 0 to 1 V.—"Tips on Using IC's," Motorola, Phoenix, Ariz., HMA-32, 1968.


V_{DS} ADJ
500K
V_{GS} ADJ
500K
330K
1μf
100K
24K
5M
1M
15K
100μf
10K
1mA
CURRENT
SOURCE
10μA
CURRENT
SOURCE
120V
50-60cps
S1A
S1B
S1C
S1D
OPEN
DVM
Z_{in} = 10MΩ
B
C
E
DRAIN
GATE
SOURCE &
SUBSTRATE

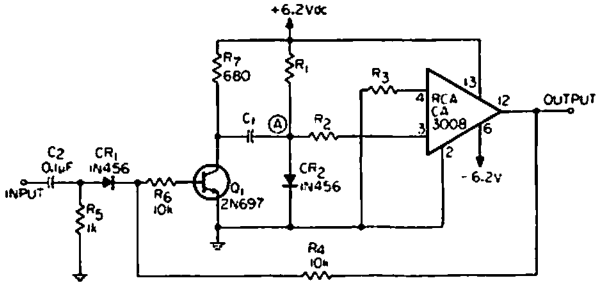
SWITCH POSITION NOMENCLATURE

Position 1 = $V_t \leq 80V$ @ 10μA
2 = $BV_D \leq 80V$ @ 10μA
3 = $BV_G \leq 80V$ @ 10μA

Position 4 = R_{ON}@ 1mA
5 = Normal Scope
6 = V_{DS} for 1nA
7 = 1nA Adj Monitor

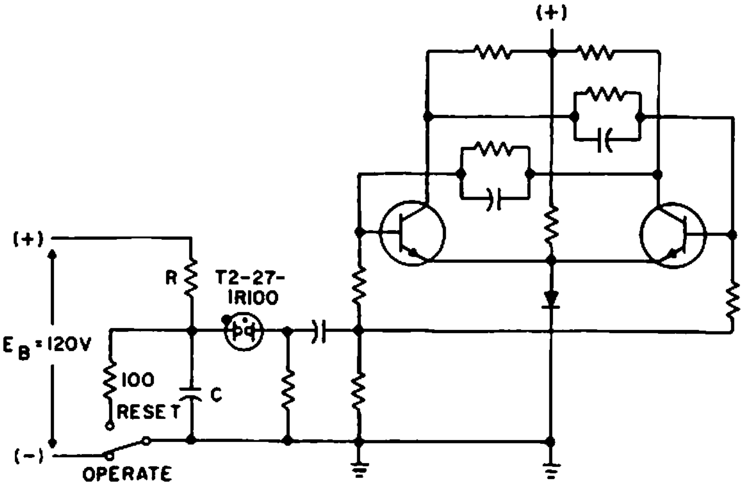
MOSFET PARAMETER TESTER—Designed for testing p-channel enhancement-mode mosfet devices. May be assembled in small box that mounts on terminal plugs of curve tracer for dynamic testing, in conjunction with static direct measurements on digital voltmeter.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 3.

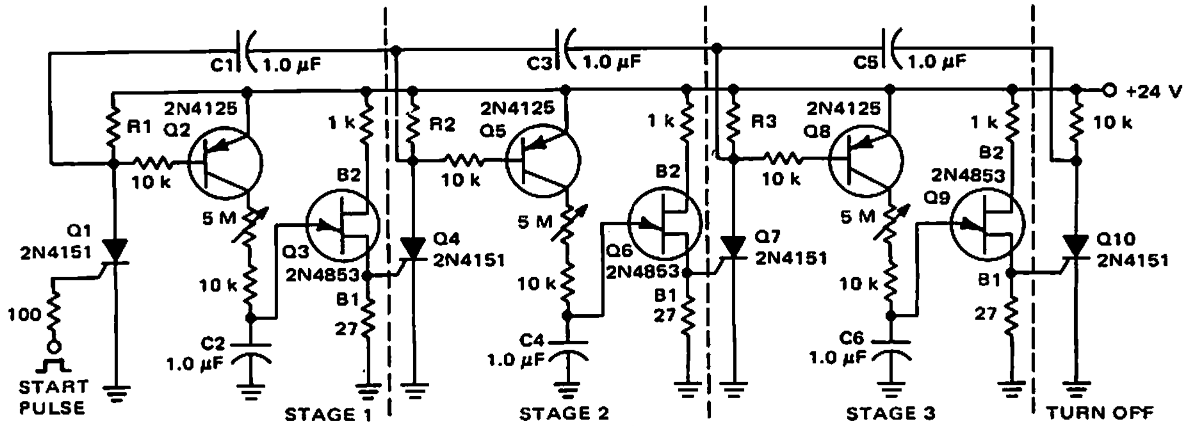
CHAPTER 89
Timer Circuits


+6.2Vdc
R7
680
R1
R3
RCA
CA
3008
4
3
13
12
6
2
OUTPUT
C1
Ⓐ
R2
- 6.2V
C2
0.1μF
CR1
1N456
INPUT
R5
1k
R6
10k
Q1
2N697
CR2
1N456
R4
10k

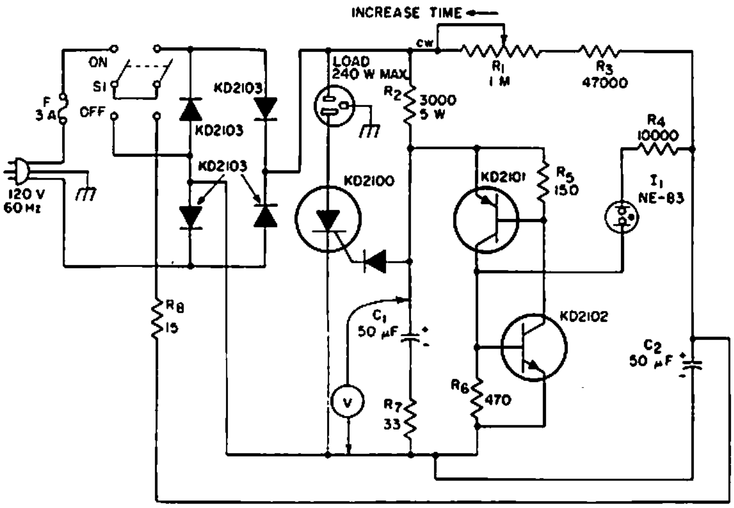
VARIABLE-DELAY ONE-SHOT—With C1 0.22 μF, R1 47–547K, and R2 and R3 10K, range of delay times is 7 to 80 ms. With C1 10 μF and other values same, range is 0.4–4 s. May also be used as countdown circuit or one-shot driving 1K load. IC opamp contributes to high performance. Input trigger should be greater than 2.5 V p-p, with 5-μs rise time and at least 10-μs pulse width.—W. R. Walters, IC Opamp Improves Stability of Monostable Multivibrator, *EEE*, Dec. 1967, p 92–93.

NEON-OPERATED FLIP-FLOP—Peak voltage and duration of driver pulse from neon are determined by value of capacitor between neon lamp and flip-flop. Book has nomograph (p 31) for determing values of R and C to give desired time.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 61.

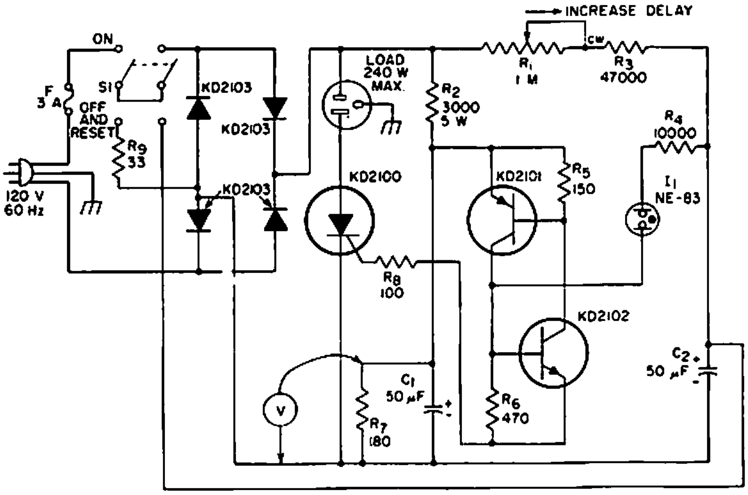

(+)
(+)
R
T2-27-
1R100
E_B = 120V
100
RESET
C
(-)
OPERATE


C1
1.0 μF
C3
1.0 μF
C5
1.0 μF
+24 V
2N4125
R1
Q2
10 k
1 k
R2
2N4125
Q5
10 k
1 k
R3
2N4125
Q8
10 k
1 k
10 k
B2
B2
B2
2N4853
Q9
5 M
5 M
5 M
Q1
2N4151
Q3
2N4853
Q4
2N4151
Q6
2N4853
Q7
2N4151
Q10
2N4151
10 k
10 k
10 k
B1
27
B1
27
B1
27
100
C2
1.0 μF
C4
1.0 μF
C6
1.0 μF
START
PULSE
STAGE 1
STAGE 2
STAGE 3
TURN OFF
CIRCUIT

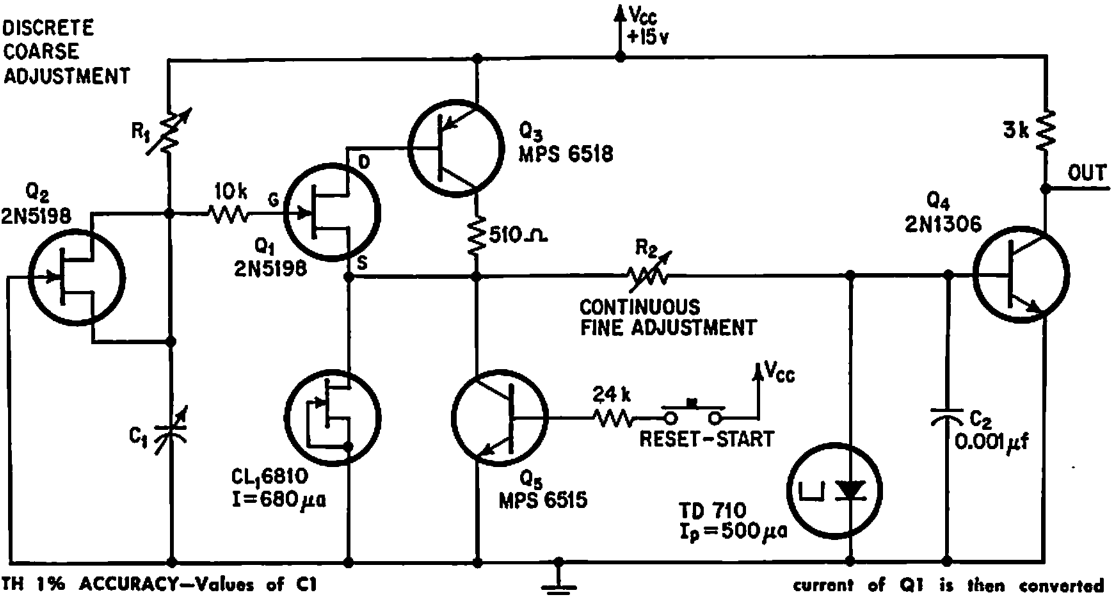
SEQUENTIAL UJT TIMER—Can have any number of stages. Output pulse from each stage follows that of previous stage by adjustable interval. Q10 serves only to turn off scr in last stage (Q7). Addition of timing circuit between Q10 and Q1 makes sequence run continuously. Delay time of each stage can be anywhere between 10 ms and 5 s, set by 5-meg pot. R1, R2, and R3 can be relays or other types of loads for scr's; if output pulses are desired from scr gates, these resistors should be 100 ohms.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–27.


INCREASE TIME
CW
R1
1 M
R3
47000
LOAD
240 W MAX
R2
3000
5 W
R4
10000
I1
NE-83
ON
S1
OFF
F
3 A
120 V
60 Hz
KD2103
KD2103
KD2103
KD2103
KD2100
KD2101
R5
150
KD2102
C1
50 μF
C2
50 μF
V
R6
470
R7
33
R8
15

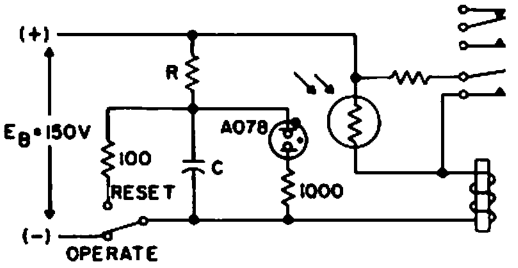
5—120 S TIMER FOR 240 W—Provides controlled on time for enlargers, house or garage lights, and universal motors, with automatic turn-off at end of interval by single scr in series with load.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 62.


INCREASE DELAY
ON
S1
OFF
AND
RESET
F
3 A
R9
33
120 V
60 Hz
KD2103
KD2103
KD2103
KD2103
LOAD
240 W
MAX.
R2
3000
5 W
R1
1 M
CW
R3
47000
R4
10000
I1
NE-83
KD2100
KD2101
R5
150
R8
100
KD2102
C2
50 μF
C1
50 μF
V
R7
180
R6
470

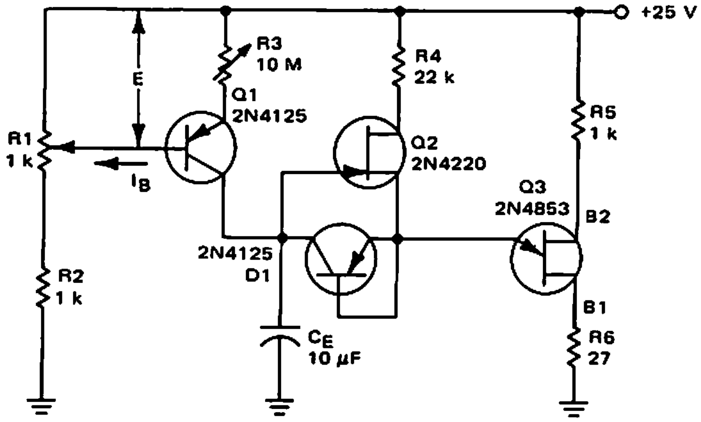
5—300 S TIMER FOR 240 W—Timing capacitor C2 gives maximum delay of 2 min before applying power with values shown, but larger capacitor will increase delay to 5 min. In addition to lamp, heater, and motor applications, can be used to turn on alarm at end of desired time interval such as for signaling 1-min limit of thinking time in chess or bridge game.—"Silicon Controlled Rectifier Experimenter's Manual," RCA, Harrison, N.J., 1967, p 66.


DISCRETE
COARSE
ADJUSTMENT
Vcc
+15 v
R1
Q2
2N5198
10k
G
D
S
Q1
2N5198
Q3
MPS 6518
510Ω
R2
CONTINUOUS
FINE ADJUSTMENT
3k
OUT
Q4
2N1306
C1
CL16810
I=680μa
Q5
MPS 6515
24 k
Vcc
RESET-START
TD 710
Ip=500μa
C2
0.001μf

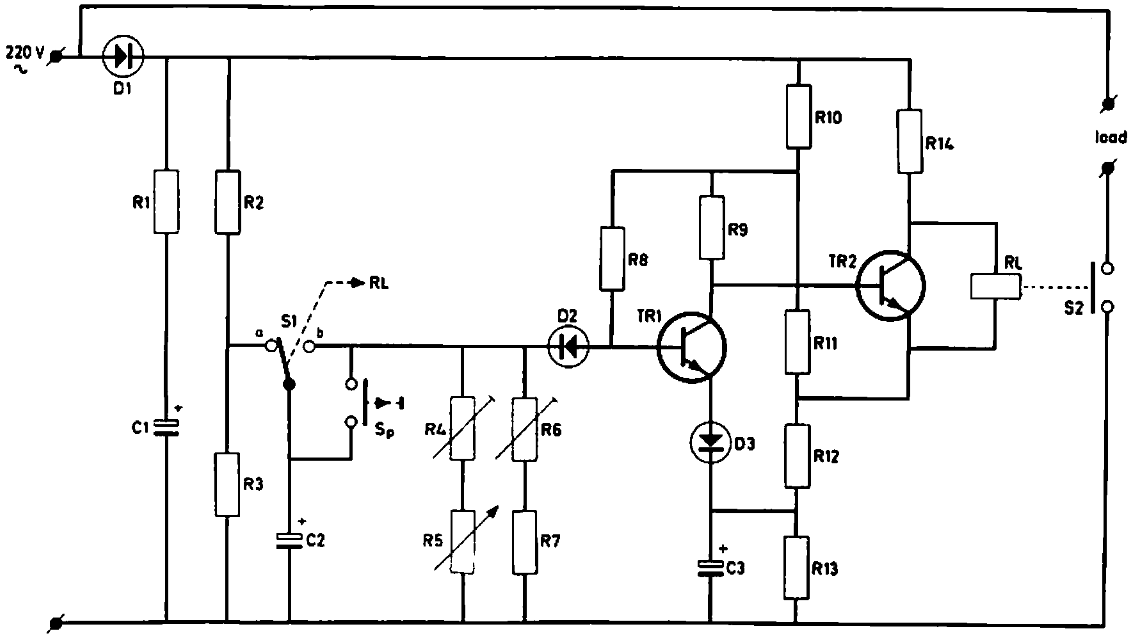
30 HR WITH 1% ACCURACY—Values of C1 and R2 have maximum effect on interval between input and output signals; 30-hr delay is obtained with 28K for R2 and 1 μF for C1. For 70-min delay, R1 is 100 billion ohms, R2 is 18K, and C1 is 0.1 μF. Circuit can also be used to measure small currents such as fet gate leakage currents in picoampere region, by removing R1 and Q2; leakage current of Q1 is then converted into time delay. With feedback from output to reset input, circuit can be used as current-frequency converter.—G. Black and K. C. Smith, BIFET Circuit Yields Time Delays Up to 30 Hours, *Electronics*, May 26, 1969, p 94.


(+)
R
E_B = 150V
100
RESET
C
A078
1000
(−)
OPERATE

NEON-OPERATED PHOTOCELL—Light from neon reduces resistance of cadmium sulfide or cadmium selenide photocell, permitting relay to lock up. Book has nomograph (p 31) for determining values of R and C to give desired time.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 59.


+25 V
E
R3
10 M
Q1
2N4125
R4
22 k
R1
1 k
I_B
Q2
2N4220
Q3
2N4853
B2
2N4125
D1
R2
1 k
C_E
10 μF
B1
R5
1 k
R6
27

10-HR FET TIMER—Circuit is basically ujt sawtooth oscillator, in which conventional charging resistor for CE is replaced by current source Q1-R1-R2-R3. For timing accuracy of 10%, voltage supply must have 2.5% regulation. Book analyzes sources of error in timing.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–24.


220 V ~
D1
R1
R2
C1
R3
S1
a
b
RL
S_p
C2
R4
R5
R6
R7
D2
R8
TR1
R9
D3
C3
R10
R11
R12
R13
R14
TR2
RL
S2
load

R_1 = 100 Ω; ¼ W
R_2 = 56 kΩ; 5.5 W
R_3 = 4.7 kΩ; ¼ W
R_4 = 20 kΩ; potentiometer
R_5 = 2 MΩ; potentiometer
R_6 = 2 MΩ; potentiometer
R_7 = 3.3 MΩ; ¼ W
R_8 = 2.7 MΩ; ¼ W
R_9 = 56 kΩ; ¼ W
R_{10} = 220 kΩ; 1 W
R_{11} = 4.7 kΩ; ¼ W
R_{12} = 120 Ω; ¼ W
R_{13} = 1.2 kΩ; ¼ W
R_{14} = 39 kΩ; 5.5 W

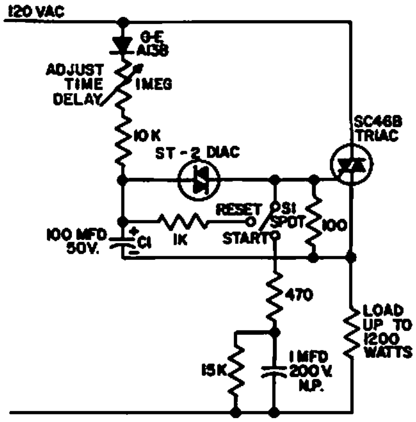
C_1 = 8 μF – 500 V
C_2 = 800 μF – 40 V (2222 060 17801)
C_3 = 5 μF – 16 V

RL = relay 35 V – 7 mA

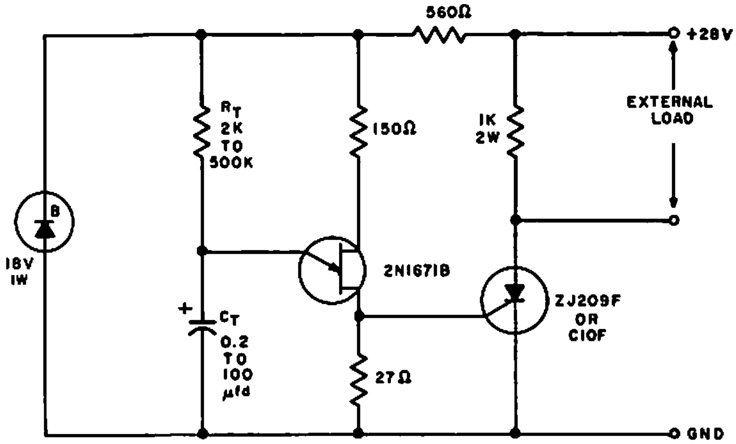
D_1 = BYX10 or BY100
D_2 = OA200 or OA202
D_3 = OA202

TR_1 = BC147
TR_2 = BC147

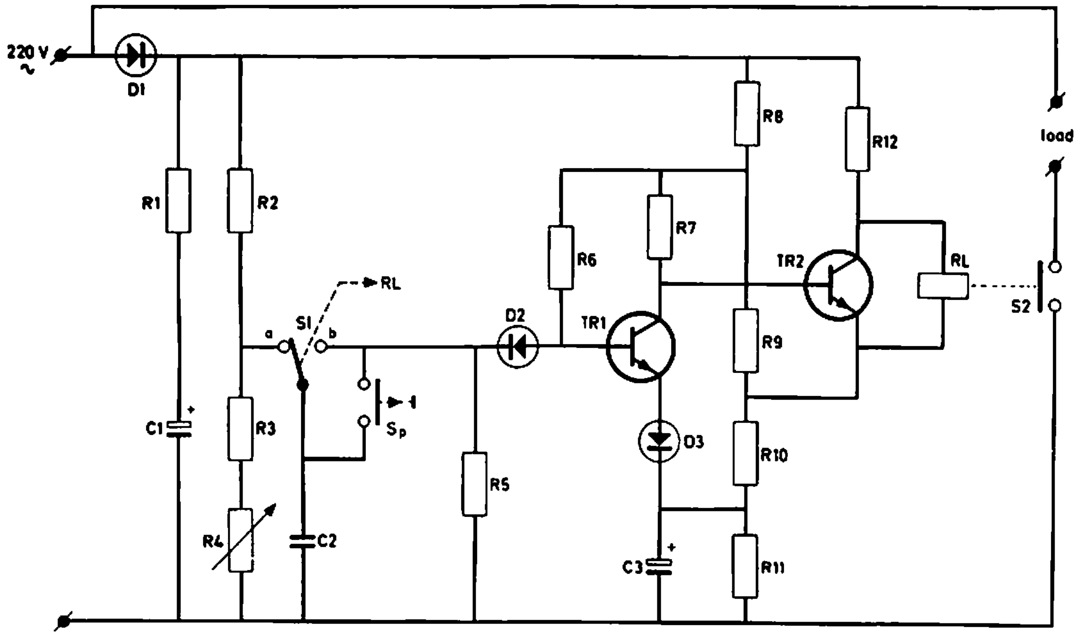
HIGH-ACCURACY 20-MIN DELAY—Energizes relay with high reproducibility at end of delay interval that is continuously adjustable up to 20 min with R5. Setting of R4 determines minimum time and R6 maximum time. Operates from 220-V a-c line through half-wave rectifier D1, with relay connected to handle a-c load.—Transistorized Timers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 443, 1968.


120 VAC
G-E A13B
ADJUST TIME DELAY
1MEG
10K
ST-2 DIAC
SC46B TRIAC
RESET
S1 SPDT
START
100
1K
100 MFD 50V.
C1
470
15K
1MFD 200V. N.P.
LOAD UP TO 1200 WATTS

1-MINUTE DELAY FOR 1,200 W—Static a-c time delay, adjustable up to 1 min, handles inductive or resistive load. Simplicity of triac a-c latch is combined with low cost of diac triggering. For industrial and commercial control applications requiring delayed switching on of load and quick reset.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 9.


560Ω
+28V
R_T 2K TO 500K
150Ω
1K 2W
EXTERNAL LOAD
B
18V 1W
2N1671B
ZJ209F OR C10F
C_T 0.2 TO 100 μfd
27Ω
GND

PRECISION UJT DELAY—Range of values indicated for RT and CT gives time delays from 0.4 ms to 1 minute. Load current is limited only by rating of scr. If RT is precision calibrated potentiometer such as Helipot, delay can be set accurately over wide range after one initial calibration.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 77.


220 V ~
D1
R1
R2
C1
R3
R4
C2
S1
a
b
RL
Sp
R5
D2
TR1
R6
R7
D3
C3
R8
R9
R10
R11
R12
TR2
RL
load
S2

R_1 = 100 Ω; ¼ W
R_2 = 47 kΩ; 5.5 W
R_3 = 18 kΩ; 1 W
R_4 = 100 kΩ; potentiometer
R_5 = 27 MΩ; ¼ W
R_6 = 2.7 MΩ; ¼ W
R_7 = 56 kΩ; ¼ W
R_8 = 150 kΩ; 1 W
R_9 = 3.9 kΩ; ¼ W
R_{10} = 120 Ω; ¼ W
R_{11} = 10 kΩ; 1 W
R_{12} = 33 kΩ; 5.5 W

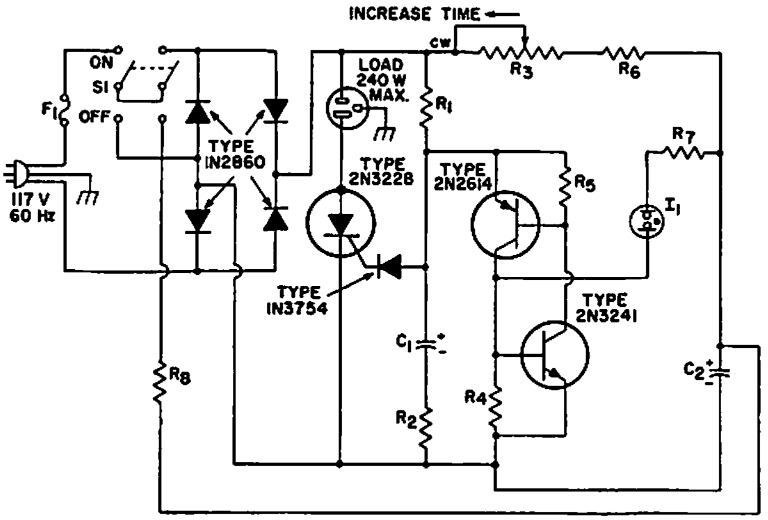
C_1 = 8 μF - 500 V
C_2 = 2×2.2 μF - 260 V
C_3 = 0.56 μF - 160 V

RL = relay 35 V - 7 mA

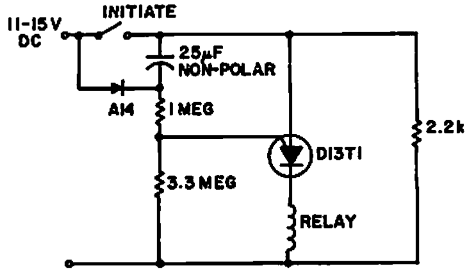
D_1 = BYX10 or BY100
D_2 = OA202
D_3 = OA202

TR_1 = BC147
TR_2 = BC147

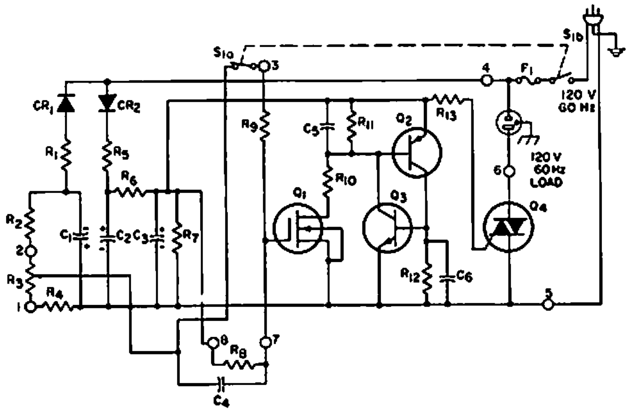
2-MINUTE TIMER—Uses foil-dielectric timing capacitor having extremely small leakage current and narrow tolerances, to eliminate need for preadjustment of time. Switching time is adjusted by varying initial capacitor voltage with R4.—Transistorized Timers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 443, 1968.


INCREASE TIME
CW
R3
R6
LOAD 240 W MAX.
R1
ON
S1
OFF
F1
TYPE 1N2860
117 V 60 Hz
TYPE 2N3228
TYPE 2N2614
R5
R7
I1
TYPE 1N3754
TYPE 2N3241
C1
C2
R8
R4
R2

5—120 S TURN-ON TIMER FOR 240 W—Will turn off enlarger, heater, lamp, or universal motor after time interval determined by setting of R3, when S1 is set at ON position. OFF position of S1 serves to discharge timing capacitor C2 so circuit is reset. Values: R1 3K; R2 33; R3 1 meg; R4 470; R5 150; R6 47K; R7 10K; R8 15; C1-C2 50 μF; F1 3AG; I1 NE-83.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 524.

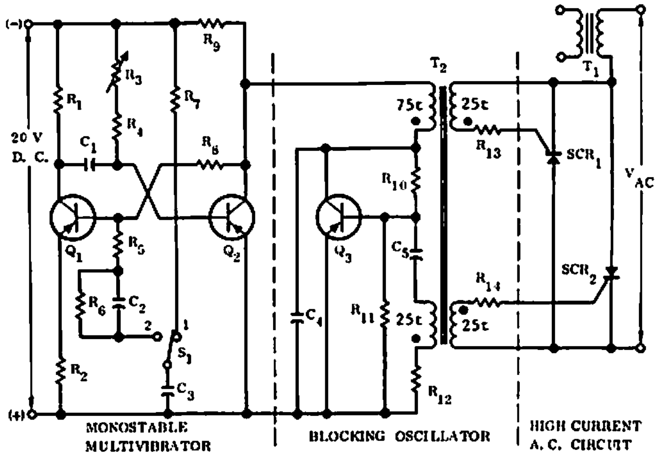

11-15 V DC
INITIATE
25μF NON-POLAR
A14
1 MEG
2.2k
D13T1
3.3 MEG
RELAY

60-S DELAY WITH D13T1—Single programmable ujt serves both as sensitive time-delay element and as switch for applying power to load. When circuit is energized, capacitor charges to full supply voltage. When INITIATE switch is closed, diode side of capacitor raises to twice supply voltage, and capacitor discharges through resistors until gate of D13T1 becomes forward-biased and ujt turns on, applying power to relay. Delay is independent of supply voltage, in range of 40 to 60 s.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 12.


S1a
3
S1b
4
F1
120 V 60 Hz
CR1
CR2
R1
R5
R9
C5
R11
Q2
R13
6
120 V 60 Hz LOAD
R6
Q1
R10
Q3
Q4
R2
2
C1
C2
C3
R7
R3
R4
1
R12
C6
5
8
R8
7
C4

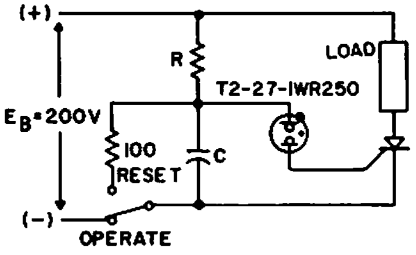
C_1 = 10 microfarads, 200 volts, electrolytic
C_2 = 10 microfarads, 200 volts, electrolytic
C_3 = 50 microfarads, 15 volts, electrolytic
C_4 = 4 microfarads, see text
$C_5 C_6$ = 0.01 microfarad, 25 volts or greater, 10%
$CR_1 CR_2$ = silicon rectifier, RCA SK3031
F_1 = fuse, size depends on expected load
Q_1 = MOS field-effect transistor, type 3N128
Q_2 = transistor, RCA SK3005
Q_3 = transistor, RCA SK3020
Q_4 = triac, RCA 40503 or RCA 40429 (the RCA 40429 may be used with Wakefield No. NC401K or equivalent heat sink.)
$R_1 R_5$ = 100 ohms, 1/2 watt, 10%
R_2 = 15,000 ohms, 1/2 watt, 10%
R_3 = potentiometer, 10,000 ohms, linear taper
R_4 = 1000 ohms, 1/2 watt, 10%
R_6 = 3000 ohms, 5 watts, 10%
R_7 = 390 ohms, 1/2 watt, 10%
R_8 = 4.7 megohms, 1/2 watt, 10%, see text
R_9 = 5.6 ohms, 1/2 watt, 10%
R_{10} = 3900 ohms, 1/2 watt, 10%
R_{11} = 150 ohms, 1/2 watt, 10%
$R_{12} R_{13}$ = 470 ohms, 1/2 watt, 10%
S_1 = switch, 125 volts, double-pole, double-throw, capable of handling the expected load.

UNIVERSAL TIMER—Turns electrical device off after predetermined interval determined by setting of R3. With 40503 triac, will handle loads up to 3.3 A. With 40429 triac, load without sink can be 2.7 A and up to 6 A with sink. For wider range of time periods, provisions can be made to switch in different values for R8 or C4.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 75.

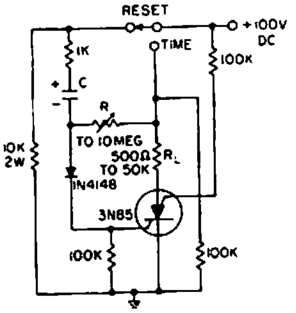

(-)
(+)
20 V D. C.
R1
R3
R4
R7
R9
R8
C1
Q1
Q2
R5
R6
C2
2
1
S1
C3
R2
T2
75t
25t
R10
Q3
C5
C4
R11
25t
25t
R12
R13
R14
T1
SCR1
SCR2
VAC
MONOSTABLE MULTIVIBRATOR
BLOCKING OSCILLATOR
HIGH CURRENT A. C. CIRCUIT

R_1 - 1.2 KΩ	R_9 - 180Ω	C_3 - 0.5 μfd	T_1 - Weld-trans.
R_2 - 300Ω	R_{10} - 68 KΩ	C_4 - 240μμfd	T_2 - Arnold Core #4T5651D1 turns as indicated on sketch above.
R_3 - 1 KΩ	R_{11} - 10 KΩ	C_5 - 0.01 μfd	
R_4 - 3 KΩ	R_{12} - 100Ω	Q_1 - 2N650	
R_5 - 240Ω	R_{13} - 10Ω	Q_2 - 2N650	
R_6 - 3 KΩ	R_{14} - 10Ω	Q_3 - 2N651	
R_7 - 5.1 KΩ	C_1 - 50 μfd	SCR_1 - 2N2577	
R_8 - 5.1 KΩ	C_2 - 0.1 μfd	SCR_2 - 2N2577	

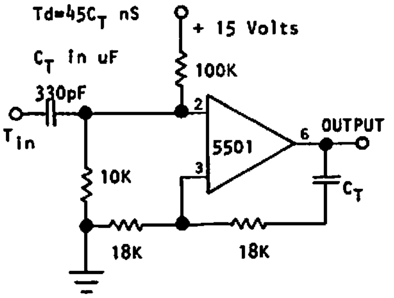
A-C BURST WELDER—Controls time duration at which a-c line voltage is applied to welding transformer T1, over range of 20 ms to 1 s. 10-kHz blocking oscillator produces 2-μs trigger pulses for scr's under control of mono mvbr.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 9-4-3.


(+)
(−)
E_B=200V
R
LOAD
T2-27-IWR250
100
RESET
C
OPERATE

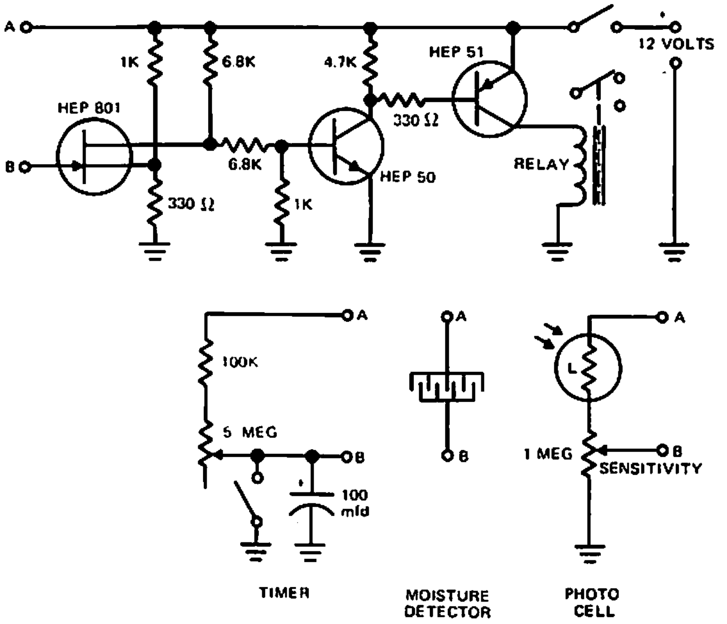
NEON-OPERATED SCR—Output from neon operates scr until circuit is reset. Book has nomograph (p 31) for determining values of R and C to give desired time.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 60.


RESET
+100V DC
1K
C
TIME
100K
R
TO 10MEG
500Ω TO 50K
R_L
10K 2W
1N4148
3N85
100K
100K

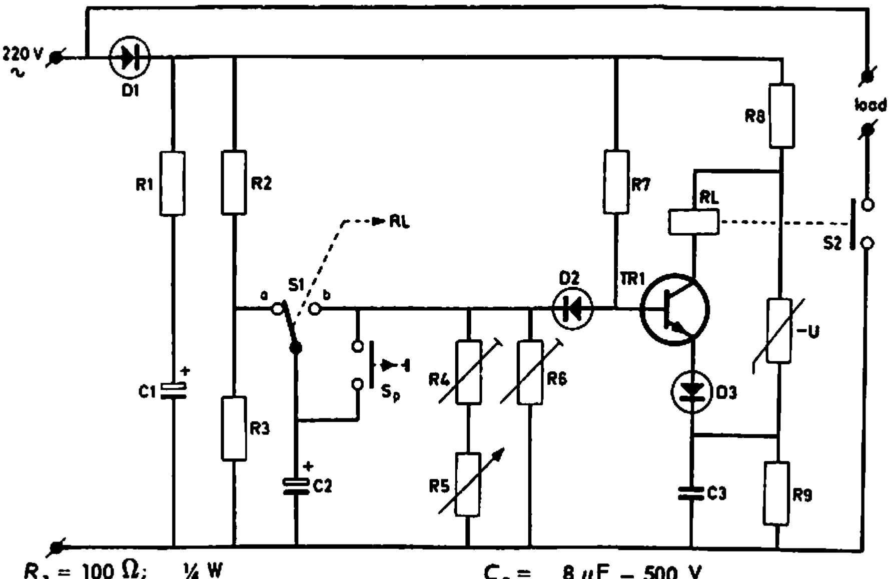
SCS TIMER—Load current begins about 0.5 RC after switch is set to TIME, and continues until switch is reset.—Planar Silicon Controlled Switch 3N84/3N85, General Electric, Syracuse, N.Y., No. 65.18, 1964.


Td=45C_T nS
C_T in uF
+ 15 Volts
100K
330pF
T_{in}
2
5501
6
OUTPUT
3
C_T
10K
18K
18K

MICROSECONDS TO MINUTES—Comparator IC connected as shown behaves as one-shot delay in which value of CT determines timing interval. Output is normally at −10 V. Negative input trigger pulse makes output switch to +10 V and hold at that level until charge on CT drops to point where pin 3 of IC is less positive than pin 2; output then reverts to −10 V. Circuit has good noise immunity.—Applying the Model 5501 Monolithic Analog Comparator, Optical Electronics, Tucson, Ariz., No. 10147.


A
B
1K
6.8K
4.7K
HEP 51
12 VOLTS
HEP 801
330 Ω
6.8K
330 Ω
1K
HEP 50
RELAY
A
100K
5 MEG
B
100 mfd
TIMER
A
B
MOISTURE DETECTOR
A
L
1 MEG
B
SENSITIVITY
PHOTO CELL

FET TIMER—Range is 5–50 s with values shown for timer input to terminals A-B. By substituting network of wires spaced 1/16" apart between A-B, circuit operates as moisture detector. With photocell, circuit becomes light-activated relay.—"Tips on Using FET's," Motorola, Phoenix, Ariz., HMA-33, 1969.

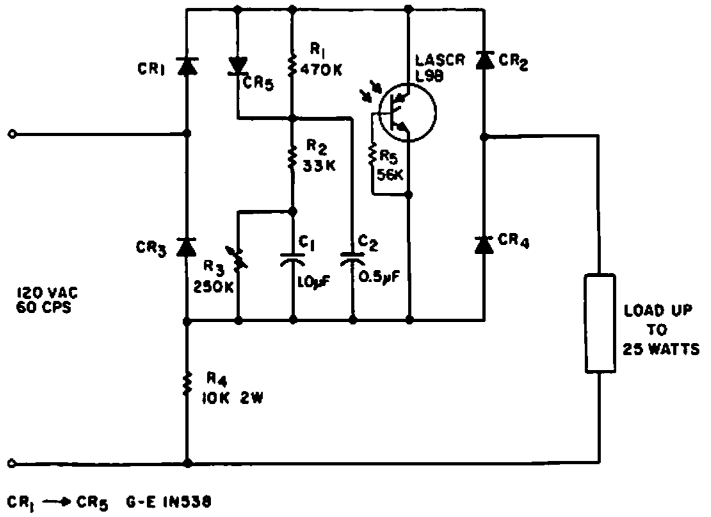

220 V ~
D1
load
R8
R1
R2
R7
RL
RL
S2
S1
a
b
D2
TR1
−U
C1
R4
R6
S_p
D3
R3
C2
R5
C3
R9

R_1 = 100 Ω; ¼ W
R_2 = 56 kΩ; 5.5 W
R_3 = 4.7 kΩ; ¼ W
R_4 = 10 kΩ; potentiometer
R_5 = 100 kΩ; potentiometer
R_6 = 500 kΩ; potentiometer
R_7 = 3.9 MΩ; ¼ W
R_8 = 33 kΩ; 5.5 W
R_9 = 1 kΩ; ¼ W
V.D.R. = 2322 552 02321

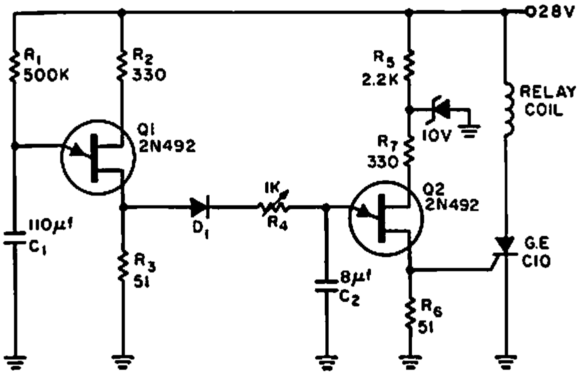
C_1 = 8 μF − 500 V
C_2 = 800 μF − 40 V (2222 060 17801)
C_3 = 5 μF − 16 V

D_1 = BYX10 or BY100
D_2 = OA200 or OA202
D_3 = OA202
TR_1 = BC147
RL = relay 35 V − 7 mA

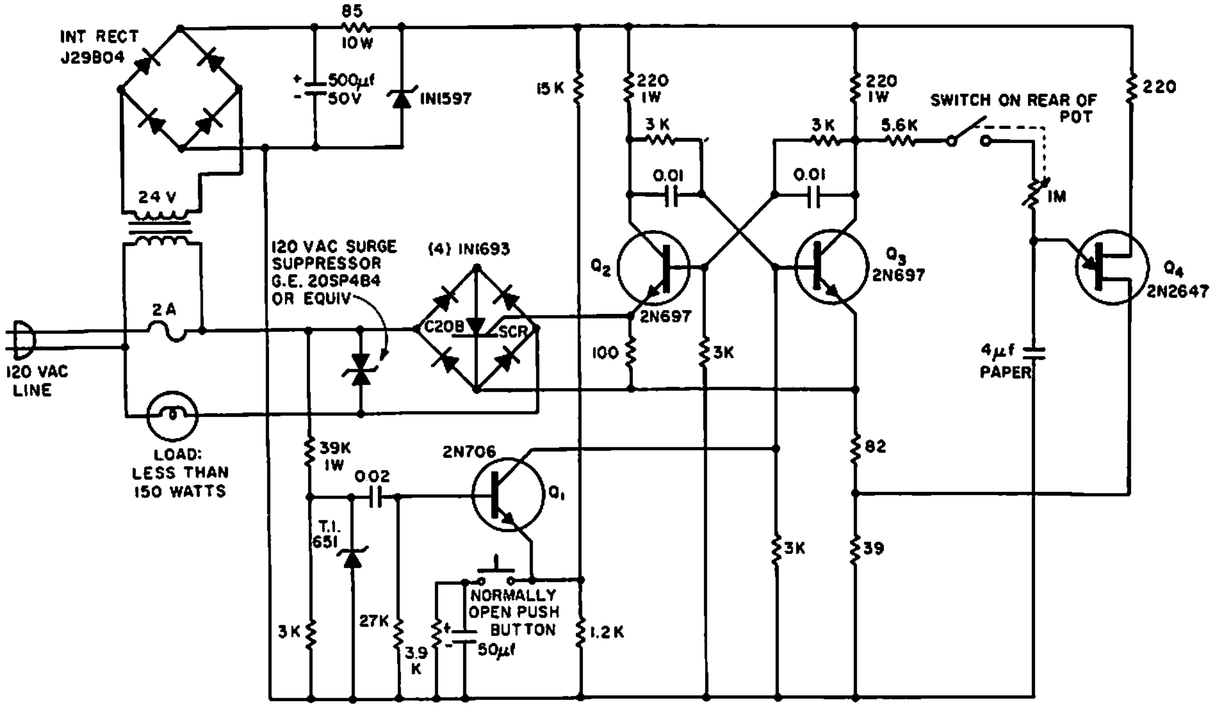
1-MIN TIMER—Interval before relay is energized can be adjusted for delay up to 1 min. Uses voltage-dependent resistor to stabilize voltage across R9, eliminating need for excessively high bleeder current.—Transistorized Timers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 443, 1968.


CR1
CR5
R1
470K
LASCR
L9B
CR2
R2
33K
R5
56K
CR3
R3
250K
C1
1.0μF
C2
0.5μF
CR4
120 VAC
60 CPS
LOAD UP
TO
25 WATTS
R4
10K 2W
CR1 → CR5 G-E IN538

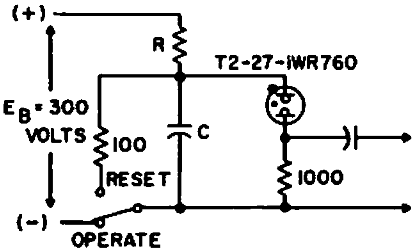
FLASH-ACTIVATED LASCR TURN-OFF DELAY—Random impulse of light fires lascr, applying full current to load, and initiating discharge of capacitors through R1-R3 and lascr. When discharge current drops below holding current of lascr, it goes off and cuts load current at next line current zero. Decreasing R3 reduces time that lascr stays on. During conduction, full sine wave is applied to load, with very little harmonic distortion, so rfi is negligible. Useful for driving lamps, solenoids, small motors, and other devices up to 25 W, particularly with optical programmer. Will turn on at any part of cycle, but go off only at zero.—E. K. Howell, The Light Activated SCR, General Electric, Syracuse, N.Y., No. 200.34, 1965.


28V
R1
500K
R2
330
R5
2.2K
RELAY
COIL
Q1
2N492
10V
R7
330
110μf
C1
D1
1K
R4
Q2
2N492
G.E
C10
R3
51
8μf
C2
R6
51

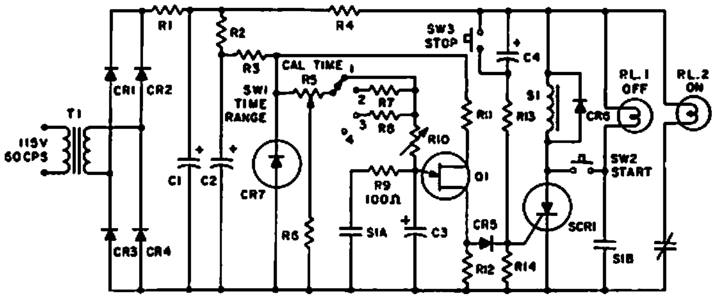
6-MINUTE UJT—Simple two-ujt circuit provides 6-min delay that is accurate within 2% from −10 to 70 C. R4 provides fine adjustment of delay. Oscillator Q1 charges C2 at rate of one pulse per minute until voltage across C2 exceeds firing point of Q2.—G. E. Huffman, Unijunction Circuit Gives Long Time Delay, *Electronic Design*, Feb. 17, 1964, p 92—93.


INT RECT
J29B04
85
10W
500μf
50V
IN1597
15 K
220
1W
220
1W
220
3 K
3 K
5.6K
SWITCH ON REAR OF POT
0.01
0.01
1M
24 V
120 VAC SURGE
SUPPRESSOR
G.E. 20SP4B4
OR EQUIV
(4) IN1693
Q2
Q3
2N697
Q4
2N2647
2A
C20B
SCR
2N697
120 VAC
LINE
100
3K
4μf
PAPER
LOAD:
LESS THAN
150 WATTS
39K
1W
0.02
2N706
Q1
82
T.I.
651
3K
39
NORMALLY
OPEN PUSH
BUTTON
3K
27K
3.9
K
50μf
1.2K

2 HZ TO 5 S—Accuracy is ideal for photographic work. Uses scr to gate diode bridge that drives ujt Q4 through binary Q2-Q3. Q1 acts as AND gate to eliminate starting ambiguity. Timing range can be extended by using larger timing capacitors. When switch on rear of pot is open, timer is bypassed for focusing.—R. A. Kawcyn, Solid-State Timer Expands Time Interval Range, *Electronic Design*, Aug. 31, 1964, p 46 and 48.

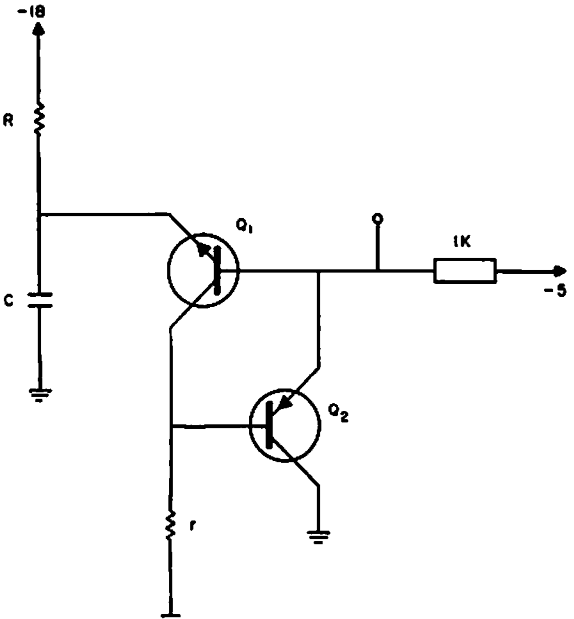

(+)
R
T2-27-IWR760
E_B = 300 VOLTS
100
RESET
C
1000
(-)
OPERATE

NEON TIMER—Output is positive-going pulse of at least 100 V. Duration is determined by value of capacitor before output. Book has nomograph (p 31) for determining values of R and C to give desired time delay.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 61.

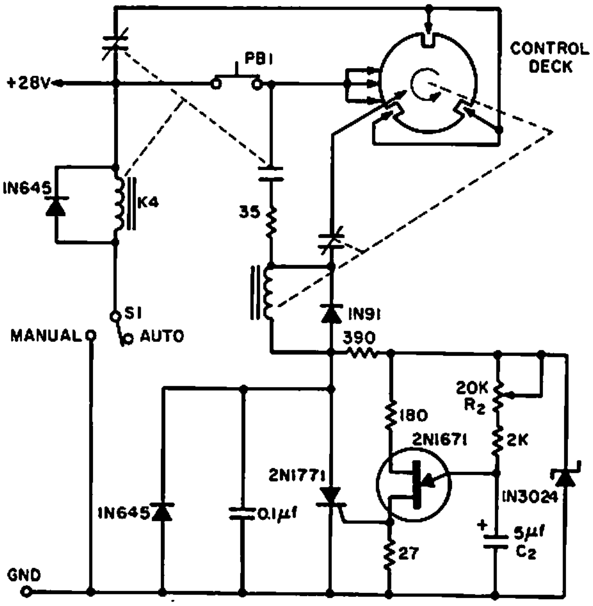

R1
R2
R3
R4
SW3 STOP
C4
T1
115V 60CPS
CR1
CR2
CR3
CR4
C1
C2
SW1 TIME RANGE
CAL TIME
R5
1
2
3
4
R7
R8
R10
R11
R13
S1
CR6
RL.1 OFF
RL.2 ON
CR7
R6
R9 100Ω
S1A
C3
Q1
CR5
R12
R14
SW2 START
SCR1
S1B

R1 - 2Ω, 1 WATT
R2, R3 - 330Ω, 1/2 WATT
R4 - 35Ω, 5 WATT
R5 - 2.5K, LINEAR POT
R6 - 25K, 1/2 WATT
R7 - 100K, 1/2%, 1/2 WATT
R8 - 200K, 1/2%, 1/2 WATT
R9 - 10Ω, 1/2 WATT
R10 - 100K, 10 TURN HELIPOT
R11 - 150Ω, 1/2 WATT
R12 - 18Ω, 1/2 WATT
R13 - 1.2K, 2 WATT
R14 - 100Ω, 1/2 WATT
C1 - 500μFD, 50V
C2 - 100μ FD, 50V
C3 - 100μFD, 20V TANTALUM
C4 - 10μFD, 50V
SCR1 - GE C15F
OR C11F
CR1-CR6 - G E A13A
CR7 - 18V, 10% 1 WATT ZENER
Q1 - GE 2N1671B
S1 - GE CR2791G122A4
4PDT RELAY
PL1, PL2 - GE 1447, 24V LAMP
T1 - 115V/25V 1A TRANSFORMER

0.25—10.25 S—Uses pushbutton initiation of timing sequence, with relay output. Timing interval is determined by setting of precision 10-turn Helipot R10, in increments of 0.01 s. Minimum value of 0.25 s is due to series resistance of time calibration pot R5. SW1 adds 100K series resistance R7 to extend time range by 10 s, and 200K for 20 s. In position 4, SW1 opens timing resistor circuit to give on-off control. Absolute timing accuracy is 0.5% after initial calibration, and repeatability is 0.05%.—"SCR Manual," 4th Edition, General Electric, 1967, p 164—165.

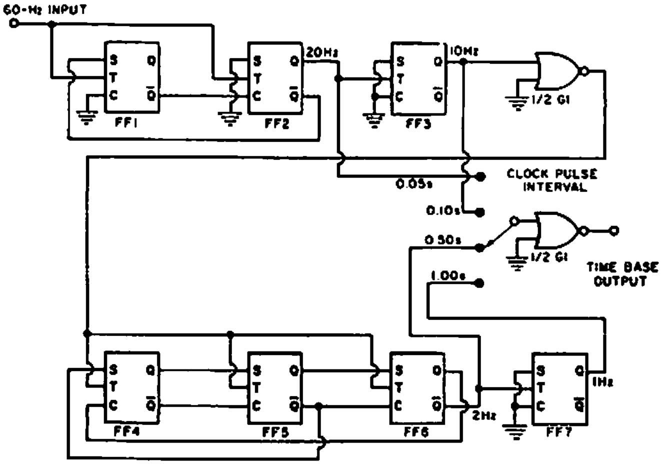

-18
R
C
Q_1
1K
-5
Q_2
r

HALF AN HOUR—Inexpensive modification of astable mvbr permits use of relatively small values of C to produce time delays up to 30 min. Component values are determined by delay time t = RC and R = 10 r. R can be 30 meg or more. Q1 is 2N1308 and Q2 is 2N1309.—J. L. Johansen, Modified Astable Multivibrator Produces Very Long Time Delay, *Electronic Design,* May 10, 1965, p 48—49.

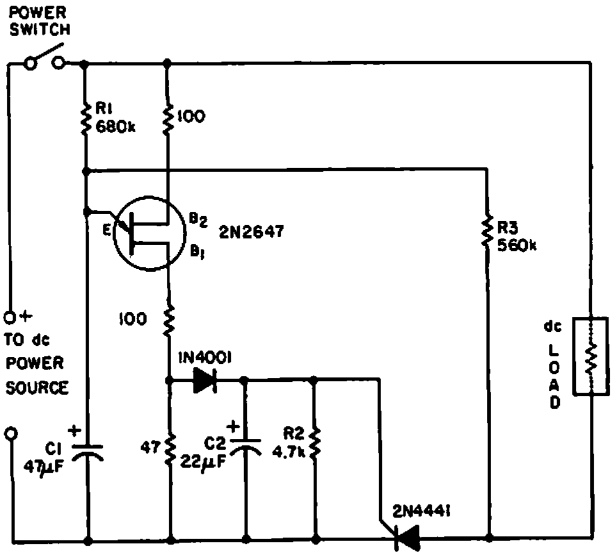

CONTROL DECK
+28V
PB1
IN645
K4
35
IN91
S1
MANUAL
AUTO
390
20K
R_2
180
2N1671
2K
2N1771
IN3024
IN645
0.1μf
5μf
C_2
27
GND

20—200 MS FOR STEPPER—R2 controls amount of delay between closing of pushbutton and stepping of 7-A rotary selector switch to next position, when circuit switch S1 is in position shown for automatic homing. Selector switch sequences additional positions until home position is reached. In manual mode, pushbutton sequences selector one position for each closure.—E. G. McCoy, Adjustable Time Delay For Rotary Switches, *Electronic Design,* April 13, 1964, p 72—73.

FOUR RANGES TO 15 S—Use of Fairchild RTμL 9923 JK flip-flops and RTμL 9914 dual two-input gates dramatically simplifies construction by experimenters of IC interval timer that would otherwise require 211 transistors and 271 resistors. Time-base generator arrangement shown provides accurately spaced clock pulses when enabled by control section, for counting during duration of event being timed, in four ranges covering 0.05 to 15 s.—D. L. Steinbach, A Digital IC Timer, *Electronics World*, May 1969, p 48–50.



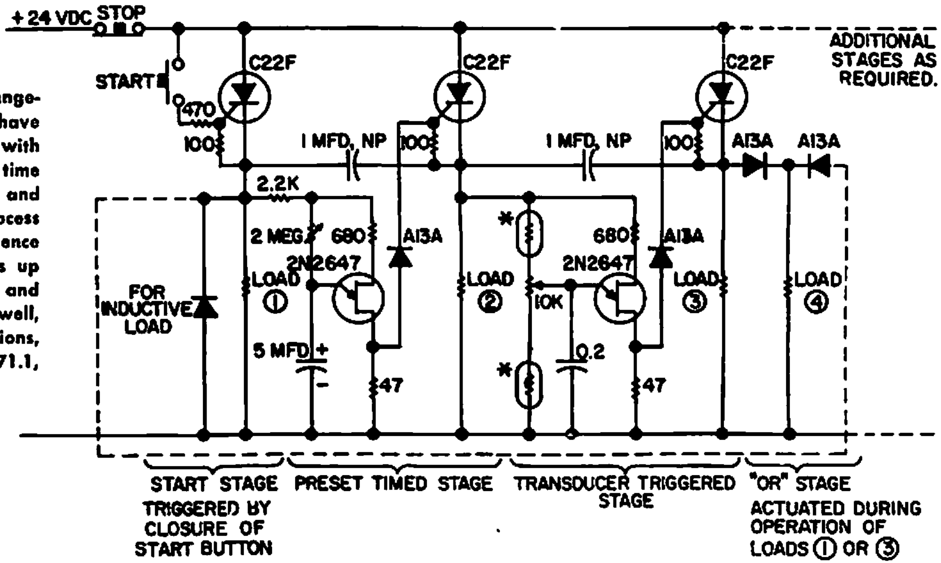
60-Hz INPUT
FF1
FF2
FF3
FF4
FF5
FF6
FF7
S
T
C
Q
Q̄
20Hz
10Hz
2Hz
1Hz
1/2 G1
CLOCK PULSE INTERVAL
0.05s
0.10s
0.50s
1.00s
TIME BASE OUTPUT



POWER SWITCH
R1 680k
100
B2
B1
E
2N2647
R3 560k
100
1N4001
+ TO dc POWER SOURCE
C1 47μF
47
C2 22μF
R2 4.7k
dc LOAD
2N4441

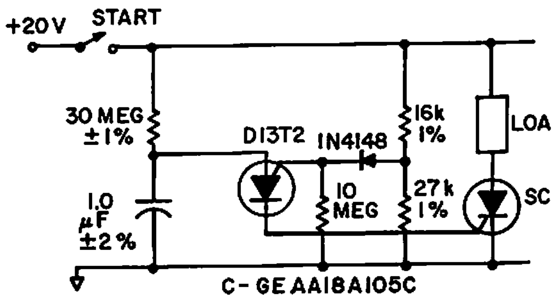
DOUBLE DELAY—Provides adjustable turn-on delay of up to 30 s after power is applied, controlled by R1-C1, and turn-off delay controlled by R2-C2. Circuit is immune to power interruptions up to several ms and will not reset for them. Operates from 12 to 36 V d-c.—G. W. Vest, Timing Circuit Has Independent Turn-On and Turn-Off Delays, *Electronic Design*, Aug. 16, 1969, p 238.

SEQUENCED TIMER—Versatile ujt-scr arrangement, operating from 24 V d-c, may have as many stages as are required, each with preset timing or transducer-triggered time intervals. Ideal for automatic starting and stopping controls, vending machines, process control, traffic control, and other sequence programmer applications. Handles loads up to 1 A, such as heater, lamps, motors, and relays.—F. W. Gutzwiller and E. K. Howell, Economy Power Semiconductor Applications, General Electric, Syracuse, N.Y., No. 671.1, 1965, p 5.

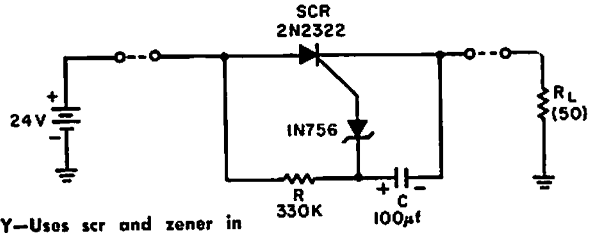


+24 VDC
STOP
START
C22F
C22F
C22F
ADDITIONAL STAGES AS REQUIRED.
470
100
1 MFD, NP
100
1 MFD, NP
100
A13A
A13A
2.2K
2 MEG
680
A13A
*
680
A13A
2N2647
2N2647
LOAD ①
LOAD ②
10K
LOAD ③
LOAD ④
FOR INDUCTIVE LOAD
5 MFD
+
-
47
*
0.2
47
START STAGE TRIGGERED BY CLOSURE OF START BUTTON
PRESET TIMED STAGE
TRANSDUCER TRIGGERED STAGE
"OR" STAGE ACTUATED DURING OPERATION OF LOADS ① OR ③

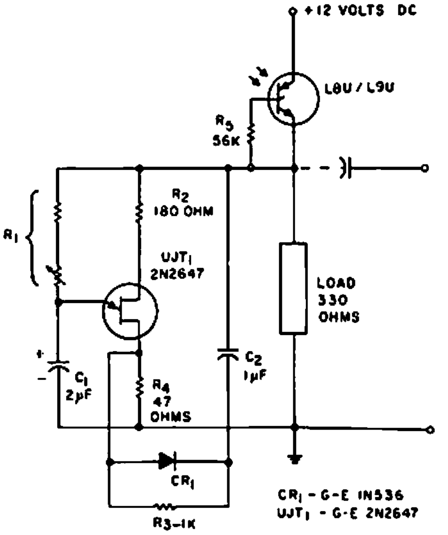
*ALTERNATE POSITIONS OF 5K-10K TRANSDUCERS (PHOTOCELLS, THERMISTORS, ETC.)


+20V
START
30 MEG ±1%
1.0 µF ±2%
D13T2
1N4148
16k 1%
LOAD
10 MEG
27k 1%
SCR
C-GE AA18A105C

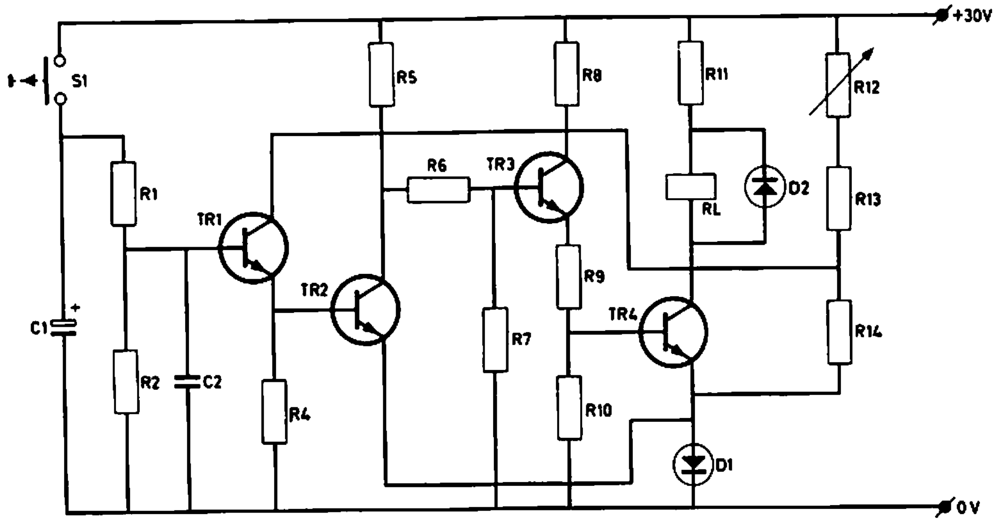
30 S WITH D13T2—Programmable ujt provides 30-s delay after switch is closed, before scr turns on and applies power to load. With tolerances shown for components, calibration is unnecessary.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 11.


SCR 2N2322
24V
1N756
RL (50)
R 330K
C 100µf

10-S POWER DELAY—Uses scr and zener in place of relay to apply power to 500-mA load 10 s after 24-V battery is switched on. Values of R, C, and zener can be changed to give different delay.—J. A. Means, SCR and Zener Diode Provide Time Delay, *Electronic Design*, March 30, 1964, p 73–75.


+12 VOLTS DC
L8U/L9U
R5 56K
R2 180 OHM
R1
UJT1 2N2647
LOAD 330 OHMS
C1 2µF
R4 47 OHMS
C2 1µF
CR1
R3-1K
CR1 - G-E 1N536
UJT1 - G-E 2N2647

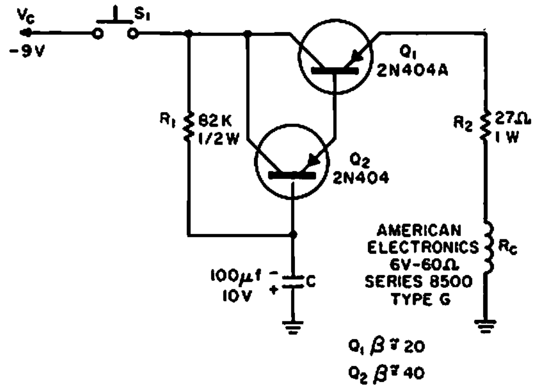
LASCR VARIABLE-PULSE-WIDTH TURN-OFF DELAY—Incident light triggers lascr and applies power to load. Voltage drop across load activates ujt timing-turn-off circuit, with delay determined by R1, C1, and ujt, to turn off load in interval of up to several seconds.—E. K. Howell, The Light Activated SCR, General Electric, Syracuse, N.Y., No. 200.34, 1965.


+30V
S1
R5
R8
R11
R12
R6
TR3
R1
TR1
RL
D2
R13
TR2
R9
TR4
C1
R7
R14
R2
C2
R4
R10
D1
0V

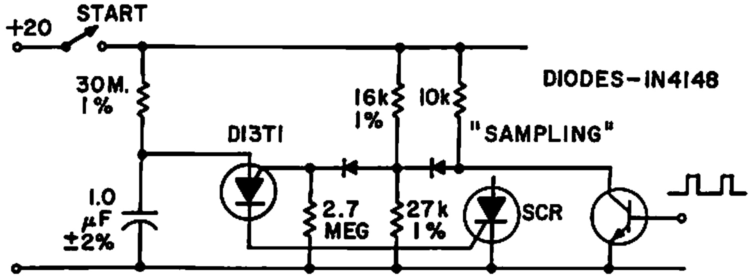
R_1 = 390 kΩ; 1/8 W
R_2 = 560 kΩ 1/8 W
R_4 = 6.8 kΩ; 1/8 W
R_5 = 12 kΩ; 1/8 W
R_6 = 5.6 kΩ 1/8 W
R_7 = 4.7 kΩ 1/8 W
R_8 = 1.2 kΩ; 1/4 W
R_9 = 270 Ω; 1/8 W
R_{10} = 270 Ω; 1/8 W
R_{11} = 10 Ω; 1 W
R_{12} = 1 kΩ; potentiometer
R_{13} = 330 Ω; 5.5 W

R_{14} = 33 Ω; 1/4 W
C_1 = 800 µF; 40 V (2222 060 17801)
C_2 = 100 nF;
RL = relay 24 V – 300 mA
TR_1 = BC147
TR_2 = BC147
TR_3 = AC127
TR_4 = AC127
D_1 = BY100
D_2 = OA200

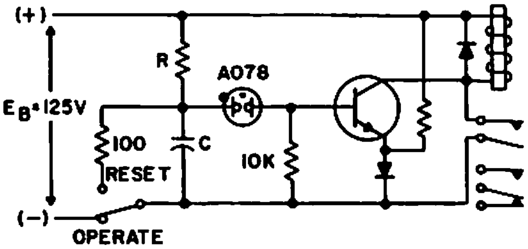
14-MIN TIMER—Operates from 30-V d-c supply and energizes relay after 14-min delay.—Transistorized Timers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 443, 1968.


Vc
-9V
S1
Q1
2N404A
R1
82K
1/2W
Q2
2N404
R2
27Ω
1 W
AMERICAN
ELECTRONICS
6V-60Ω
SERIES 8500
TYPE G
Rc
100μf
10V
C
Q1 β ≈ 20
Q2 β ≈ 40

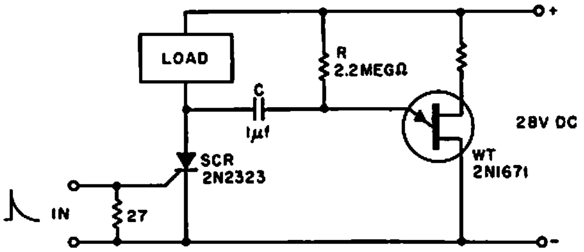
COST-CUTTING RELAY DELAY—Darlington connection of transistors gives time delay of 8 s for relay pull-in with values shown. With larger values of C, delay can be several minutes. For still greater delays, use higher-beta transistors and higher-resistance relay coil. Article gives delay equation.—M. Leopold and A. L. Plovy, Relay Arrangement Increases Time Delay—Reduces Cost, *Electronic Design*, Dec. 21, 1964, p 55–56.


+20
START
30M.
1%
16k
1%
10k
DIODES-IN4148
D13T1
"SAMPLING"
1.0
μF
±2%
2.7
MEG
27k
1%
SCR

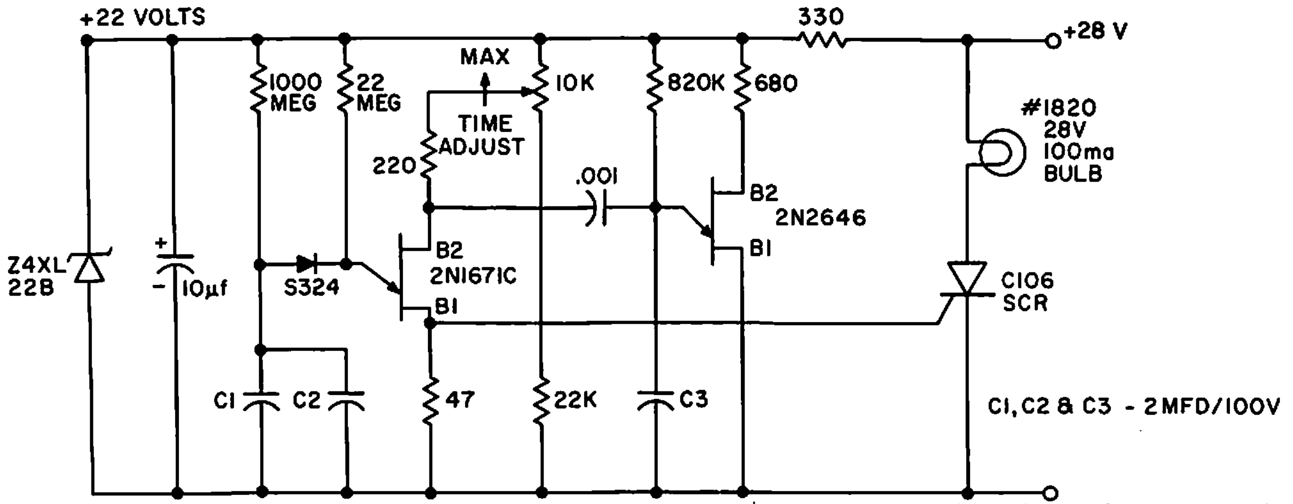
30 S WITH SAMPLING—Programmable ujt provides 30-s delay after switch is closed, before scr turns on and applies power to load that is connected between anode of scr and +20 V. Both diodes are 1N4148; right-hand diode serves with 10K resistor and sampling transistor to apply external 1-kHz pulse train for modulating intrinsic standoff voltage once per ms to sample capacitor voltage during delay interval.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 11.


(+)
(−)
EB=125V
R
A078
C
100
RESET
10K
OPERATE

NEON-OPERATED TRANSISTOR—Output from neon operates transistor which pulls in relay. Book has nomograph (p 31) for determining values of R and C to give desired time.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 60.

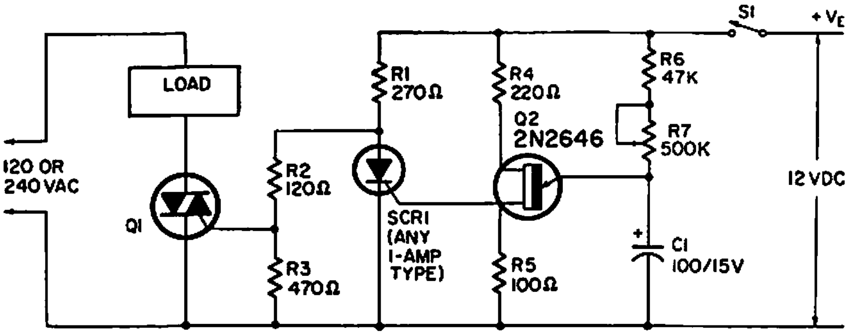

+
LOAD
R
2.2MEGΩ
C
1μf
28V DC
SCR
2N2323
WT
2N1671
IN
27
−

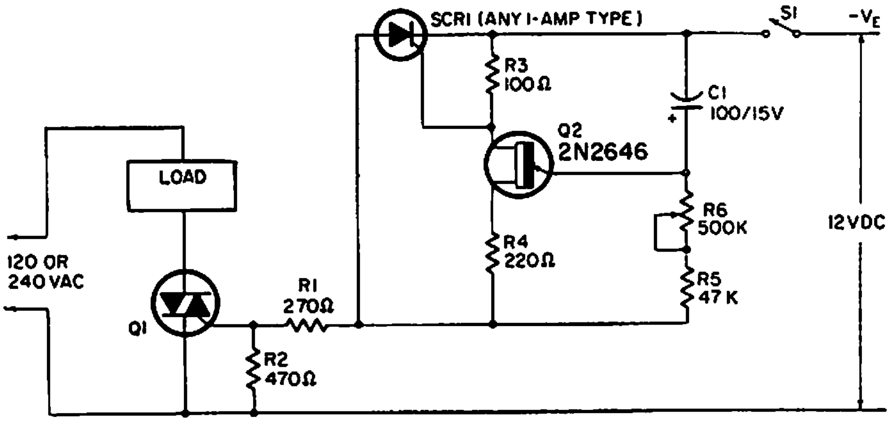
PULSE-TRIGGERED 4-S TIMER—Can be triggered by pulse as short as a few microseconds, to apply power to load for time duration determined by RC time constant. Inductive load requires clamping, along with parallel resistor to facilitate triggering.—A. Balint, SCR and UJT Form Simple Precision Timer, *Electronic Design*, Sept. 14, 1964, p 76.


+22 VOLTS
330
+28 V
1000
MEG
22
MEG
MAX
10K
TIME
ADJUST
220
820K
680
#1820
28V
100ma
BULB
.001
B2
2N2646
B1
Z4XL
22B
10μf
S324
B2
2N1671C
B1
C106
SCR
C1
C2
47
22K
C3
C1, C2 & C3 - 2MFD/100V

45-MIN TIMER—Gives long and adjustable time delays without using tantalum or electrolytic capacitors. Uses low-cost 2N2646 ujt to apply sampling pulse to base 2 of other ujt, thereby reducing required trigger current by 1,000:1 or more.—D. V. Jones, Semiconductor Timers and Low Frequency Oscillators, General Electric, Syracuse, N.Y., No. 671.3, 1966, p 15.

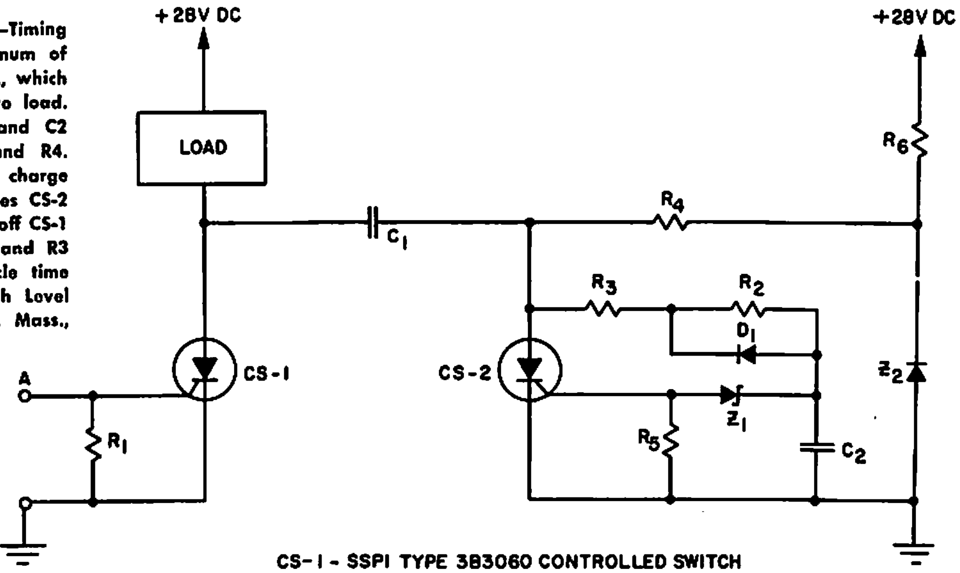
8–80 S TURN-OFF DELAY—Closing S1 makes triac turn on and handle up to 6 A load current. After interval determined by setting of R7, ujt fires and delivers trigger pulse that turns on scr and makes it self-latch. This breaks drive to triac gate and triac turns off. Circuit is reset by opening S1 briefly. Use RCA 40429 triac for 120 V and 40430 for 240 V.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.


LOAD
120 OR 240 VAC
Q1
R2 120Ω
R3 470Ω
R1 270Ω
SCR1 (ANY 1-AMP TYPE)
R4 220Ω
Q2 2N2646
R5 100Ω
R6 47K
R7 500K
C1 100/15V
S1
+VE
12 VDC


SCR1 (ANY 1-AMP TYPE)
S1
-VE
R3 100Ω
C1 100/15V
Q2 2N2646
LOAD
R6 500K
R4 220Ω
R5 47 K
12VDC
120 OR 240 VAC
Q1
R1 270Ω
R2 470Ω

8–80 S DELAYED TURN-ON—R6 determines interval between closing of S1 and turning on of triac Q1 by ujt and scr. Triac then remains on as long as S1 is closed. Use RCA 40429 triac for 120 V and 40430 for 240 V.—R. M. Marston, 20 Triac Circuits, *Radio-Electronics*, June 1970, p 51–53 and 97.

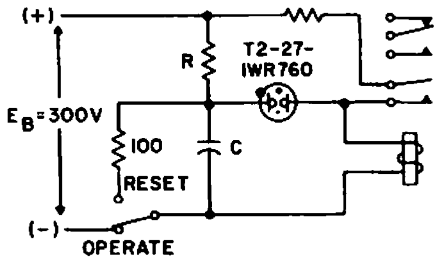
INTERVAL TIMER FOR 3-A D-C LOAD—Timing cycle is initiated by low-level (minimum of 1 V) 5-μs pulse applied to terminal A, which turns on scr CS-1 to supply power to load. Simultaneously, CS-2 is turned off and C2 begins charging through R2, R3, and R4. Zener minimizes timing error. When charge reaches 7.5 V, Z1 conducts and makes CS-2 fire, 1 s after initiating pulse, to turn off CS-1 and remove power from load. D1 and R3 discharge C2 rapidly, to keep recycle time under 1 ms.—Interval Timer for High Level Output, Solid State Products, Salem, Mass., No. 1.


+28V DC
+28V DC
LOAD
R_6
R_4
C_1
R_3
R_2
D_1
CS-1
CS-2
A
R_1
Z_1
Z_2
R_5
C_2

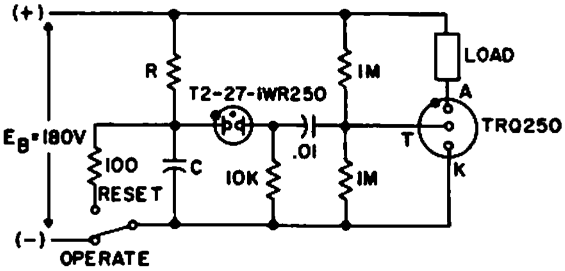
CS-1 - SSPI TYPE 3B3060 CONTROLLED SWITCH
CS-2 - SSPI TYPE AA100 CONTROLLED SWITCH

Z_1 - 6.8 VOLT ZENER DIODE, TYPE IN710A
Z_2 - 18 VOLT ZENER DIODE, TYPE IN720A
R_1 - 1000 OHMS
R_2 - 50,000 OHMS
R_3 - 10 OHMS
D_1 - IN483 SILICON DIODE

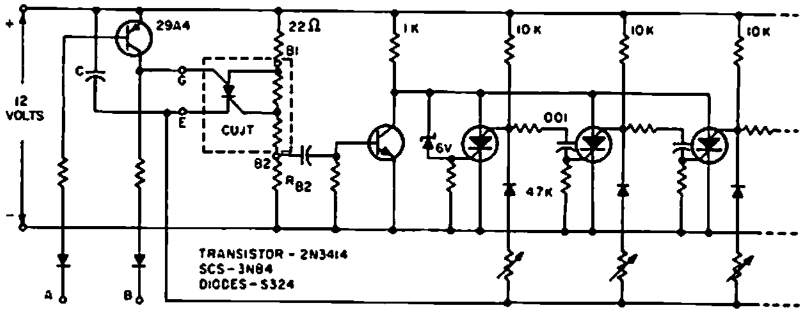
C_1 - 6μf, 30V
C_2 - 40μf, 10V
R_4 - 2200 OHMS
R_5 - 6800 OHMS
R_6 - 2200 OHMS
ALL RESISTORS - 1/4 WATT


(+)
R
T2-27-
IWR760
E_B=300V
100
RESET
C
(-)
OPERATE

NEON TIMER—Relay latches when capacitor charges to breakdown voltage of lamp. Book has nomograph (p 31) for determining values of R and C to give desired time.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 58.

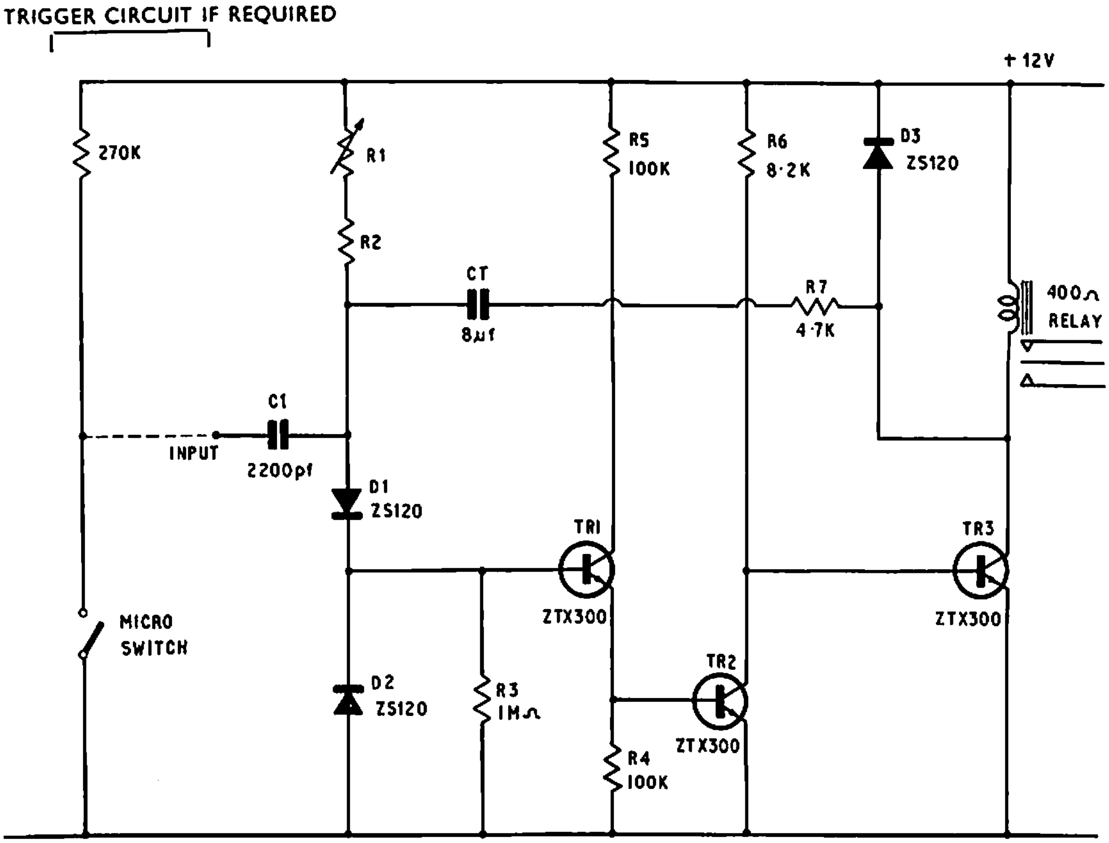

(+)
R
T2-27-IWR250
IM
LOAD
A
E_B=180V
.01
T
TRQ250
100
RESET
C
10K
IM
K
(-)
OPERATE

NEON-PULSED THYRATRON—Output pulse from neon causes thyratron to ignite and remain on until circuit is reset. Handles ½-W load. Book has nomograph (p 31) for determining values of R and C to give desired time.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 59.

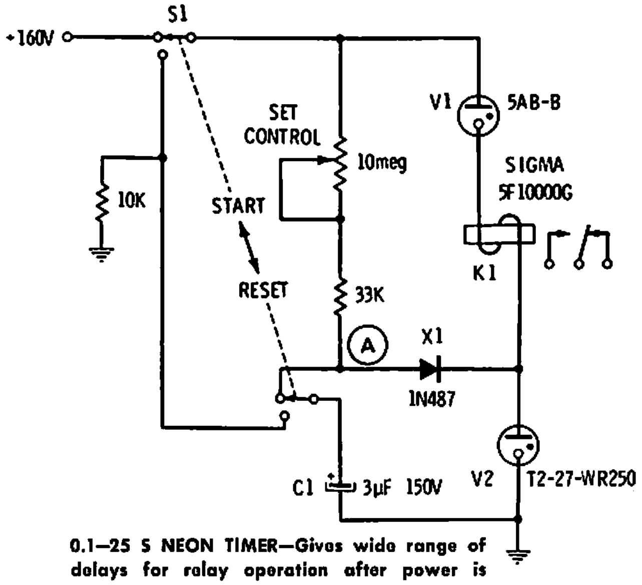

+
29A4
22Ω
B1
1K
10K
10K
10K
C
G
12
VOLTS
E
CUJT
001
B2
R_{B2}
6V
47K
-
TRANSISTOR - 2N3414
SCS - 3N84
DIODES - S324
A
B

A OR B INHIBIT C FROM FIRING. EITHER INPUT MUST BE ZERO VOLTS TO FIRE A INHIBITS AT THE PEAK POINT, B INHIBITS IN THE VALLEY

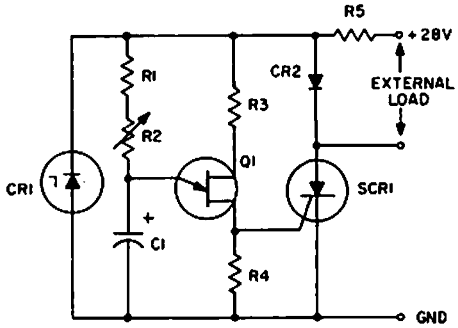
SEQUENTIAL TIMER—RC timer is driven from scs ring counter at right. Only one scs is on at a time, with successive timer output pulses at B2 advancing ON stage to right. Time interval is adjustable for each scs stage. Timer itself uses four-lead complementary ujt such as 3N81 (dashed box), which can be inhibited from firing by applying appropriate voltages to terminals A and B.—W. R. Spofford, Jr., Complementary Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.72, 1968, p 14.


TRIGGER CIRCUIT IF REQUIRED
+12V
270K
R1
R5
100K
R6
8·2K
D3
ZS120
R2
CT
8µf
R7
4·7K
400Ω 12V
RELAY
C1
INPUT
2200pf
D1
ZS120
TR1
ZTX300
TR3
ZTX300
MICRO
SWITCH
TR2
D2
ZS120
R3
1MΩ
ZTX300
R4
100K

PROCESS TIMER—Holds relay closed for time interval adjustable between 1 and 10 s after timing action is initiated by negative input pulse from external circuitry or by simple microswitch. For range of 1 to 10 s, R2 is 200K and R1 is 2-meg pot.—E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 40.


+160V
S1
SET CONTROL
10meg
START
RESET
33K
10K
V1
5AB-B
SIGMA
5F10000G
K1
A
X1
1N487
C1
3μF 150V
V2
T2-27-WR250

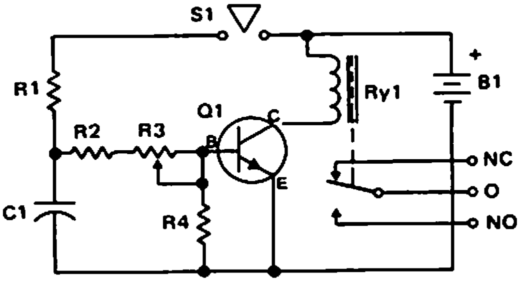
0.1—25 S NEON TIMER—Gives wide range of delays for relay operation after power is applied with S1. Power must be removed with S1 to release relay after it pulls in.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," Howard W. Sams & Co., Indianapolis, Ind., 1969, p 72.


R5
+28V
EXTERNAL LOAD
CR2
R1
R2
R3
Q1
CR1
C1
SCR1
R4
GND

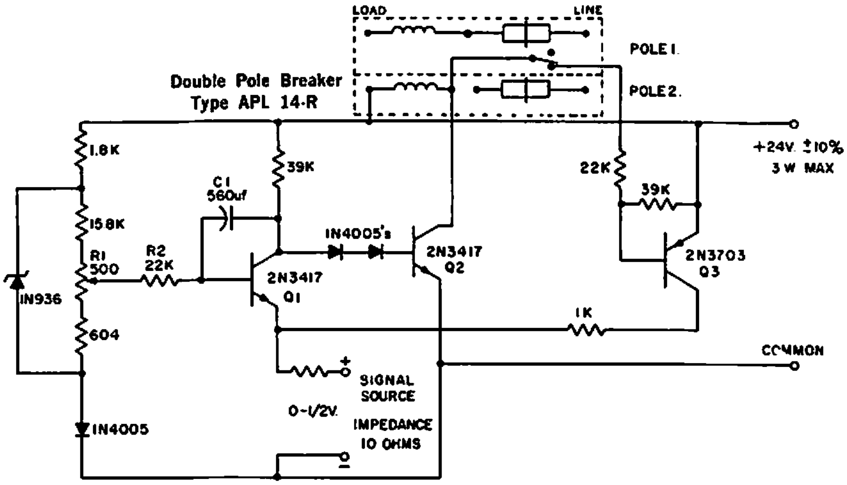
R1 - 2.2K, 1/2 WATT
R2 - 1K TO 500K LINEAR POT
R3 - 150Ω, 1/2 WATT
R4 - 27,Ω , 1/2 WATT
R5 - 560Ω, 2 WATT
C1 - 0.2 TO 100 MFD, 15V
SCR1 - GE C22F OR C11F
CR1 - 18V, 10%, 1 WATT ZENER, 1N1776
CR2 - GE A13A
Q1 - GE 2N1671B

UJT-SCR DELAY—Simple, versatile, and accurate circuit applies power to load at predetermined interval after initiating signal is applied. Timing is initiated either by applying supply voltage or opening shorting contact across C1. Delay depends on values of R1, R2, and C1. For reset, scr must be turned off by momentarily shorting it or by opening d-c supply.—"SCR Manual," 4th Edition, General Electric, 1967, p 163—164.

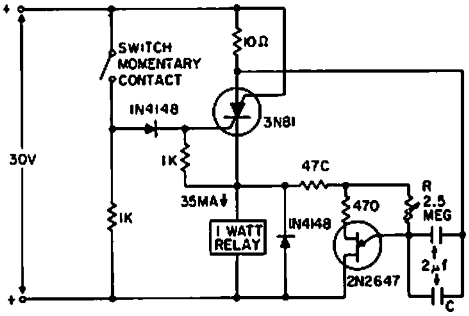
VERSATILE TIMER—Easily assembled one-transistor circuit pulls in relay when switch S1 is closed, charging C1 to battery supply voltage. C1 then discharges and turns on Q1, which pulls in relay. Circuit stays in this condition until C1 is discharged below saturation level of Q1, as determined by setting of R3, to turn off Q1 and release relay. Gives choice of intervals from 10 to 100 s, and even greater timing range if values of R1 and C1 are changed. No on-off switch is required in battery circuit, because leakage through transistor when it is off is only about 1 μA. Can be used for enlarger control in dark room or for delay in turning off garage light.—"Calectro Handbook," GC Electronics, Rockford, Ill., FR-69-C, p 45.


S1
R1
Ry1
+
B1
Q1
C
R2
R3
B
E
NC
O
NO
C1
R4

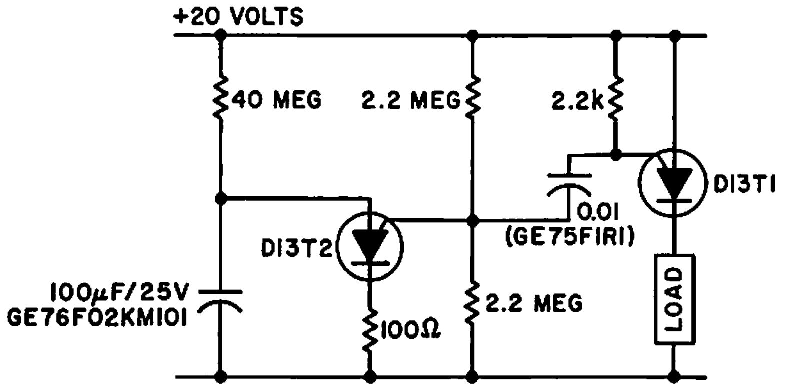
Q1	NPN Transistor Silicon
R1	10 Ω Resistor ½ Watt 10%
R3	50,000 Ω Potentiometer
R2	1,000 Ω Resistor ½ Watt 10%
R4	270,000 Ω Resistor ½ Watt 10%
C1	1000 μF 25 Volt Electroytic
S1	Push Button, Normally open Switch
RY1	1000 Ω Sensitive Relay
B1	Battery, 9V Transistor Radio


LOAD
LINE
POLE 1
POLE 2
Double Pole Breaker
Type APL 14-R
1.8K
39K
22K
39K
+24V ±10%
3 W MAX
C1
560uf
1N4005's
15.8K
R1
500
R2
22K
2N3417
Q1
2N3417
Q2
2N3703
Q3
1N936
1K
604
COMMON
SIGNAL SOURCE
0-1/2V
IMPEDANCE
10 OHMS
1N4005

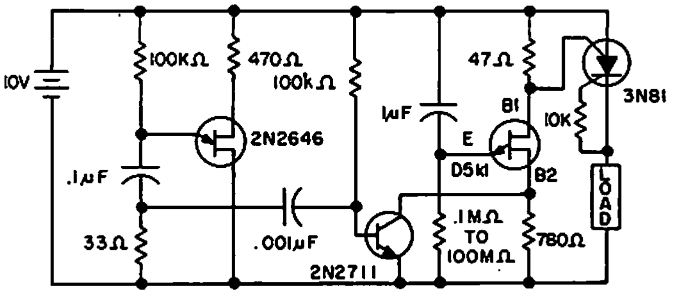
DOUBLE-THRESHOLD DELAY—Allows adjustable time delay that responds to average (not rms) value of an overload, with essentially zero delay above adjustable limit. R1 determines first threshold, while C1 and R2 determine time delay. With 560 μF for C1, there is no tripping of Airpax APL14-R double-pole breaker (dashed box) at 100% load, delay of about 20 s at 150% load, 5 s at 200% load, and minimum delay of about 0.01 s beyond 240% load.—Double Threshold Time Delay (Airpax ad), *Electronics*, Dec. 9, 1968, p 156.


+
SWITCH MOMENTARY CONTACT
10Ω
IN4148
3N81
30V
1K
47C
35MA
R 2.5 MEG
IK
1 WATT RELAY
IN4148
470
2μf
2N2647
+
C

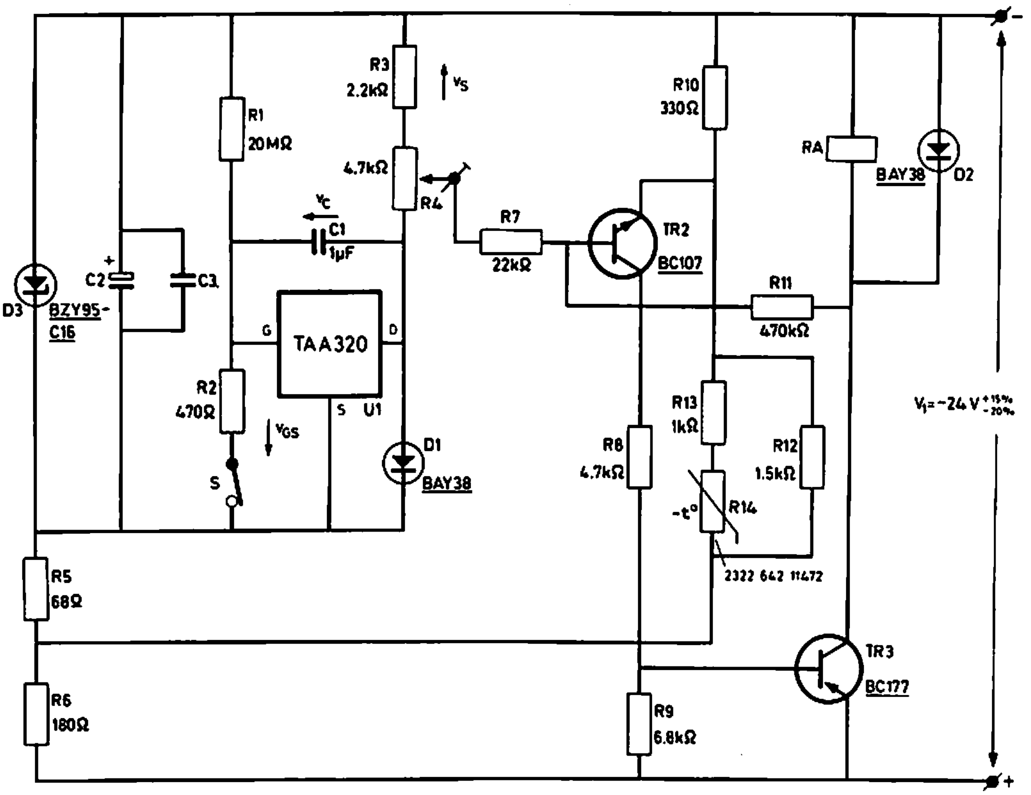
10-5 SCS—Positive pulse to gate of 3N81 scs triggers it on, for supplying power to relay load and ujt timing circuit. At completion of timing interval based on RC, negative pulse is applied to anode of scs to turn it off.—Planar Silicon Controlled Switch 3N81/3N82, General Electric, Syracuse, N.Y., No. 65.16, 1964.


+20 VOLTS
40 MEG
2.2 MEG
2.2k
D13T1
0.01 (GE75F1R1)
D13T2
100μF/25V GE76F02KM101
100Ω
2.2 MEG
LOAD

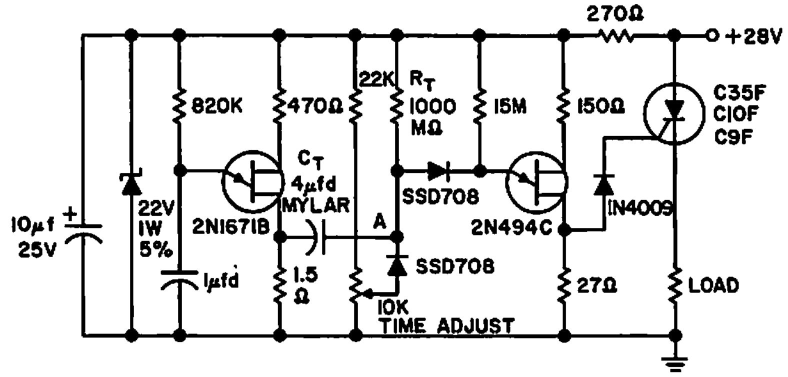
LONG DELAY WITH D13T2—At end of timing interval, D13T2 produces sharp negative pulse for triggering D13T1 programmable ujt acting as thyristor for controlling load current.—W. R. Spofford, Jr., The D13T—A Programmable Unijunction Transistor, General Electric, Syracuse, N.Y., No. 90.70, 1967, p 12.


10V
100KΩ
470Ω
100kΩ
47Ω
3N81
1μF
B1
10K
2N2646
E
.1μF
D5K1
B2
LOAD
.1MΩ TO 100MΩ
780Ω
33Ω
.001μF
2N2711

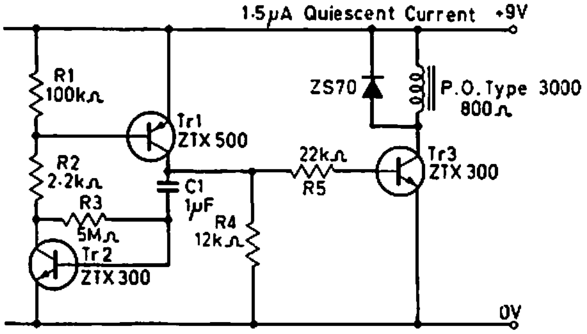
0.1–90 S—Timing interval starts when power is applied, and stops when voltage is applied to load. Ujt operates as oscillator that pulses base 2 of D5K1 complementary ujt for triggering of 3N81 scs. Chief advantage of circuit is use of larger timing resistor and smaller timing capacitor than in conventional timers.—Silicon Complementary Unijunction Transistor D5K1, General Electric, Syracuse, N.Y., No. 60.15, 1967.


R3 2.2kΩ
Vs
R10 330Ω
R1 20MΩ
RA
BAY38 D2
4.7kΩ R4
R7 22kΩ
TR2 BC107
Vc
C1 1μF
R11 470kΩ
C2 +
C3
D3 BZY95-C16
G
TAA320
D
R2 470Ω
S U1
VGS
D1 BAY38
R13 1kΩ
R12 1.5kΩ
R8 4.7kΩ
-t°
R14
2322 642 11472
$V_1 = -24\,V^{+15\%}_{-20\%}$
S
R5 68Ω
R6 180Ω
TR3 BC177
R9 6.8kΩ
-
+

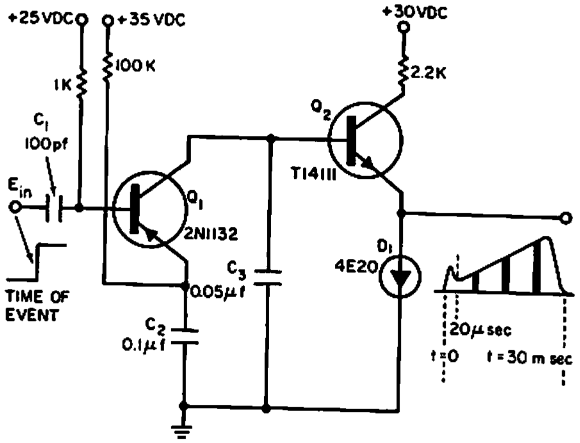
HIGH-ACCURACY ADJUSTABLE TIMER—Provides adjustable delay after switch S is closed, before relay RA is energized. Includes temperature compensation with R14, along with voltage stabilization, to minimize time terror. Actual timer is Miller integrator that includes IC, with zener reference voltage. Report includes mathematical analysis of performance.—The TAA320 Integrated Circuit Used in Long Delay Time Switches, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 447, 1969.


270Ω
+28V
820K
470Ω
22K
R_T 1000 MΩ
15M
150Ω
C35F
C10F
C9F
10μf 25V
22V 1W 5%
2N1671B
C_T 4μfd MYLAR
A
SSD708
2N494C
1N4009
1μfd
1.5 Ω
SSD708
10K TIME ADJUST
27Ω
LOAD

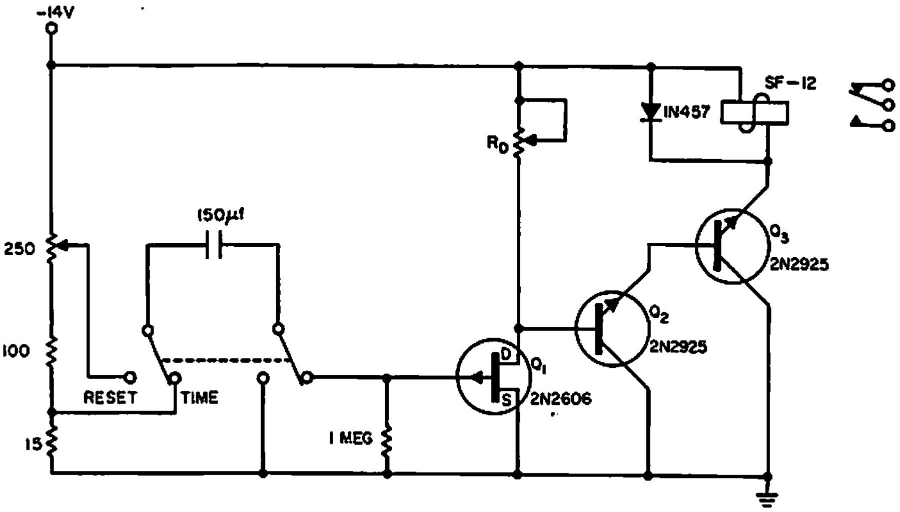
UP TO 1 HR—Requires only low-leakage 4-μF mylar capacitor for time delays up to 1 hr because effective firing current is reduced by factor of 1,000. Voltage on timing capacitor CT is periodically sampled by sampling pulse generated by 2-Hz ujt relaxation oscillator.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 9.


1·5μA Quiescent Current +9V
R1 100kΩ
Tr1 ZTX 500
ZS70
P.O. Type 3000 800Ω
22kΩ R5
Tr3 ZTX 300
R2 2·2kΩ
C1 1μF
R3 5MΩ
R4 12kΩ
Tr2 ZTX 300
0V

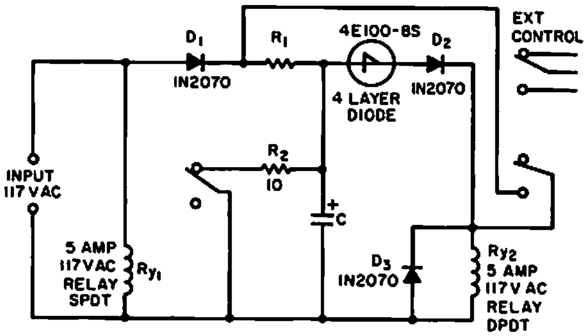
SELF-REPEATING TIMER—C1 is charged quickly almost to 9 V through resistors and first two transistors. When it approaches full charge, charging current drops and both transistors turn off. Capacitor then discharges through R3, giving 5-s delay. When base voltage of TR2 rises above emitter voltage, TR1 and TR2 turn on and process repeats. Positive pulse is applied to TR3 every 5 s as TR1 turns on, turning on TR3 and energizing relay. —E-Line Transistor Applications, Ferranti Ltd., Oldham, Lancs., England, 1969, p 48.


+25VDC
+35VDC
1K
100K
C_1 100pf
E_{in}
TIME OF EVENT
Q_1 2N1132
C_3
0.05μf
C_2 0.1μf
Q_2
T1411
+30VDC
2.2K
D_1 4E20
20μsec
t=0
t=30 m sec

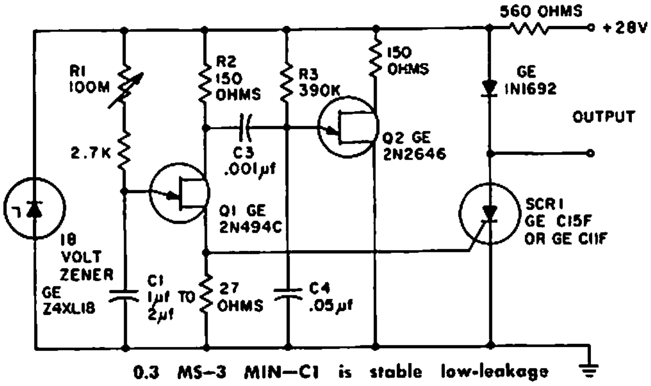
TIME OF OCCURRENCE—Simple two-stage transistor circuit with Shockley diode gives highly precise timing of start of event. For values shown, three samples of input waveform are taken at predetermined intervals to establish slope and base line, from which exact time of initiation of input signal can be computed.—L. M. Germain, Occurrence Generator Uses Shockley Diode, *Electronic Design*, Nov. 22, 1965, p 64.


-14V
SF-12
1N457
R_0
150μf
250
100
15
RESET
TIME
1 MEG
D
S
Q_1 2N2606
Q_2 2N2925
Q_3 2N2925

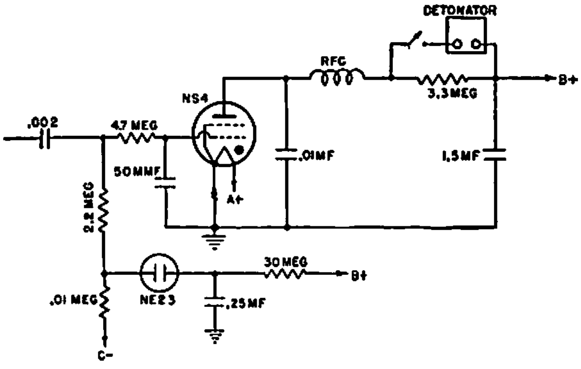
BASIC FET TIMER—Circuit shown, covered in Siliconix application note, has near-zero temperature coefficient. Charge and discharge time of R-C tank determines period of timer above 90 s. For shorter periods, use of junction fet's operating as constant sources with linear charging rates is recommended. Regenerative circuitry is added to provide on-off timing.—FETs for Timers, *Electronic Design*, Nov. 8, 1965, p 94.


D1
IN2070
R1
4E100-8S
D2
IN2070
4 LAYER DIODE
EXT CONTROL
INPUT 117 VAC
R2
10
C
5 AMP 117VAC RELAY SPDT
Ry1
D3
IN2070
Ry2
5 AMP 117V AC RELAY DPDT

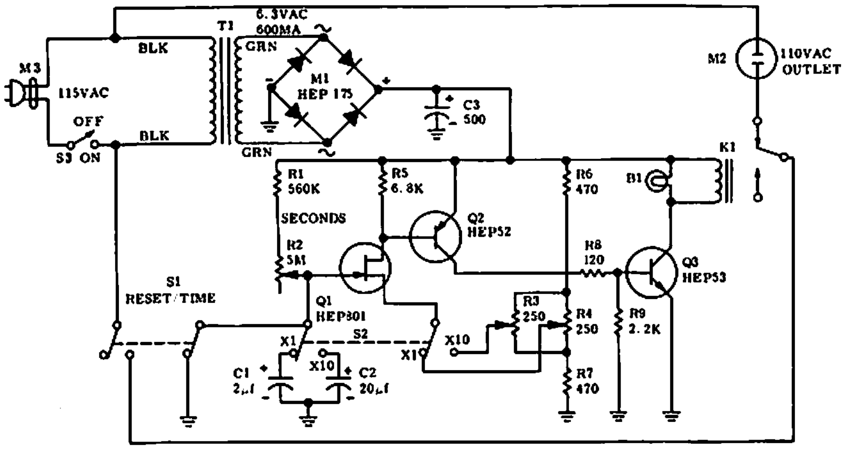
VARIABLE DELAY WITH INSTANT RESET—Shockley diode in series with relay provides instant reset for time delays from fraction of second to several minutes. For typical 5-A a-c relay, C should be above 1 μF.—B. Evans, Four-Layer Diode Provides Time Delay with Instant Reset, *Electronic Design*, March 29, 1965, p 33–34.


560 OHMS
+28V
R1 100M
2.7K
R2 150 OHMS
R3 390K
150 OHMS
C3 .001μf
Q2 GE 2N2646
Q1 GE 2N494C
GE IN1692
OUTPUT
SCR1 GE C15F OR GE C11F
18 VOLT ZENER GE Z4XL18
C1 1μf TO 2μf
27 OHMS
C4 .05μf

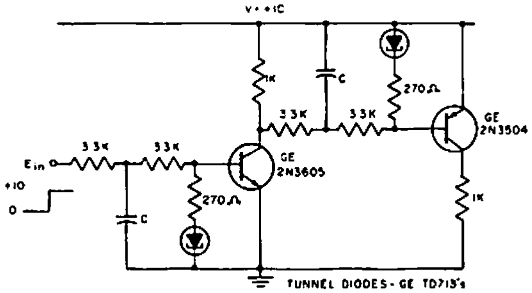
0.3 MS–3 MIN—C1 is stable low-leakage paper or mylar capacitor. Peak-point requirement of timing ujt Q1 is reduced up to 1,000 times by pulsing its upper base with 0.75-V negative pulse derived from free-running oscillator Q2. If R1 is 2,000 meg and C1 2-μF mylar, circuit gives stable time delays of over 1 hr.—"SCR Manual," 4th Edition, General Electric, 1967, p 165–166.


DETONATOR
RFC
3,3MEG
B+
NS4
.002
4.7 MEG
50MMF
.01MF
1,5MF
A+
2.2 MEG
30 MEG
B+
.01 MEG
NE23
.25MF
C-

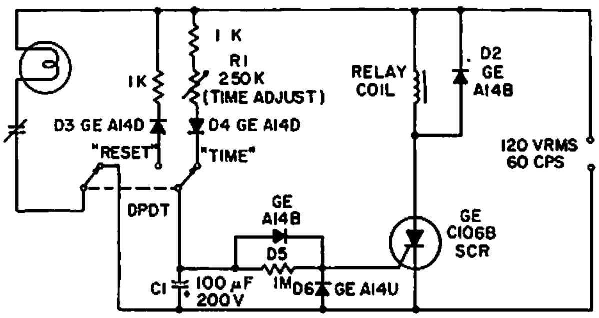
SELF-DESTRUCTION FOR FUZES—Used in T-5 antiaircraft battery-powered fuze for 4.5-inch M-8 rocket, to explode fuze from 6 to 11 s after missile was launched, if it had not been triggered by proximity to enemy aircraft, to preclude explosion on ground approach over friendly territory after miss. Delay circuit connects to grid of thyratron and uses NE23 neon tube along with R-C components. Small amount of radioactive material on neon tube keeps neon sufficiently ionized to minimize variations in striking voltage. When delay circuit trips thyratron, 1.5-μF capacitor discharges through armed (switch closed) detonator.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 131.


6.3VAC 600MA
T1
BLK
GRN
M1 HEP 175
M3
115VAC
OFF
S3 ON
BLK
GRN
C3 500
M2
110VAC OUTLET
K1
R1 560K
R5 6.8K
R6 470
B1
SECONDS
Q2 HEP52
R2 5M
R8 120
Q3 HEP53
S1 RESET/TIME
Q1 HEP801
R3 250
R4 250
R9 2.2K
X1
S2
X10
X1
X10
C1 2μf
C2 20μf
R7 470

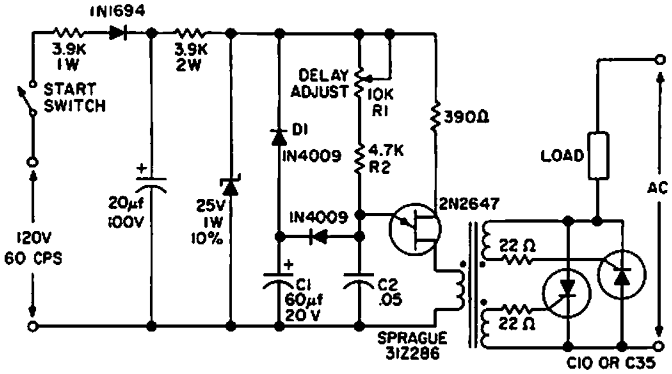
0.6–60 S FET—Device connected to timer receives power for precise interval, adjustable from 0.6 to 6 s for X1 range and 6 to 60 s for X10 range. K1 is 6-V relay and B1 is 12-V No. 1815 pilot lamp. Useful in photography and other short-term timing applications.—Article gives construction and calibration details.—"Field Effect Transistor Projects," Motorola, Phoenix, Ariz., 1966, p 35–47.


V = +10
1K
C
270Ω
3.3K
3.3K
GE
2N3504
Ein
3.3K
3.3K
+10
0
C
270Ω
GE
2N3605
1K
TUNNEL DIODES - GE TD713's

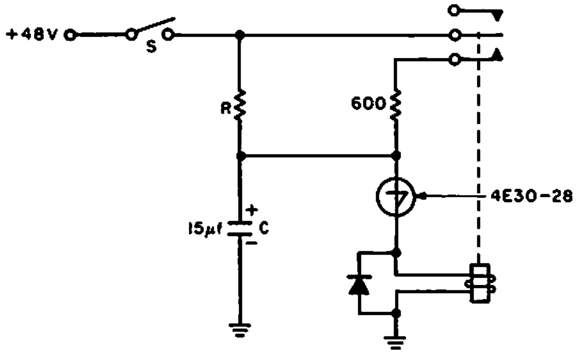
CASCADED TUNNEL-DIODE TIME DELAY—Two identical time delay stages are cascaded. When current threshold of first tunnel diode is reached while capacitor is charging, this diode switches into high-voltage state and turns on first transistor, to initiate similar timing action for second stage. Time delay equations are given in article.—W. R. Spofford, Jr., Applications For The New Low Cost TD 700 Series Tunnel Diodes, General Electric, Syracuse, N.Y., No. 90.66, 1967, p 8.


1K
1 K
R1
250K
(TIME ADJUST)
RELAY
COIL
D2
GE
A14B
D3 GE A14D
D4 GE A14D
"RESET"
"TIME"
120 VRMS
60 CPS
DPDT
GE
A14B
D5
GE
C106B
SCR
C1
100 μF
200 V
1M
D6
GE A14U

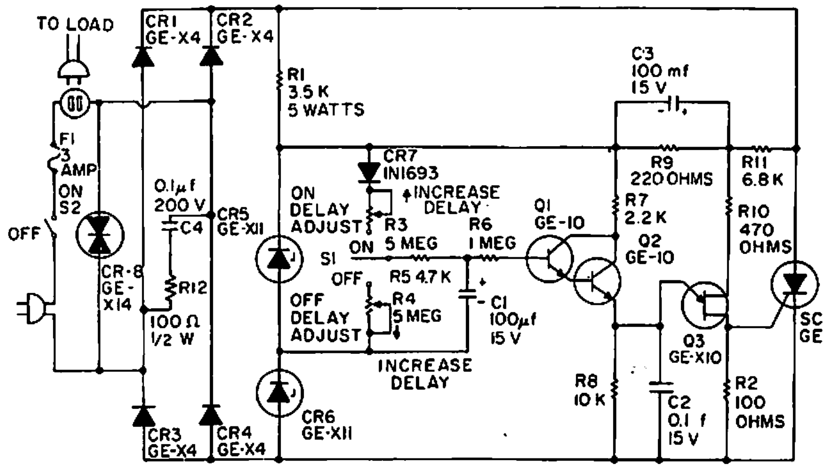
GARAGE-LIGHT TURN-OFF DELAY—Simple timing circuit gives adjustable delay of 0.01 to 60 s before light is turned off by relay after actuation of switch. Can also be used as timer for enlarger.—D. R. Grafham, Time-Delay Relay, General Electric, Syracuse, N.Y., No. 201.11, 1967.


1N1694
3.9K
1W
3.9K
2W
START
SWITCH
DELAY
ADJUST
10K
R1
390Ω
D1
1N4009
4.7K
R2
LOAD
AC
120V
60 CPS
20μf
100V
25V
1W
10%
1N4009
2N2647
22 Ω
22 Ω
C1
60μf
20 V
C2
.05
SPRAGUE
31Z286
C10 OR C35

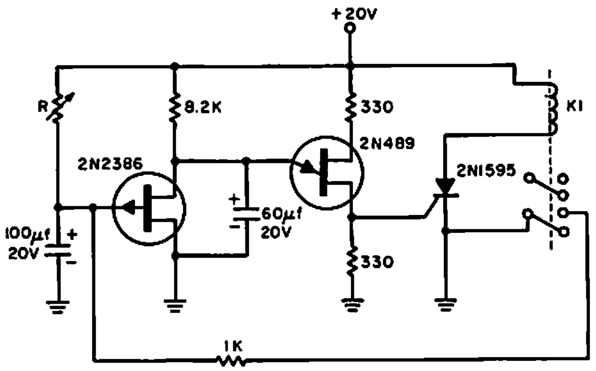
1-S A-C TIME DELAY—Requires only single ujt, oscillating much higher than a-c line frequency so switching of scr's is practically from full on to full off. Time delay is determined by (R1 + R2)(C1 + C2). For greater delay, increase C2.—"Unijunction Circuit Hints," General Electric, Syracuse, N.Y., Fig. 10.


+48V
S
R
600
4E30-28
15μf
C

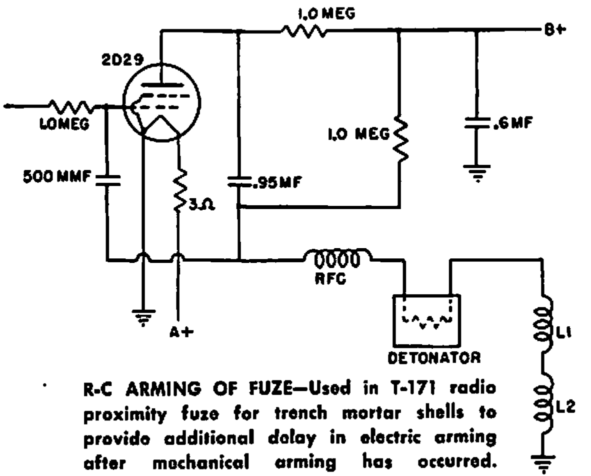
10 MS TO 10 MIN—Four-layer diode acts as self-latching pnpn switch that closes (fires) when C charges to firing voltage through R. Delay time in seconds is 0.000006R, or 10 min if R is 100 meg. Relay remains energized until S is opened.—J. McNellis, PNPN Switch Affords Wide Range Time Delay, *Electronic Design*, March 2, 1964, p 65–66.


TO LOAD
CR1
GE-X4
CR2
GE-X4
R1
3.5 K
5 WATTS
C3
100 mf
15 V
F1
3
AMP
ON
S2
OFF
CR-8
GE-
X14
0.1μf
200 V
C4
R12
100 Ω
1/2 W
CR5
GE-X11
CR7
1N1693
ON
DELAY
ADJUST
INCREASE
DELAY
R3
5 MEG
R6
1 MEG
S1
ON
OFF
R5 4.7 K
R4
5 MEG
C1
100μf
15 V
OFF
DELAY
ADJUST
INCREASE
DELAY
Q1
GE-10
Q2
GE-10
R9
220 OHMS
R7
2.2 K
R11
6.8 K
R10
470
OHMS
Q3
GE-X10
SCR1
GE-X1
R8
10 K
C2
0.1 f
15 V
R2
100
OHMS
CR6
GE-X11
CR3
GE-X4
CR4
GE-X4

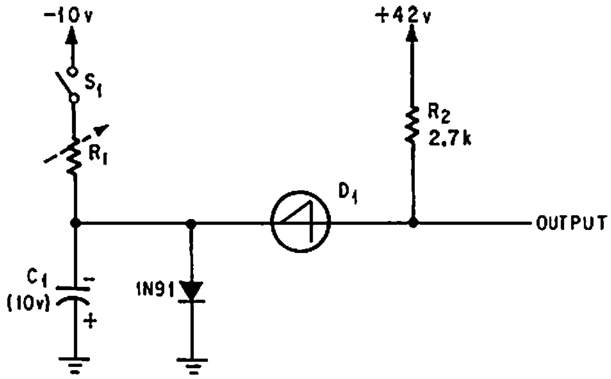
500-W 10-MIN DELAY—Will turn off soldering iron or clothes-pressing iron after adjustable delay of up to 10 min after weight of iron in holder closes S1. This keeps iron warm and ready for use within delay interval while eliminating fire hazard of forgetting to turn it off when leaving. Can also be used for delayed turn-off of garage or porch lights, or for turning on lamp or appliance after similarly adjustable delay.—"Hobby Manual," General Electric, Owensboro, Ky., 1965, p 142.


+20V
R
8.2K
330
K1
2N489
2N2386
2N1595
100µf
20V
60µf
20V
330
1K

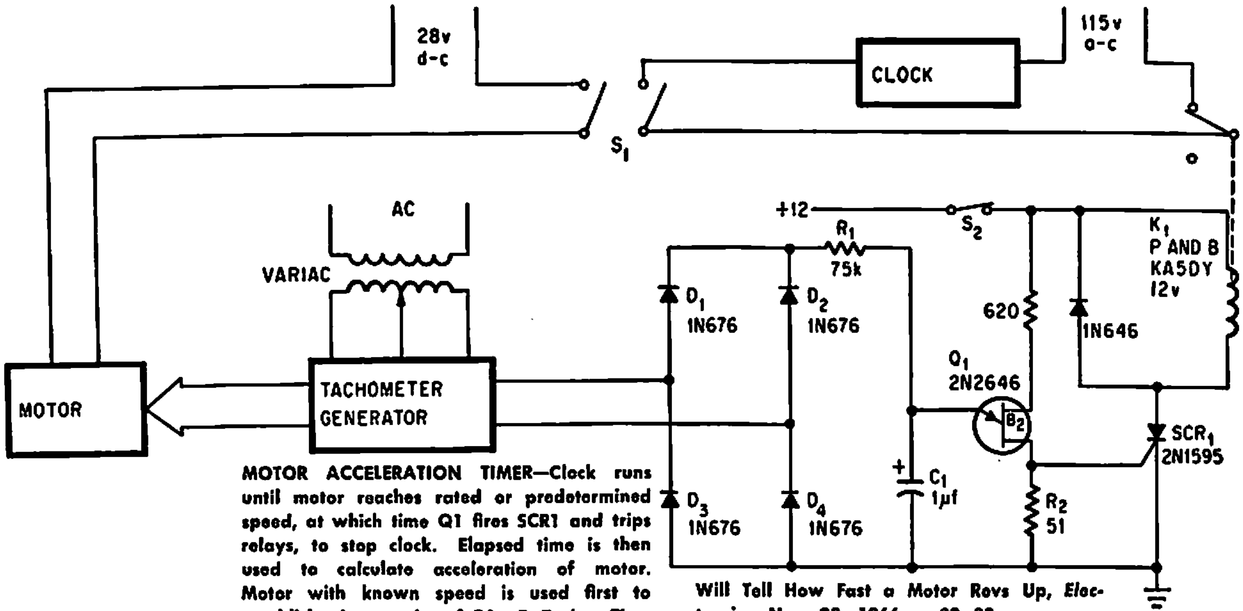
1–60 MIN WITH 5% ACCURACY—Fet follower, ujt, and scr provide adjustable time intervals, determined by R, for recycling intervals of 5 to 10 min. R can be 12-position rotary switch having 12 values of R ranging from 350K to 20 meg. Value of T in minutes is approximately equal to 2.86 times value of R in megohms.—E. B. Croson, Solid-State Timer Improves Recycling Accuracy, *Electronic Design*, July 6, 1964, p 51–52.


1.0 MEG
B+
2D29
1.0 MEG
LOMEG
.6MF
500 MMF
3Ω
.95MF
RFC
A+
DETONATOR
L1
L2

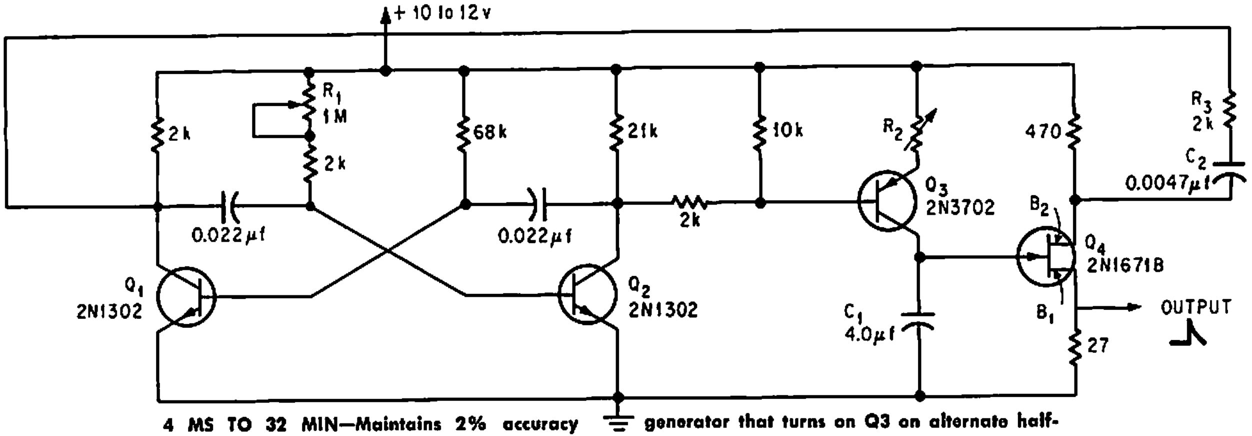
R-C ARMING OF FUZE—Used in T-171 radio proximity fuze for trench mortar shells to provide additional delay in electric arming after mechanical arming has occurred. Time delays up to 8 s can be obtained, depending upon size of arming resistor between anode of 2D29 thyratron and B supply. Fuze cannot be tripped by input signal to thyratron until 0.95-µF detonator firing capacitor has been fully charged by delay circuit after mechanical arming.—A. V. Astin, Editor, "Radio Proximity Fuzes for Fin-Stabilized Missiles," Div. 4, NDRC, Vol. I, 1946 (available from Clearinghouse, Springfield, Va.), p 125–130.


-10v
+42v
S1
R2
2.7k
R1
D1
OUTPUT
C1
(10v)
1N91

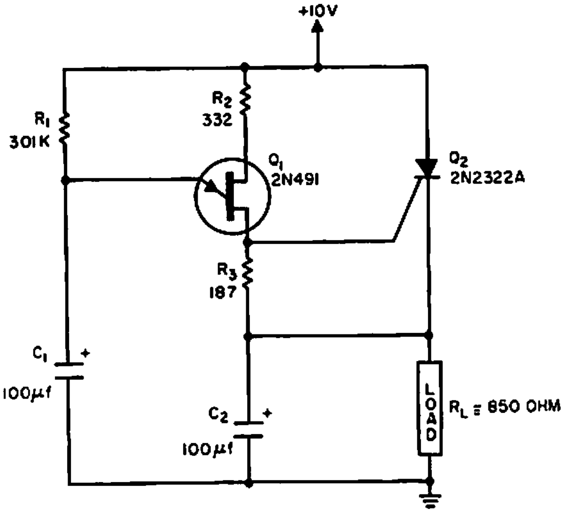
TIME STRETCHER—Modification of Shockley diode delay eliminates need for large capacitor to give delays up to 30 min. When anode of D1 is tied to 42-V supply, C1 needs to supply only remaining 8 V of 50-V breakdown voltage of D1. R1 can be as large as necessary to give desired R1C1 time constant, and C1 proportionally small. D1 is 4E50.—A. L. Plevy, Time Delay Stretched With New Bias Scheme, *Electronics*, Oct. 30, 1967, p 72.


28v
d-c
CLOCK
115v
a-c
S1
AC
+12
S2
K1
P AND B
KA5DY
12v
R1
75k
VARIAC
D1
1N676
D2
1N676
620
1N646
Q1
2N2646
B2
MOTOR
TACHOMETER
GENERATOR
SCR1
2N1595
C1
1µf
D3
1N676
D4
1N676
R2
51

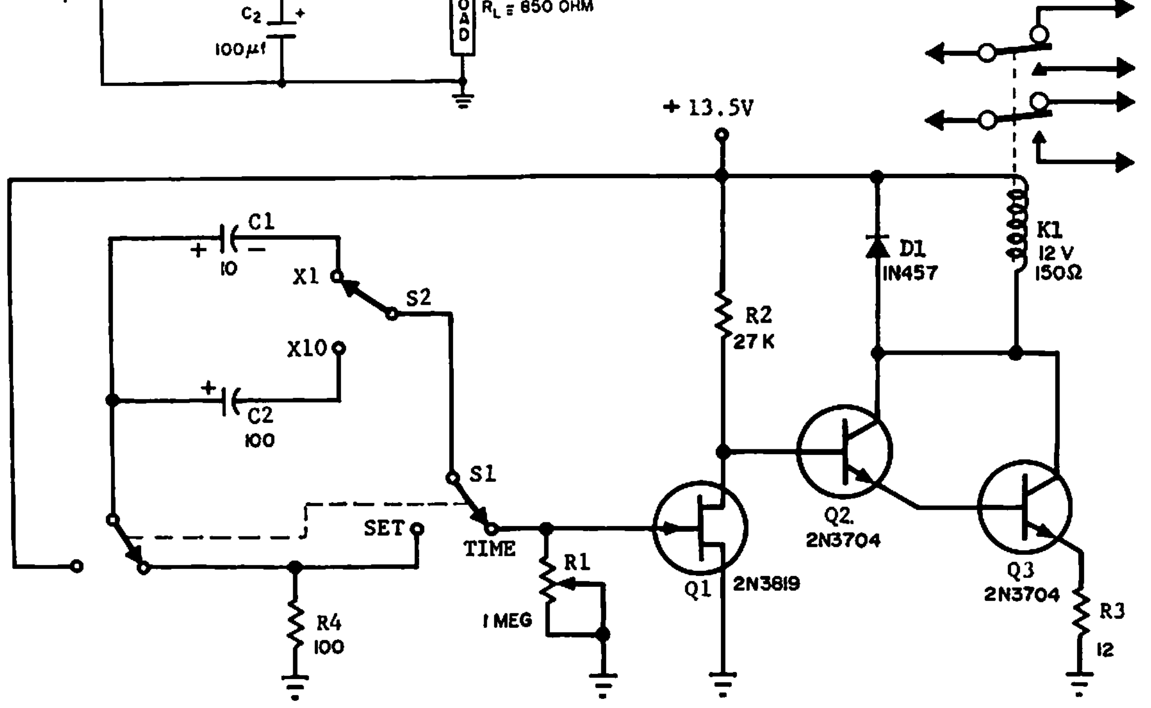
MOTOR ACCELERATION TIMER—Clock runs until motor reaches rated or predetermined speed, at which time Q1 fires SCR1 and trips relays, to stop clock. Elapsed time is then used to calculate acceleration of motor. Motor with known speed is used first to establish trigger point of Q1.—R. Traina, Time Will Tell How Fast a Motor Revs Up, *Electronics*, Nov. 28, 1966, p 82–83.


+10 to 12 v
2k
R1
1M
2k
68k
21k
10k
R2
470
R3
2k
C2
0.0047µf
0.022µf
0.022µf
2k
Q3
2N3702
B2
Q4
2N1671B
Q1
2N1302
Q2
2N1302
C1
4.0µf
B1
OUTPUT
27

4 MS TO 32 MIN—Maintains 2% accuracy over wide timing range controlled by R2, with R1 providing fine adjustment. Uses only low-cost components. Astable mvbr Q1-Q2 operates as variable-frequency pulse generator that turns on Q3 on alternate half-cycles. Q1 charges C1 to point at which ujt Q4 fires and generates output pulse.—A. J. Lim, Unijunction Improves Timing-Circuit Accuracy, *Electronics*, Oct. 30, 1967, p 69–70.


+10V
R1
301K
R2
332
Q1
2N491
Q2
2N2322A
R3
187
C1
100µf
C2
100µf
LOAD
RL = 850 OHM

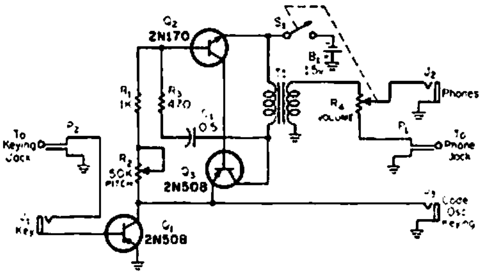
40-S POWER-SWITCH DELAY—Modified ujt trigger Q1 provides delay up to 40 s, depending on values of R1 and C1, after 10-V source voltage is applied, before firing scr Q2 to apply power to load. Scr then remains on until 10-V source voltage is removed. Temperature range is −30 to 100 C.—A. M. Hildebrandt, SCR and UJT Form Time-Delay Switch, *Electronic Design*, Sept. 13, 1965, p 82–83.


+ 13.5V
C1
10
X1
S2
X10
C2
100
S1
SET
TIME
R1
1 MEG
R4
100
D1
IN457
K1
12 V
150Ω
R2
27K
Q1
2N3819
Q2
2N3704
Q3
2N3704
R3
12

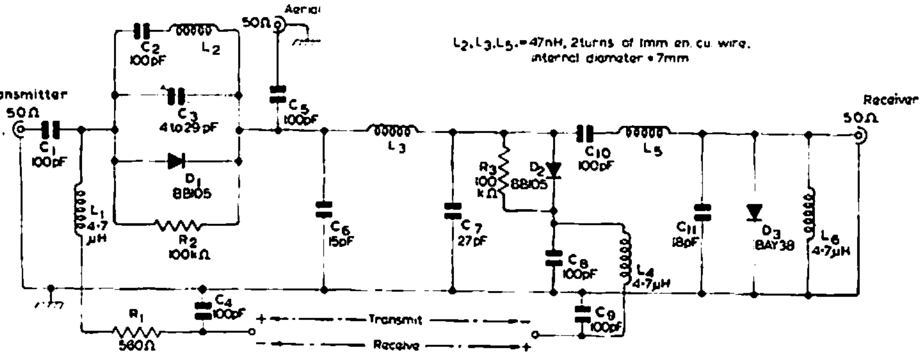
1 S TO 5 MIN—Potentiometer R1 in fet circuit determines time delay before relay pulls in after S1 is moved to TIME position. Darlington-connected transistors provide additional power amplification to ensure fast pull-in of relay. Use of S2 with second timing capacitor C2 increases versatility by providing two timing ranges. Maximum current drain is only 75 mA during actual timing interval, dropping to 0.5 mA between timing intervals, so battery supply can be used.—G. L. Jackson, Wide-Range Electronic Timer, *Electronics World*, Nov. 1967, p 56–57.

CHAPTER 90

Transceiver Circuits

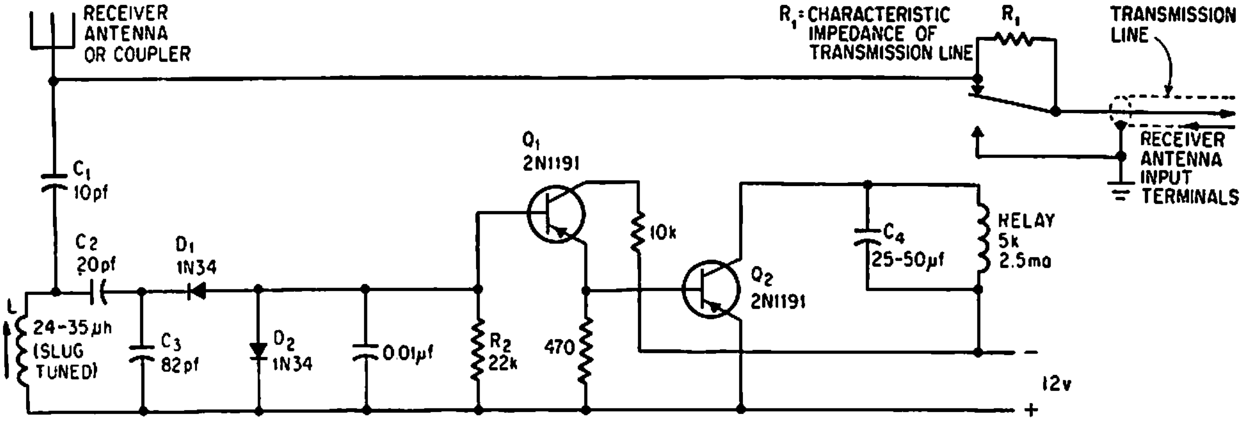

Q2
2N170
S1
B1
1.5v
T1
R1
1K
R3
470
C1
.05
R4
VOLUME
J2
Phones
To Keying Jack
P2
R2
50K
PITCH
Q3
2N508
P1
To Phone Jack
J3
Code Osc Keying
J1
Key
Q1
2N508

C-W MONITOR—Self-contained three-transistor circuit operating from single 1.5-V cell has sufficient output to drive speaker connected in place of 100-ohm primary of T1. Only connections required are to terminals of transceiver keying jack. May also be used as code-practice oscillator.—A. D'Onofrio and P. Stark, A C. W. Monitor for Grid-Block Keyed Transceivers, CQ, April 1965, p 62–63.

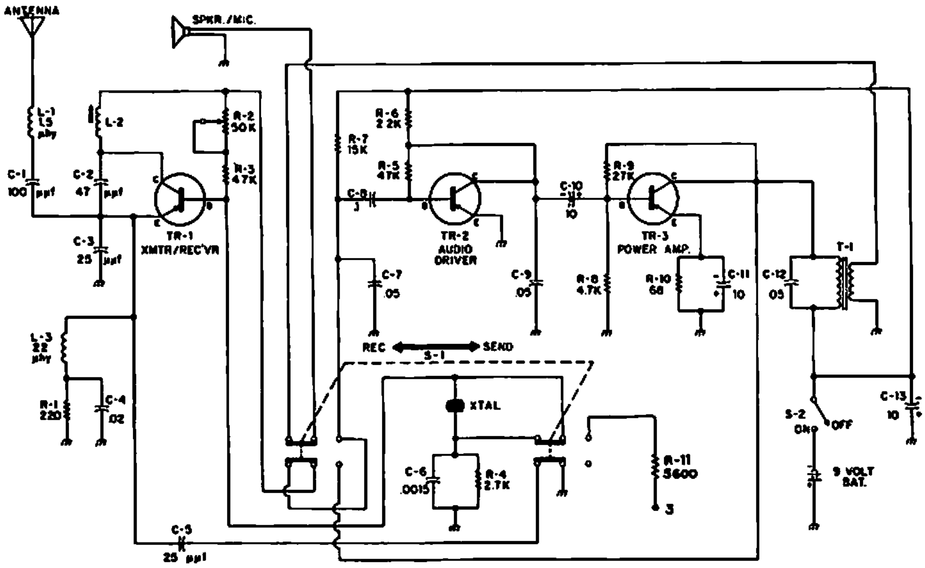

Aerial
50Ω
C2
100pF
L2
C5
100pF
Transmitter
50Ω
C1
100pF
C3
4 to 29 pF
D1
BB105
L1
4·7 μH
R2
100kΩ
C6
15pF
L3
C7
27pF
R3
100 kΩ
D2
BB105
C10
100pF
L5
C8
100pF
L4
4·7μH
C11
18pF
D3
BAY38
L6
4·7μH
Receiver
50Ω
R1
560Ω
C4
100pF
C9
100pF
Transmit
Receive

L2, L3, L5 = 47nH, 2 turns of 1mm en. cu. wire, internal diameter = 7mm

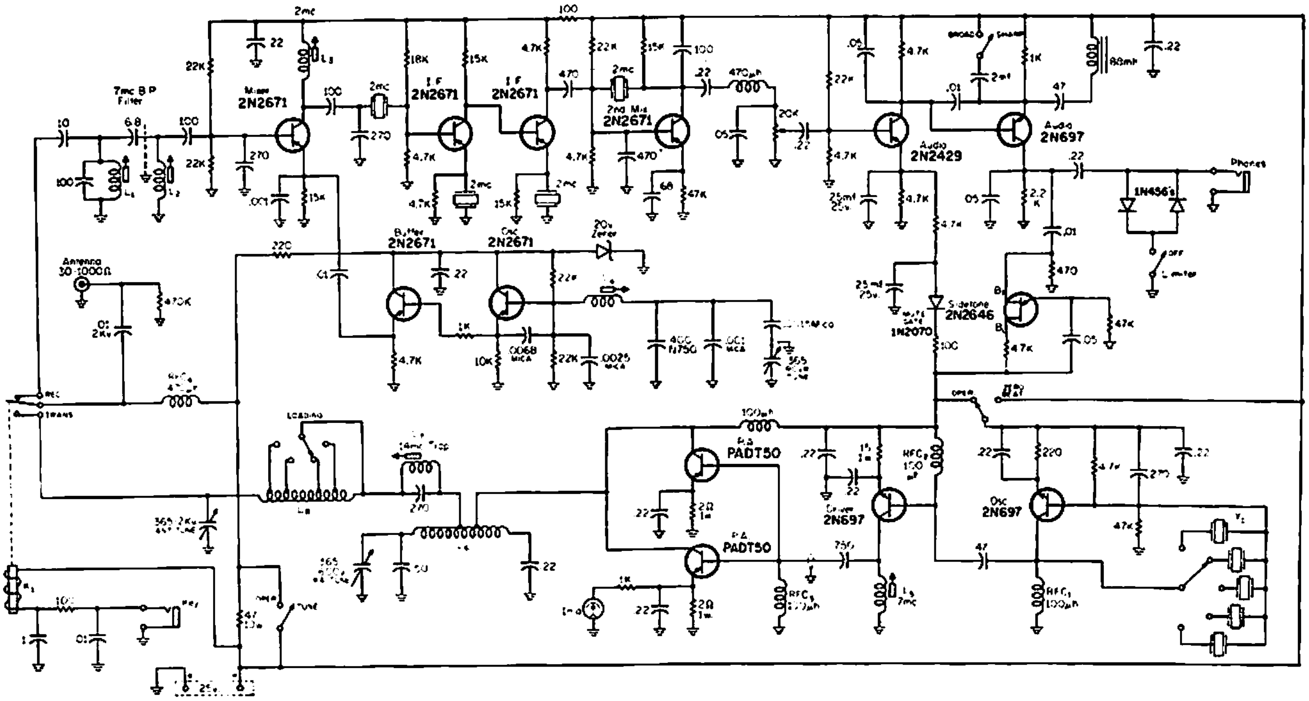
165-MHZ T-R SWITCH—Developed for mobile application having transmitter power of 12 W. Switching is done by BB105 variable-capacitance diode. During reception, D1 and D2 are reverse-biased and present high-Q capacitance. When transmitter is operating, these diodes are forward-biased and present only small resistance. Bias voltage is 13.8 V, with polarity being reversed to change from transmit to receive.—J. M. Siemonsma, Electronic Aerial Switch for Mobile Transceivers, *Mullard Technical Communications*, Jan. 1968, p 30–31.


RECEIVER ANTENNA OR COUPLER
R1 = CHARACTERISTIC IMPEDANCE OF TRANSMISSION LINE
R1
TRANSMISSION LINE
RECEIVER ANTENNA INPUT TERMINALS
C1
10pf
Q1
2N1191
10k
C4
25-50μf
RELAY
5k
2.5ma
Q2
2N1191
C2
20pf
D1
1N34
L
24-35μh
(SLUG TUNED)
C3
82pf
D2
1N34
0.01μf
R2
22k
470
12v

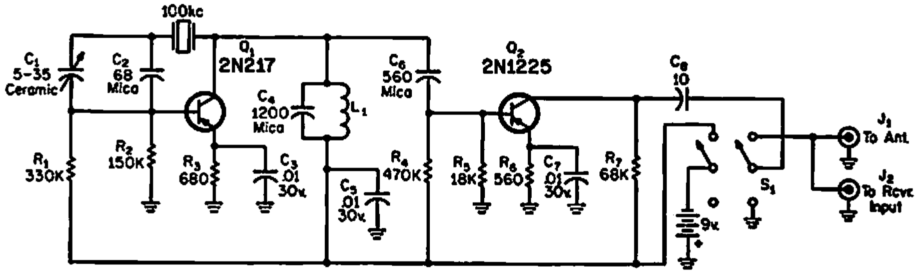
T/R ACTUATOR—When protection circuit Q1-Q2 is actuated by r-f signal exceeding 1 V at predetermined frequency, relay is pulled in to ground transmission line going to receiver, to terminate receiving antenna in its characteristic impedance. This protects input stage of receiver, without using expensive coaxial relays and disabling circuits. Circuit can be made to operate at other r-f signal levels by changing ratios C2:C3 and R2:470. K. C. Morton, R-f Signals Actuate Transmit-Receive Switch, *Electronics*, June 12, 1967, p 103–104.


ANTENNA
SPKR./MIC.
L-1 1.5 μhy
L-2
C-1 100 μμf
C-2 47 μμf
C-3 25 μμf
TR-1 XMTR/REC'VR
R-2 50K
R-3 47K
R-6 2.2K
R-7 15K
R-5 47K
C-8 .1
TR-2 AUDIO DRIVER
C-10 10
R-9 27K
TR-3 POWER AMP.
T-1
C-7 .05
C-9 .05
R-8 4.7K
R-10 68
C-11 10
C-12 .05
REC
SEND
S-1
XTAL
C-6 .0015
R-4 2.7K
R-11 5600
L-3 22 μhy
R-1 220
C-4 .02
C-5 25 μμf
S-2 ON OFF
9 VOLT BAT.
C-13 10

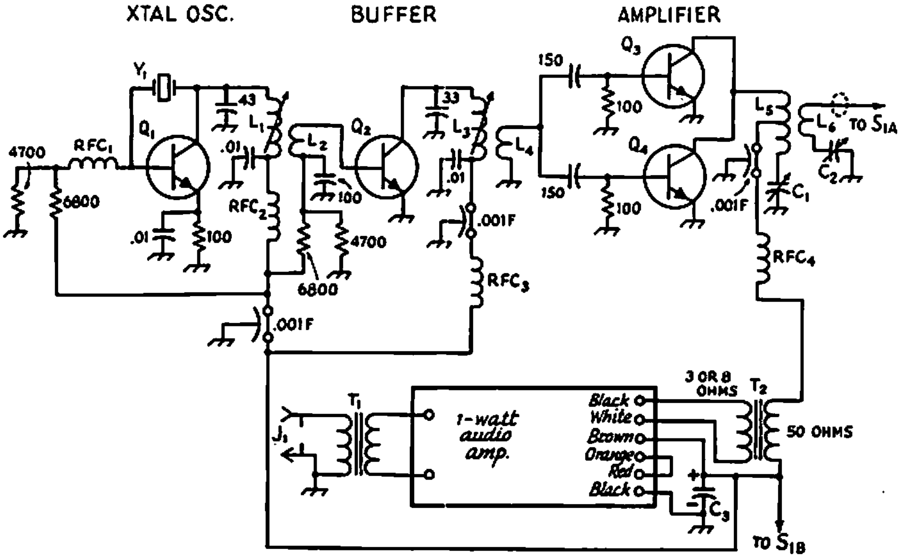
50-MC CONVERSION FROM CB—Requires only addition of R-11 to parts furnished with low-priced CB kit, for short-range communication (0.5 to 3 miles, depending on fixed station) in 6-meter amateur band. Book gives changes required in coils and crystals.—E. C. Pienkowski, Converting the Knight C-100 CB Transceiver to 50 Mc, "The Mobile Manual for Radio Amateurs," ARRL, Newington, Conn., 1968, p 218–219.


7mc B P Filter
Mixer 2N2671
I F 2N2671
I F 2N2671
2nd Mix 2N2671
Audio 2N2429
Audio 2N697
BROAD
SHARP
88mh
Phones
1N456's
Antenna 30-1000Ω
470K
Buffer 2N2671
Osc 2N2671
20v Zener
Sidetone 2N2646
1N2070
REC
TRANS
LOADING
14mc Trap
P.A. PADT50
P.A. PADT50
Driver 2N697
Osc 2N697
Key
Y1

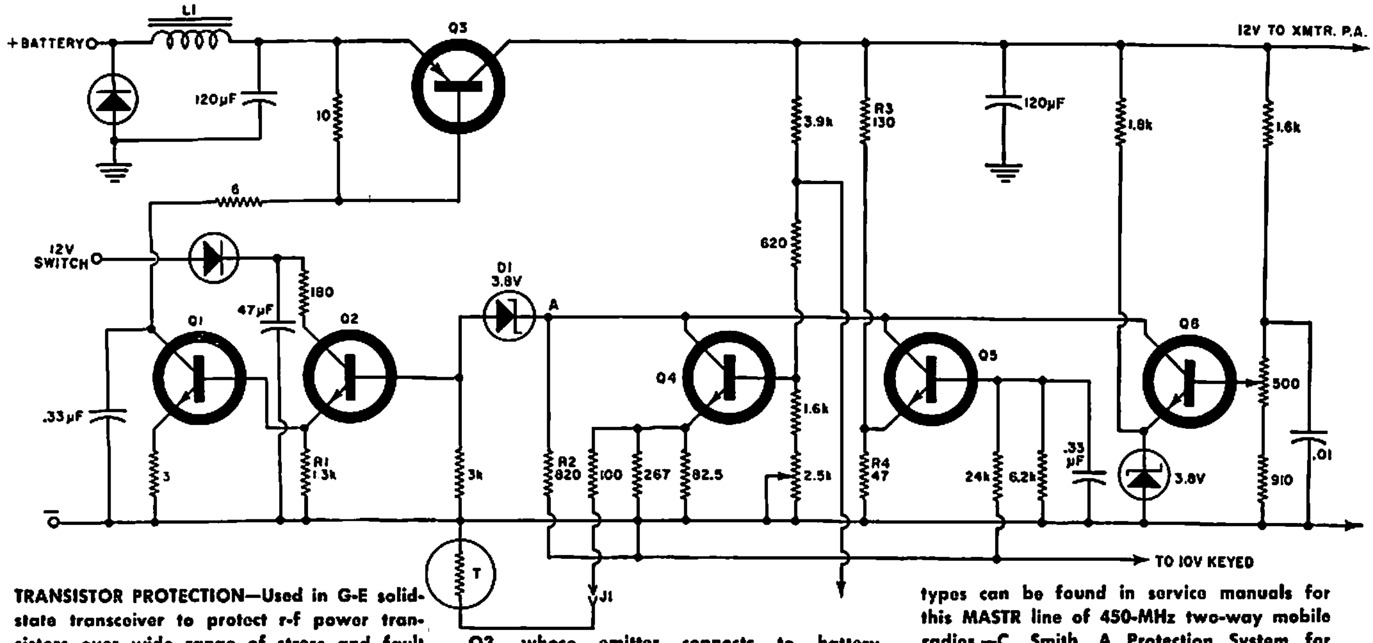
40-METER C-W TRANSCEIVER—Receiver section has sensitivity of 0.1 μV and transmitter has output of 23 W, operating from 28 V d-c supply. Receiver is single-conversion superhet with no r-f stage but with two tuned circuits ahead of mixer to form 7-MHz bandpass filter. Oscillator is zener regulated to reduce warmup or temperature drift at 5 MHz. I-f value is 2.105 MHz. Second detector is single-transistor oscillator-mixer followed by two direct-coupled audio stages having muting, side-tone injection, and additional selectivity. Article describes operation of entire circuit and gives construction details. Can be operated on 20-meter and 80-meter amateur bands as well, simply by changing coils.—J. S. Hill, A Compact 40 Meter Transceiver, CQ, June 1966, p 22–27.


100kc
C_1 5-35 Ceramic
C_2 68 Mica
Q_1 2N217
C_4 1200 Mica
L_1
C_6 560 Mica
Q_2 2N1225
C_8 10
R_1 330K
R_2 150K
R_3 680
C_3 .01 30v
C_5 .01 30v
R_4 470K
R_5 18K
R_6 560
C_7 .01 30v
R_7 68K
9v
S_1
J_1 To Ant.
J_2 To Rcvr. Input

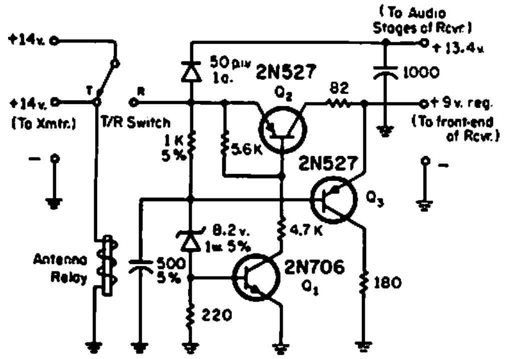
PORTABLE CALIBRATOR—Simple circuit can be used for checking frequency points in receiver or transmitter up to at least 150 MHz. Article gives construction details.—W. M. Scherer, Harmonic-Rich 100 Kc Crystal Calibrator, CQ, Dec. 1965, p 28–30.


XTAL OSC.
BUFFER
AMPLIFIER
Y_1
Q_1
43
L_1
4700
RFC_1
.01
6800
.01
100
RFC_2
L_2
100
Q_2
33
L_3
.01
4700
6800
.001F
RFC_3
.001F
L_4
150
100
Q_3
Q_4
150
100
.001F
L_5
L_6
TO S_{1A}
C_2
C_1
RFC_4
T_1
J_1
1-watt audio amp.
Black
White
Brown
Orange
Red
Black
3 OR 8 OHMS
T_2
50 OHMS
C_3
TO S_{1B}

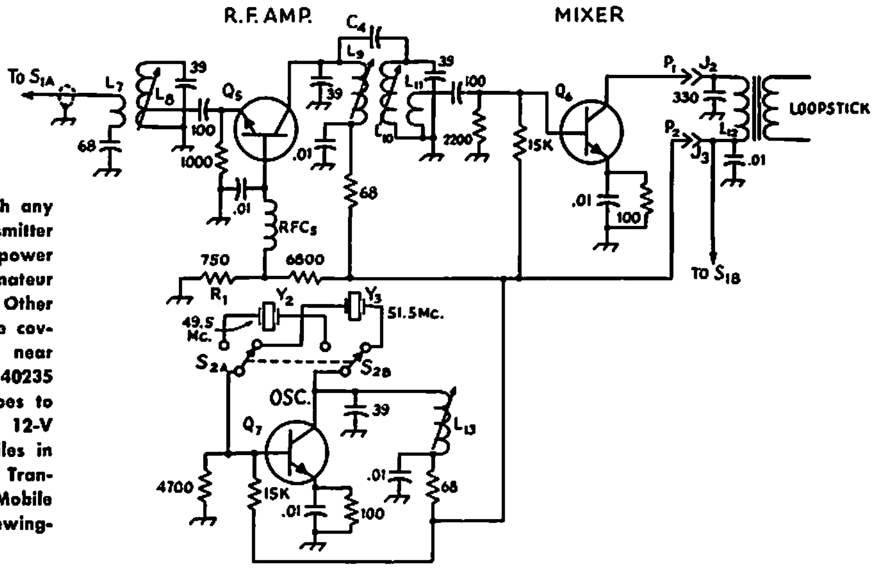
50-MHZ TRANSMITTER SECTION—Modification of earlier design uses transistors throughout, with power output depending on choice of silicon transistors used for Q3 and Q4; possibilities are 27R131, 2N3553, and 2N-3866. Q1 and Q2 are 2N706 or equivalent. IC is Radio Shack 277-038 rated at 1 W. Y1 is third-overtone 50.11–54 MHz crystal. Book gives all coil and transformer data.—E. P. Tilton, 50-Mc Transistor Transceiver, Mark II, "The Mobile Manual for Radio Amateurs," ARRL, Newington, Conn., 1968, p 222–231.


+BATTERY
L1
120µF
10
Q3
12V TO XMTR. P.A.
3.9k
R3 130
120µF
1.8k
1.6k
6
12V SWITCH
620
D1 3.8V
A
180
47µF
Q1
Q2
Q4
Q5
Q6
.33µF
500
1.6k
3
R1 1.3k
3k
R2 820
100
267
82.5
2.5k
R4 47
24k
6.2k
.33 µF
3.8V
910
.01
T
J1
TO 10V KEYED

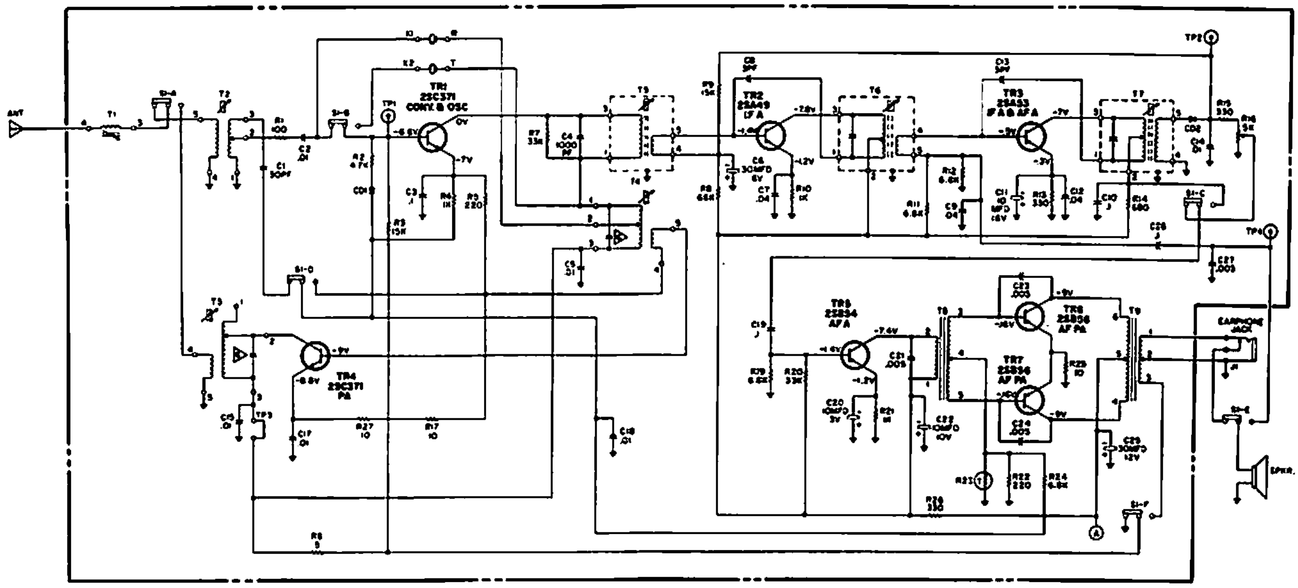
TRANSISTOR PROTECTION—Used in G-E solid-state transceiver to protect r-f power transistors over wide range of stress and fault conditions without affecting efficiency. High transmit current is carried and controlled by Q3, whose emitter connects to battery through. L1 at all times. Article describes other protective actions in detail. Transistor types can be found in service manuals for this MASTR line of 450-MHz two-way mobile radios.—C. Smith, A Protection System for Solid-State Transmitters, *Electronics World*, Feb. 1969, p 38–39 and 77.

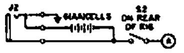

(To Audio Stages of Rcvr.)
+13.4v.
+14v.
+14v. (To Xmtr.)
T
R
T/R Switch
50piv 1a.
2N527
Q2
82
1000
+9v. reg. (To front-end of Rcvr.)
1K 5%
5.6K
2N527
Q3
8.2v. 1w 5%
4.7K
Antenna Relay
500 5%
2N706
Q1
180
220

PROTECTING RECEIVER FRONT END—Circuit delays application of supply voltage to receiver section 0.6 s to prevent burnout of delicate transistors by residual radiation from turned-off transmitter.—R. Jayaraman, Delayed Switching for Transistor Receivers, CQ, Feb. 1970, p 39–40 and 98.

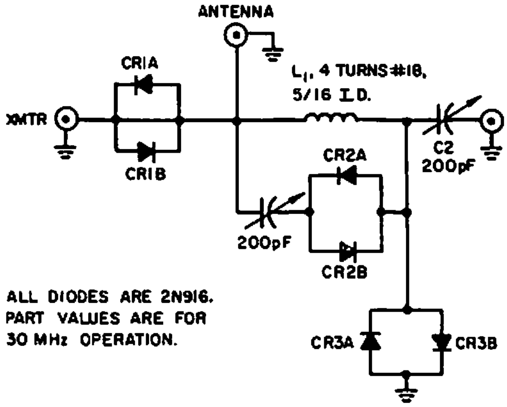

R.F. AMP.
MIXER
To S_{1A}
L_7
L_8
39
68
100
1000
Q_5
.01
RFC5
C_4
L_9
39
.01
68
L_{11}
39
100
10
2200
15K
Q_6
.01
100
P_1
J_2
330
L_{12}
P_2
J_3
.01
LOOPSTICK
To S_{1B}
750
6800
R_1
Y_2
Y_3
49.5 Mc.
51.5Mc.
S_{2A}
S_{2B}
OSC.
Q_7
39
L_{13}
.01
68
4700
15K
.01
100

50-MHZ CONVERTER—May be used with any small receiver and small 50-MHz transmitter to give transceiver having reasonable power for portable operation in 6-meter amateur band while weighing under 5 lb. Other crystals may be used for Y3 to provide coverage of any 1-MHz segment in or near 50-MHz band. Transistors are RCA 40235 silicon. Book gives coil data. S1B goes to transceiver switch. Operates from 12-V auto battery. Range is up to 100 miles in mountain locations.—E. P. Tilton, 50-Mc Transistor Transceiver, Mark II, "The Mobile Manual for Radio Amateurs," ARRL, Newington, Conn., 1968, p 222-231.


ANT
T1
S1-A
T2
R1 100
C2 .01
C1 30PF
S1-B
TP1
TR1 2SC371 CONV. & OSC
-6.8V
0V
-7V
R2 4.7K
C3 .1
R4 1K
R5 220
R3 15K
R7 33K
C4 1000 PF
T3
S1-D
T5
TR4 2SC371 PA
-9V
-8.8V
C15 .01
TP3
C17 .01
R27 10
R17 10
C18 .01
R8 5
C5 .01
R9 15K
R8 68K
TR2 2SA49 I.F.A
-7.8V
-1.2V
C6 30MFD 6V
C7 .04
R10 1K
T6
R12 6.8K
R11 6.8K
C9 .04
C13 3PF
TR3 2SA53 IFA & AFA
-7V
-3V
C11 10 MFD 6V
R13 330
C12 .04
T7
C10 .1
R14 680
CD2
C14 .01
R15 330
R16 5K
S1-C
TP2
TP4
C26 .1
C27 .005
TR5 2SB34 AFA
-7.4V
-1.2V
C19 .1
R19 6.8K
R20 33K
C21 .005
C20 10MFD 3V
R21 1K
T8
C23 .005
TR6 2SB56 AF PA
-9V
TR7 2SB56 AF PA
R25 10
C24 .005
C22 10MFD 10V
R23
R22 220
R24 6.8K
R26 330
T9
C25 30MFD 12V
EARPHONE JACK
S1-E
SPKR.
S1-F
A

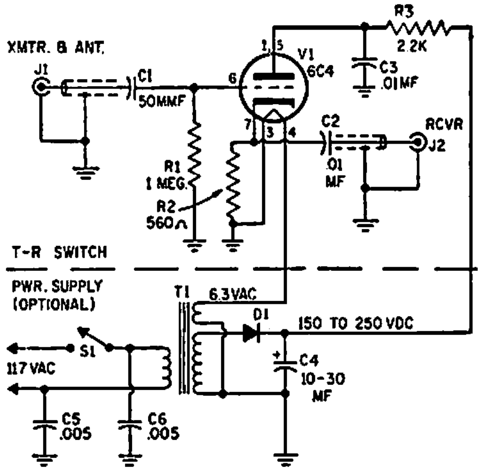

J2
6-1½V CELLS
S2 ON REAR OF RIG
A

CB TRANSCEIVER—Seven-transistor portable transmitter-receiver operates on any of 22 different frequencies in 27-MHz Citizens Band, depending on crystal used in transmitting. When receiving, unit operates like a-m radio except that intermediate frequency is determined by separate crystal whose output is mixed with incoming signal to produce 455-kHz i-f signal. Talk-receive switch S1 is shown in receive position.—1R1007 Citizens Band Transceiver, Magnavox Service Manual 6299, Fort Wayne, Ind., 1970.

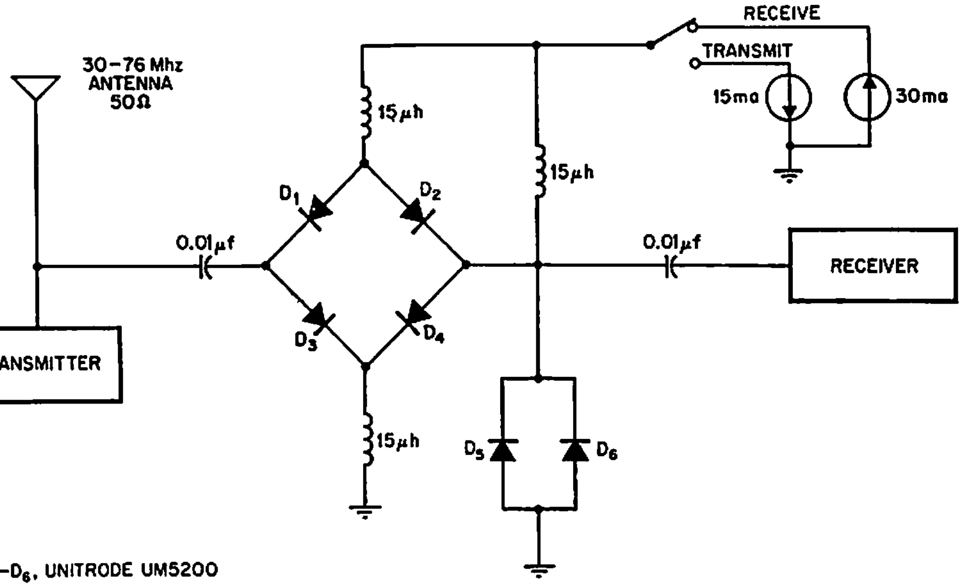

ANTENNA
L₁, 4 TURNS #18, 5/16 I.D.
XMTR
CR1A
CR1B
CR2A
CR2B
C2 200pF
RCVR
200pF
CR3A
CR3B

ALL DIODES ARE 2N916. PART VALUES ARE FOR 30 MHz OPERATION.

10–50 MHZ DUPLEXER—All diodes conduct in transmit mode, and none conduct in receive mode, to give simple and low-cost transmit-receive switch requiring no external bias supplies or switching signals. Isolation is greater than 26 dB for 30-V peak signal.—R. Van Sickle, Simple Duplexer Requires Only Inexpensive Components, *Electronic Design*, July 5, 1969, p 80.


XMTR. & ANT.
J1
C1 50MMF
6
1,5
V1 6C4
R3 2.2K
C3 .01MF
7
3
4
C2 .01 MF
RCVR J2
R1 1 MEG.
R2 560Ω
T-R SWITCH
PWR. SUPPLY (OPTIONAL)
T1
6.3VAC
D1
150 TO 250 VDC
S1
117 VAC
C4 10-30 MF
C5 .005
C6 .005

TRANSMIT-RECEIVE SWITCH—Permits instant break-in during pauses in amateur c-w transmissions. Eliminates need for antenna relay, because transmitter is connected all the time. Similarly, receiver is operating all the time, permitting monitoring of station interference during transmissions. Book gives complete construction and operation data.—M. Lincoln, All-Electronic T-R Switch for Hams, "Bench-Tested Communications Projects," Haydon Book Co., N.Y., p 22–25.


30-76 Mhz ANTENNA 50Ω
TRANSMITTER
0.01μf
15μh
15μh
15μh
D1
D2
D3
D4
D5
D6
RECEIVE
TRANSMIT
15ma
30ma
0.01μf
RECEIVER

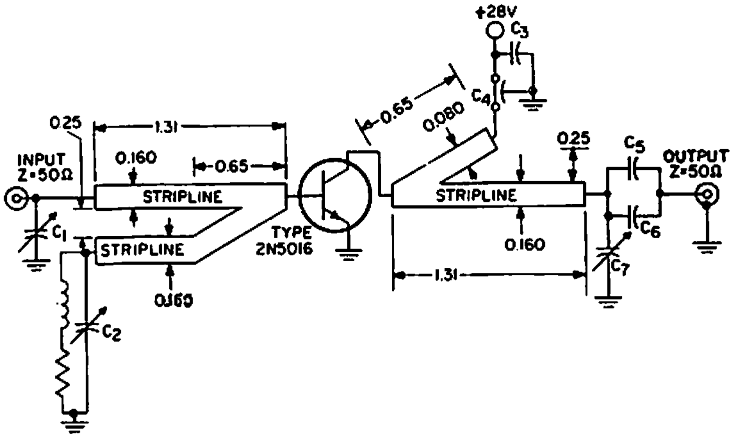
D_1–D_6, UNITRODE UM5200

BRIDGE T-R SWITCH—With switch in RECEIVE position shown, current of 30 mA from constant-current source flows through diode bridge, forward-biasing diodes at 1.2 V. Receiver is then connected to antenna through 1.2 ohms. With switch in TRANSMIT position, D5 and D6 conduct, grounding receiver input, while bridge diodes are reverse-biased and open-circuited, so transmitter is ungrounded and feeding antenna.—P. V. Wanek, Transmit-Receive Switch Exceeds 60-dB Isolation, *Electronics*, Aug. 18, 1969, p 93.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 91
Transmitter Circuits

400-MHZ MICROSTRIPLINE AMPLIFIER—Delivers 15 W to 50-ohm line. Correct bias is obtained without d-c blocking, as long as d-c impedance of source is above 50 ohms.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 349.



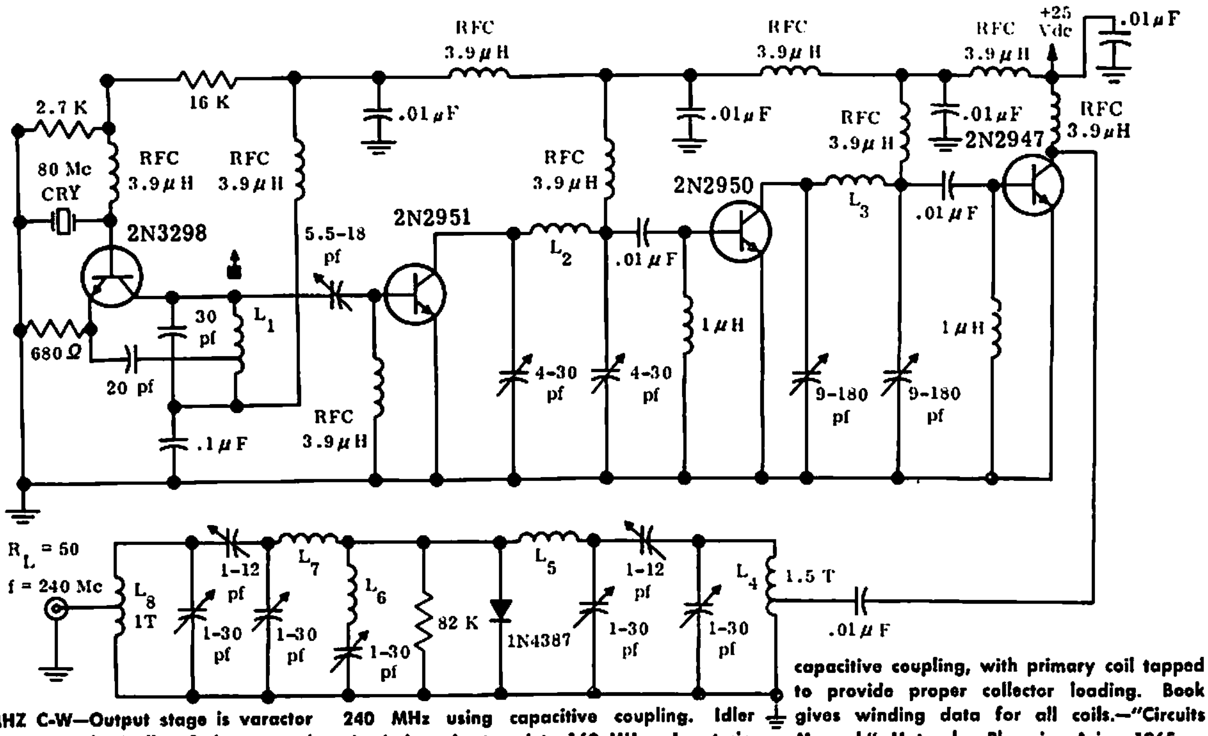
+28V
C_3
C_4
0.65
0.080
0.25
C_5
OUTPUT Z=50Ω
0.25
1.31
INPUT Z=50Ω
0.160
0.65
STRIPLINE
C_1
STRIPLINE
TYPE 2N5016
STRIPLINE
C_6
0.160
C_7
1.31
0.160
C_2

C_1, C_2, C_7 = trimmer capacitor, 2 to 18 pF, Amperex HT10A/218 or equiv.
C_3 = 0.03 μF, ceramic disc
C_4 = 470 pF, feedthru, Allen Bradley FA5C or equiv.
C_5, C_6 = 0.005 μF, ceramic disc

R_1 = 5.1 ohms, 0.5 watt, carbon

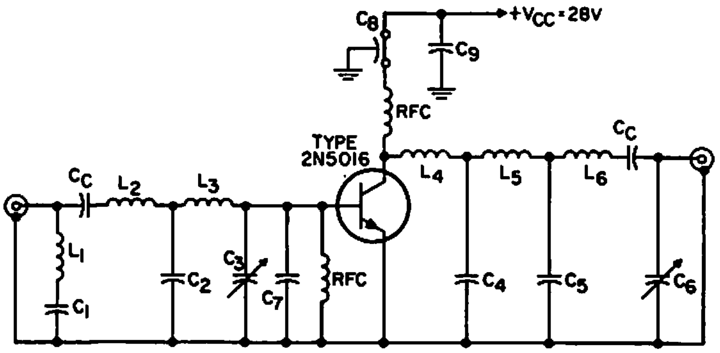
Notes:

1. Broad = 1/16" Teflon board (ε = 2.6), Budd Co. Polychem Div., Grade 108T, 1 oz, double-clad copper, or equiv.
2. Dimensions in inches.



RFC 3.9μH
RFC 3.9μH
RFC 3.9μH
+25 Vdc
.01μF
2.7 K
16 K
.01μF
.01μF
RFC 3.9μH
.01μF
2N2947
RFC 3.9μH
80 Mc CRY
RFC 3.9μH
RFC 3.9μH
RFC 3.9μH
2N2950
L_3
.01μF
2N3298
2N2951
5.5-18 pf
L_2
.01μF
30 pf
L_1
1μH
1μH
680Ω
20 pf
4-30 pf
4-30 pf
9-180 pf
9-180 pf
RFC 3.9μH
.1μF
R_L = 50
f = 240 Mc
L_8 1T
1-12 pf
L_7
L_6
L_5
1-12 pf
L_4
1.5 T
1-30 pf
1-30 pf
1-30 pf
82 K
1N4387
1-30 pf
1-30 pf
.01μF

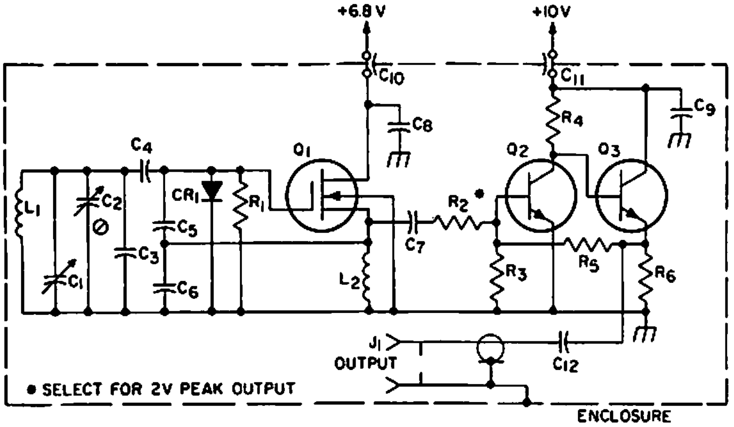
8-W 240-MHZ C-W—Output stage is varactor tripler that consists basically of three tuned circuits. Output circuit is double-tuned to 240 MHz using capacitive coupling. Idler circuit is series-tuned to 160 MHz. Input circuit is double-tuned to 80 MHz and uses capacitive coupling, with primary coil tapped to provide proper collector loading. Book gives winding data for all coils.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-8-2.



225–400 MHZ POWER AMPLIFIER—Uses low-pass L-C ladder networks for impedance transformation. With 6 W drive, provides 17 W output power across entire band with total output variation of 0.5 dB.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 350.

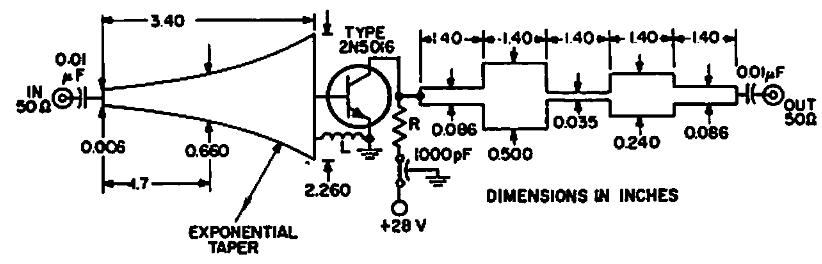
C_c = 2000 pF
C_1, C_6 = 7.5 pF
C_2 = 10 pF
C_3 = 1.5 to 30 pF (Johanson type or equiv.)
C_4 = 26.5 pF
C_5 = 17.5 pF
C_7 = 26.5 pF
L_1 = 4.5 nH
L_2 = 14 nH (includes inductance of input coupling capacitor C_c)
L_3 = 8.5 nH
L_4 = 5.6 nH
L_5 = 10 nH
L_6 = 19.5 nH (includes inductance of output coupling capacitor C_c)

Note:
All fixed components measured at 400 MHz

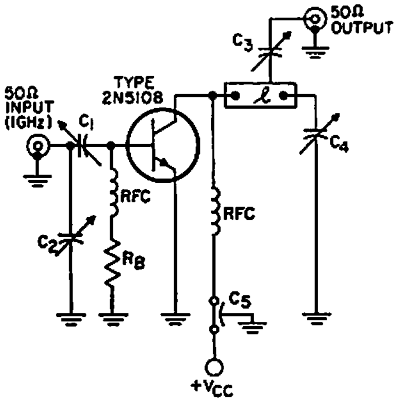


C_1 = variable capacitor, high-quality, double-bearing type, Miller 23100 or 23050 or equivalent (See Table VII for value)
C_2 = 25-picofarad air-type trimmer capcitor; Hammarlund APC-25 or equivalent
C_3 C_4 C_5 C_6 = silver mica capacitors, 300 volts (See Table VII for values)
C_7 = 2200 picofarads, 300 volts, silver mica
C_8 = 0.05 picofarad, 50 volts or greater, ceramic disc
C_9 = 0.1 picofarad, 50 volts or greater, ceramic disc
C_{10} C_{11} = 1500 picofarads, 500 volts, feedthrough type
C_{12} = 0.025 microfarad, 50 volts or greater, ceramic disc
CR_1 = silicon rectifier, type 1N914
J_1 = coaxial connector, chassis-mount vhf type
L_1 = (See Table VII for values)
L_2 = 2.5 millihenries, minature rf choke, iron core, Millen J300-2500 or equivalent
Q_1 = MOS field effect transistor, type 3N128
Q_2 = transistor, RCA 40245
Q_3 = transistor, RCA SK3020
R_1 = 22,000 ohms, 1/2 watt, 10%
R_2 = 12,000 to 47,000 ohms, 1/2 watt, 10%; select for 2-volt peak output
R_3 = 12,000 ohms, 1/2 watt, 10%
R_4 = 820 ohms, 1/2 watt, 10%
R_5 = 47,000 ohms, 1/2 watt, 10%
R_6 = 240 ohms, 1/2 watt, 10%

VFO—Variable-frequency oscillator is basically Colpitts type, covering 1.75 to 9 MHz in five ranges each having different values for L1 and C1-C6. Each range is bandspread over almost all of tuning dial, for accurate calibration and resettability. Can be used with fixed or mobile amateur radio transmitter. Book gives construction details and values for all ranges.—"Hobby Circuits Manual," RCA, Harrison, N.J., HM-90, p 144.

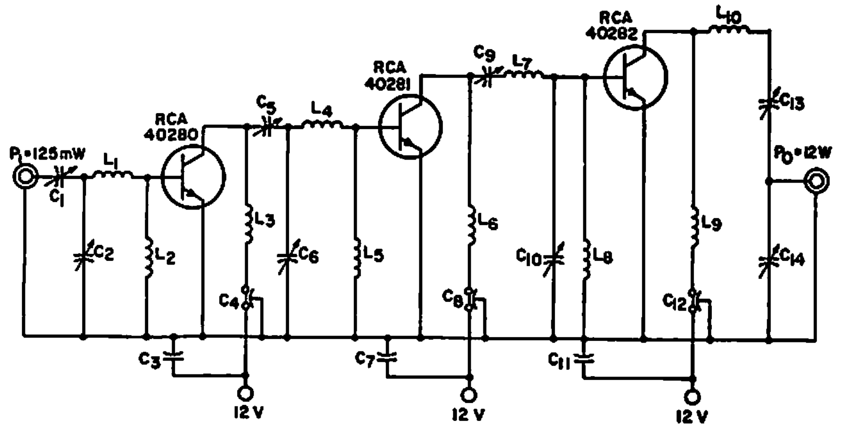

3.40
TYPE 2N5016
1.40
1.40
1.40
1.40
1.40
0.01 µF
IN 50Ω
0.01 µF
OUT 50Ω
0.006
0.660
L
R
0.086
0.500
0.035
0.240
0.086
1000pF
1.7
2.260
+28 V
DIMENSIONS IN INCHES
EXPONENTIAL TAPER

200–400 MHZ MICROSTRIPLINE AMPLIFIER—With 5 W drive, delivers 15 W across entire band with less than 1.5 dB output variation.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 349.

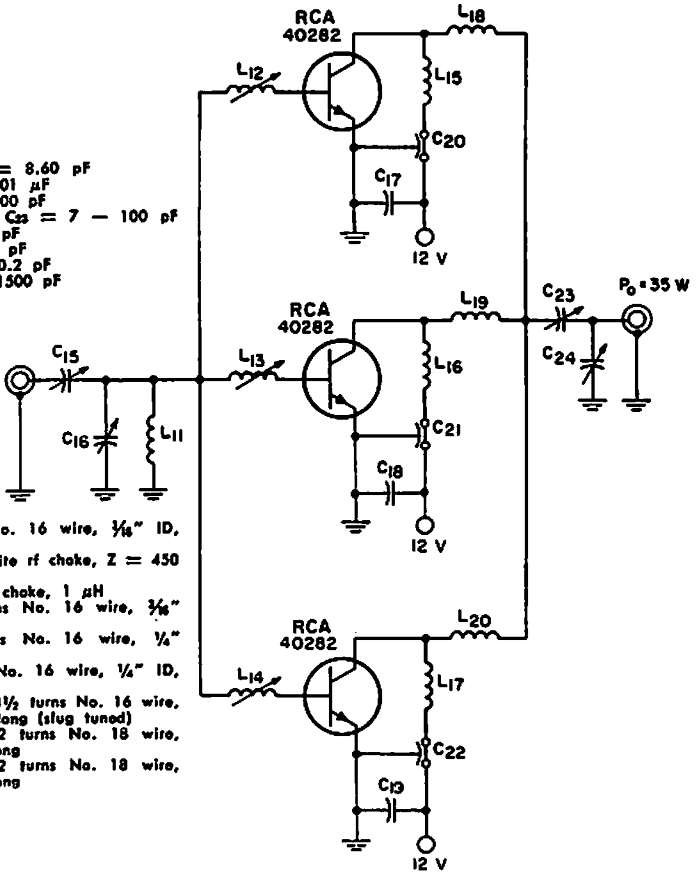

50Ω OUTPUT
C3
TYPE 2N5108
l
50Ω INPUT (1GHz)
C1
C4
RFC
RFC
C2
RB
C5
+VCC

C_1, C_2, C_3, C_4 = Variable capacitor, 0.3 to 3.5 pF, Johanson piston type or equiv.
C_5 = 420 pF, feedthru
l = As described in text
R_B = 2.7 ohms, ¼ W
RFC = 0.1 µH

1-GHZ 1-W AMPLIFIER—Emitter is directly connected to ground plane of stripline circuit board. Power gain is 6 dB.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 361.

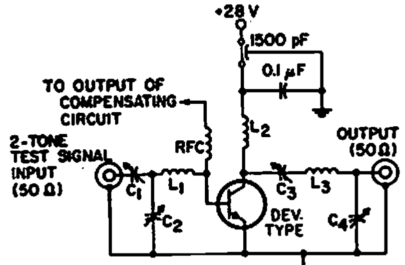

RCA 40282
L10
C9
L7
RCA 40281
C13
C5
L4
RCA 40280
P1=125mW
L1
Po=12W
C1
L3
C2
L2
C6
L5
L6
C10
L8
L9
C14
C4
C8
C12
C3
C7
C11
12 V
12 V
12 V

C_1 = 3.35 pF
C_2, C_6, C_{10}, C_{24} = 8.60 pF
C_3, C_7, C_{11} = 0.01 µF
C_4, C_8, C_{12} = 1500 pF
C_5, C_{10}, C_{13}, C_{14}, C_{23} = 7 — 100 pF
C_9 = 14 — 150 pF
C_{15} = 1.5 — 20 pF
C_{17}, C_{18}, C_{19} = 0.2 pF
C_{20}, C_{21}, C_{22} = 1500 pF


RCA 40282
L18
L12
L15
C20
C17
12 V
RCA 40282
L19
C23
Po=35 W
C15
L13
L16
C24
C16
L11
C21
C18
12 V
RCA 40282
L20
L14
L17
C22
C19
12 V

L_1 = 2 turns No. 16 wire, $\frac{3}{16}$" ID, ¼" long
L_2, L_5, L_8 = ferrite rf choke, Z = 450 ohms
L_3, L_6, L_{11} = rf choke, 1 µH
L_4, L_7 = 3 turns No. 16 wire, $\frac{3}{16}$" ID, ¼" long
L_9 = 1½ turns No. 16 wire, ¼" ID, ⅜" long
L_{10} = 2 turns No. 16 wire, ¼" ID, $\frac{5}{16}$" long
L_{12}, L_{13}, L_{14} = 3½ turns No. 16 wire, ¼" ID, 3'8" long (slug tuned)
L_{15}, L_{16}, L_{17} = 2 turns No. 18 wire, ⅛" ID, ⅛" long
L_{18}, L_{19}, L_{20} = 2 turns No. 18 wire, ¼" ID, ¼" long

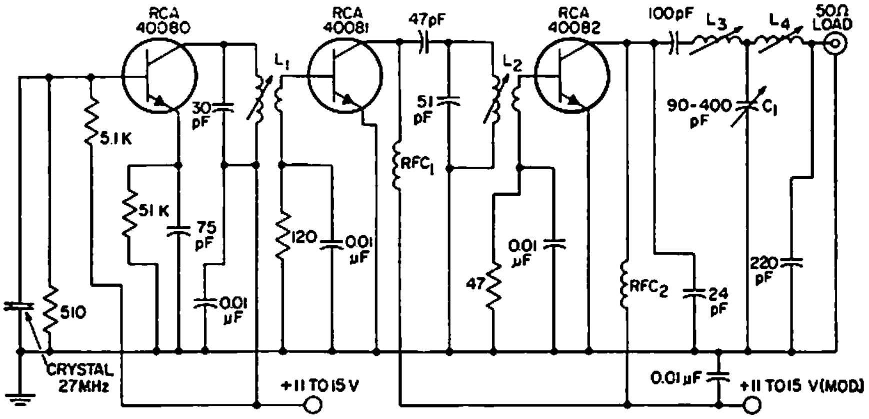
175-MHZ 35-W POWER AMPLIFIER—Incorporates matching networks and techniques for avoiding low-frequency oscillation when operating from 12-V battery for mobile radio application.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 309.


+28 V
1500 pF
0.1 µF
TO OUTPUT OF COMPENSATING CIRCUIT
L2
RFC
2-TONE TEST SIGNAL INPUT (50 Ω)
OUTPUT (50Ω)
C1
L1
C3
L3
C2
DEV. TYPE
C4

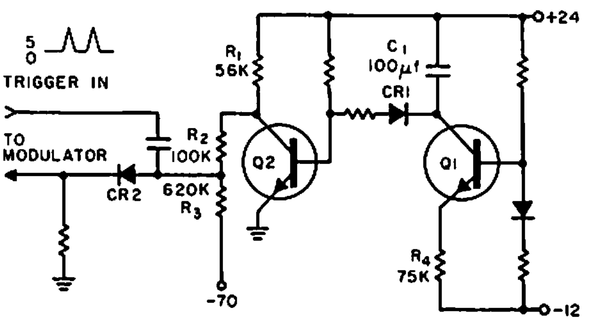
C_1 = Arco 426 or equiv.
C_2 = Arco 427 or equiv.
C_3 = 80-480 pF, Arco 469 or equiv.
C_4 = 140-680 pF, Arco 466 or equiv.
L_1 = 3 turns No. 14 wire, ¼" ID, ½" long
L_2 = 3 turns No. 10 wire, ½" ID, ⅜" long
L_3 = 3-½ turns No. 10 wire, ⅝" ID, ½" long

30-MHZ NARROW-BAND 100-W AMPLIFIER—Developed for use with 28-V mobile radio supply. Uses RCA SSB developmental transistor.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 320.

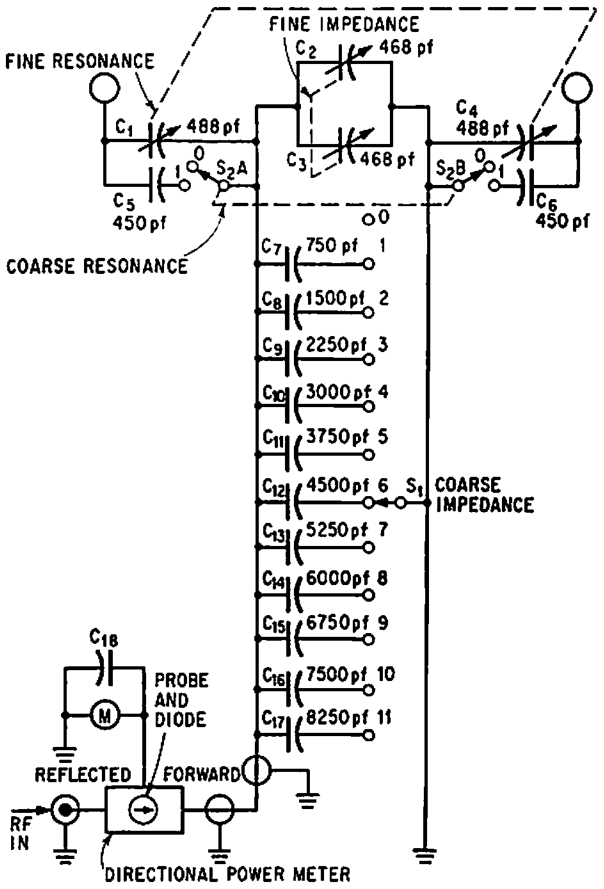
27-MHZ CB TRANSMITTER—Straightforward design consists of modulator and transmitter. Number of tuning components is minimized. One section of double-pi network is peaked for maximum output, and the other is adjusted to limit of 5 W d-c input to final amplifier, as required by FCC.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 304.

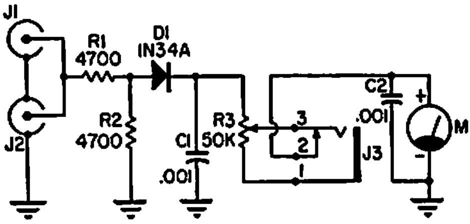

RCA 40080
RCA 40081
RCA 40082
47pF
100pF
L1
L2
L3
L4
50Ω LOAD
30 pF
51 pF
90-400 pF
C1
5.1K
51K
75 pF
RFC1
120
0.01 μF
0.01 μF
0.01 μF
47
RFC2
24 pF
220 pF
510
CRYSTAL 27MHz
+11 TO 15 V
0.01μF
+11 TO 15 V(MOD)

C1 = Arco No. 429 or equiv.
L1 = 14:3 turns No. 22 wire, ¼" CTC coil form with "green dot" core, 0.75-1.2 μH, Q = 100
L2 = 14:2¾ turns No. 22 wire, ¼" CTC coil form with "green dott' core, 0.75-1.2 μH, Q = 100
L3 = 11 turns No. 22 wire, ¼" CTC coil form with "green dot" core, 0.5-0.9 μH, Q = 120
L4 = 7 turns No. 22 wire, ¼" CTC coil form with "green dot" core, 0.21-0.34 μH, Q = 140
RFC1, RFC2 = 15 μH, Millor No. 4624 or equiv.


5
0
TRIGGER IN
TO MODULATOR
CR2
R1 56K
R2 100K
620K R3
C1 100μf
CR1
Q2
Q1
R4 75K
+24
-70
-12

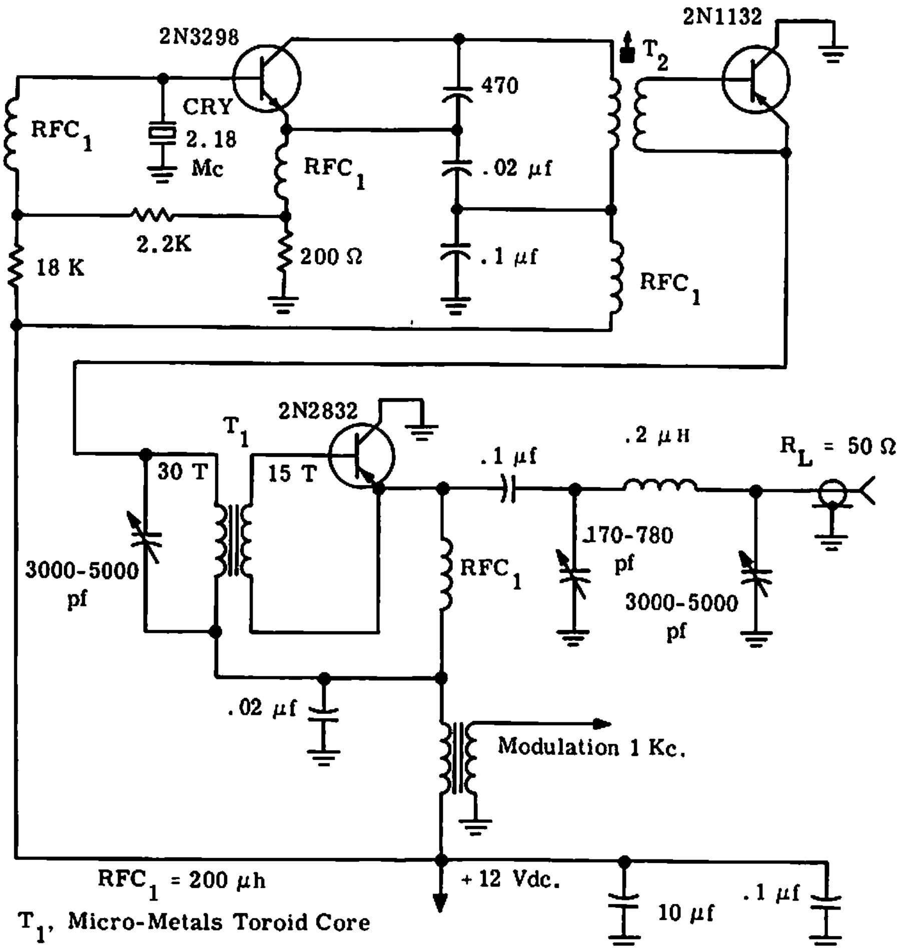
60-S TRANSMITTER WARM-UP—Allows filaments in pulse-modulated transmitter to warm up before modulation pulses are applied. Transistor types are not critical. Article gives time delay equation. With silicon transistors and tantalum capacitors, circuit operates from −55 to +85C.—E. Rosenbaum, Sixty-Second Timer Allows Transmitter Warm-Up, *Electronic Design*, Jan. 20, 1964, p 82.


FINE IMPEDANCE
FINE RESONANCE
C2 468 pf
C1 488 pf
C3 468 pf
C4 488 pf
S2A
S2B
C5 450pf
C6 450pf
COARSE RESONANCE
C7 750 pf 1
C8 1500pf 2
C9 2250pf 3
C10 3000pf 4
C11 3750pf 5
C12 4500pf 6
S1 COARSE IMPEDANCE
C13 5250pf 7
C14 6000pf 8
C15 6750pf 9
C16 7500pf 10
C17 8250pf 11
C18
M
PROBE AND DIODE
REFLECTED
FORWARD
RF IN
DIRECTIONAL POWER METER


J1
J2
R1 4700
D1 IN34A
R2 4700
C1 .001
R3 50K
C2 .001
J3
M1

CITIZENS BAND TUNING MONITOR—Miniature illuminated S meter M1 peaks when CB transmitter has good modulation and is tuned for maximum r-f output. Monitor can be permanently connected to transmission line. Book gives construction details.—H. Friedman, CB Tuning Monitor, "Bench-Tested Communications Projects," Hayden Book Co., N.Y., p 48–50.

MATCHING VERTICAL LOOP—Depends on switching of low-loss fixed mica capacitors and variable air-dielectric capacitors instead of customary taps or links. High-impedance, low-value capacitor is divided into two equal sections to provide close balance with respect to ground and thereby permit higher voltages. Used with equilateral octagonal portable vertical loop antenna having 5-foot sides, in jungle locations where minimum height of conventional long-wire, dipole, or rhombic antenna would have to be at least 40 feet for comparable performance. Will work in ham bands if military-quality capacitors can be obtained.—K. H. Patterson, Down-To-Earth Army Antenna, *Electronics*, Aug. 21, 1967, p 111–114.


2N3298
2N1132
T$_2$
RFC$_1$
CRY
2.18
Mc
470
RFC$_1$
.02 µf
2.2K
18 K
200 Ω
.1 µf
RFC$_1$
2N2832
T$_1$
30 T
15 T
.1 µf
.2 µH
R$_L$ = 50 Ω
3000-5000
pf
RFC$_1$
170-780
pf
3000-5000
pf
.02 µf
Modulation 1 Kc.
+12 Vdc.
10 µf
.1 µf

RFC$_1$ = 200 µh

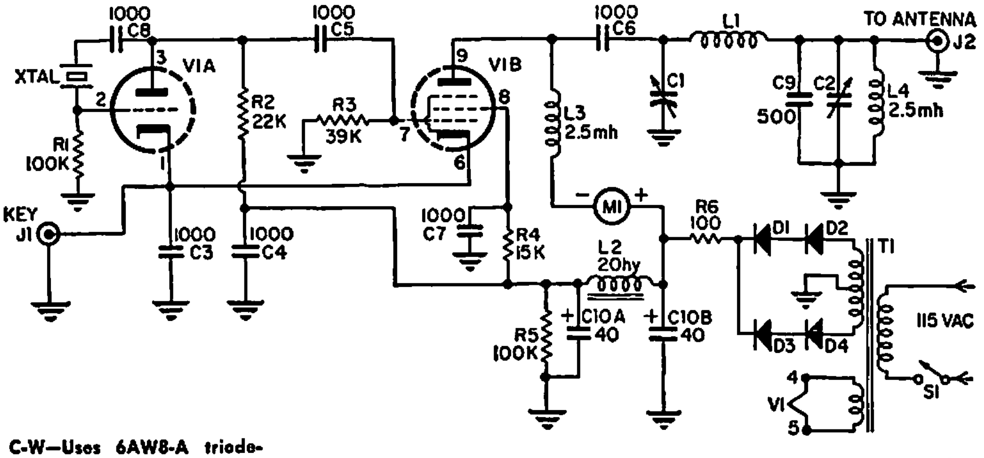
T$_1$, Micro-Metals Toroid Core

T-50-2 Bifilar

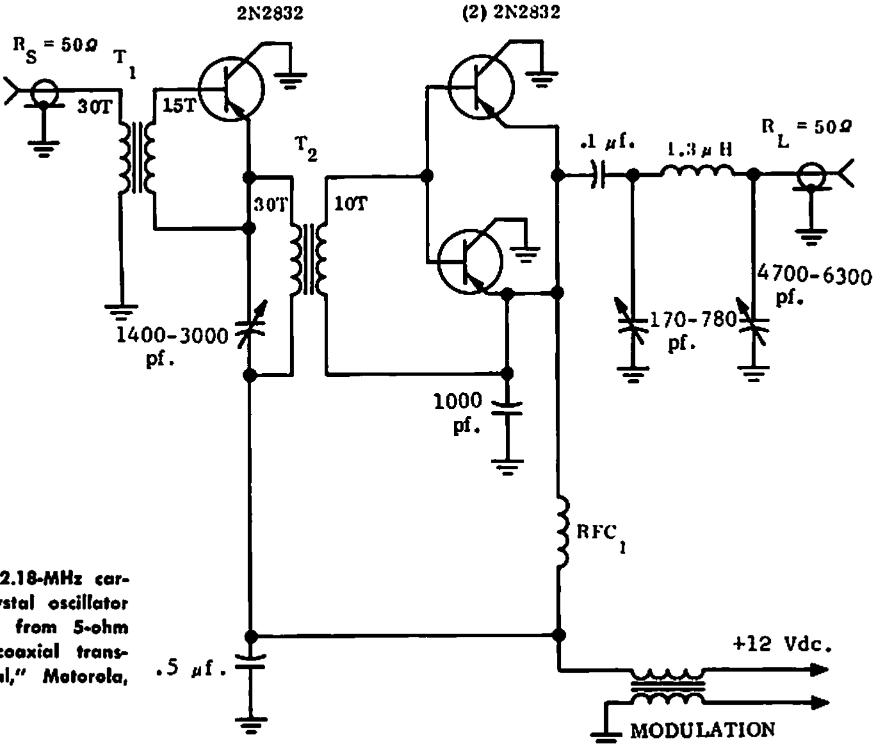
T$_2$, Pri. 40 T, #28, 1/4" ID Slug Tuned Form

Sec. 8 T, #28, Wound over Pri.

20 W AT 2.18 MHz—Designed for marine-band radiotelephone use. Consists of crystal oscillator, driver, and output stage. Requires 7-W modulation power from 10-ohm source.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-1-2.


1000
C8
XTAL
3
VIA
2
1
R1
100K
KEY
J1
1000
C3
1000
C4
R2
22K
1000
C5
R3
39K
9
VIB
8
7
6
1000
C7
R4
15K
1000
C6
L1
TO ANTENNA
J2
C1
L3
2.5mh
C9
500
C2
L4
2.5mh
M1
R6
100
D1
D2
T1
L2
20hy
C10A
40
C10B
40
R5
100K
D3
D4
115 VAC
S1
4
V1
5

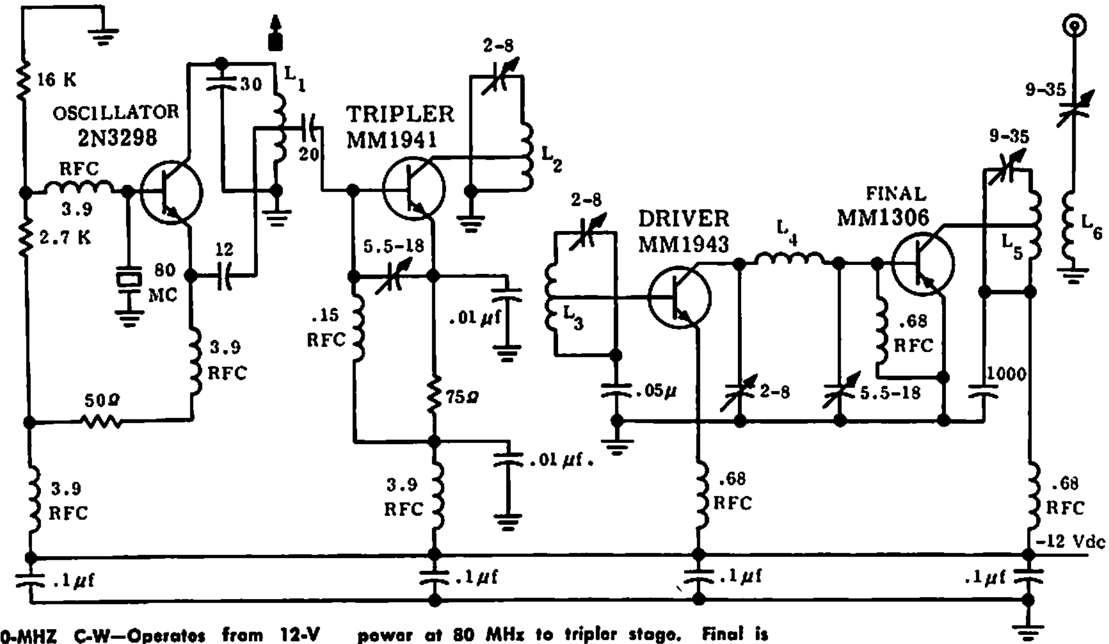
5-W ONE-TUBE C-W—Uses 6AW8-A triode-pentode. Can be operated on 160, 80, 40, and 20 meter bands, by using appropriate crystal frequency and appropriate plug-in coils for L1. Diodes D1-D4 are 750-mA 400-piv silicon. C1 is 10—365 µµF and C2 is 100—580 µµF mica trimmer. Book gives complete construction details.—E. N. Noll, One-Tube 5-Watter, "Bench-Tested Communications Projects," Hayden Book Co., N.Y., p 31—33.


2N2832
(2) 2N2832
R_S = 50Ω
T1
30T
15T
T2
30T
10T
1400-3000 pf.
.1 μf.
1.3 μH
R_L = 50Ω
4700-6300 pf.
170-780 pf.
1000 pf.
RFC1
+12 Vdc.
.5 μf.
MODULATION

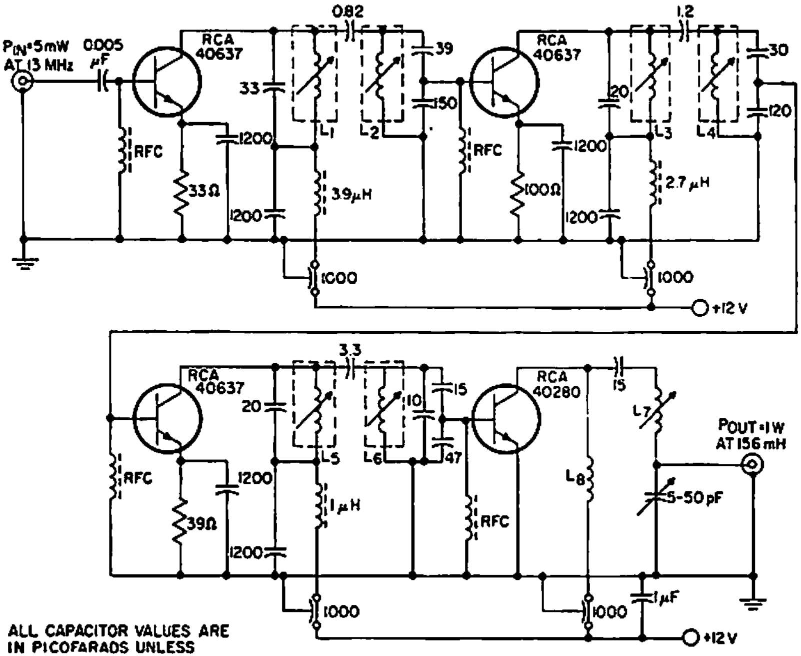
$RFC_1 = 200\mu H$

T_1, T_2, Micro-Metals Toroid Core T-50-2 Bifilar

40 W at 2.18 MHZ—Requires 2.18-MHz carrier signal from standard crystal oscillator and 18-W modulation power from 5-ohm source. Feeds into 50-ohm coaxial transmission line.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-1-4.


16 K
OSCILLATOR
2N3298
RFC
3.9
2.7 K
80 MC
30
L1
20
12
3.9 RFC
50Ω
3.9 RFC
.1μf
TRIPLER
MM1941
2-8
L2
5.5-18
.15 RFC
.01μf
75Ω
.01μf.
3.9 RFC
.1μf
2-8
DRIVER
MM1943
L3
.05μ
L4
2-8
5.5-18
.68 RFC
.1μf
FINAL
MM1306
9-35
9-35
L5
L6
.68 RFC
1000
.68 RFC
-12 Vdc
.1μf

0.5-W 240-MHZ C-W—Operates from 12-V storage battery with total current drain of 180 mA. Oscillator is common-base crystal-controlled Hartley delivering about 15 mW of power at 80 MHz to tripler stage. Final is zero-biased class C loaded by double-tuned close-coupled transformer with impedances ranging from 25 to 100 ohms. Book gives winding data for all coils.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-7-2.


P$_{IN}$=5mW AT 13 MHz
0.005 μF
RCA 40637
0.82
39
33
150
L1
L2
RFC
1200
33Ω
1200
3.9μH
1000
RCA 40637
1.2
30
120
120
L3
L4
RFC
1200
100Ω
1200
2.7μH
1000
+12 V
RCA 40637
3.3
20
15
10
47
L5
L6
RFC
1200
39Ω
1200
1μH
1000
RCA 40280
15
L7
L8
RFC
POUT=1W AT 156 mH
5-50 pF
1000
1μF
+12 V

ALL CAPACITOR VALUES ARE IN PICOFARADS UNLESS OTHERWISE SPECIFIED

ALL RESISTORS 1/4 W

L_1, L_2 = 10½ turns No. 22 enamel wire, closewound, 10/32" slug tuned coil forms 15/64" OD, shield can ½" x ½" x 1"; slug = carbonyl S.F. or equiv.

L_3, L_4 = 4½ turns No. 22 enamel wire, closewound, 10/32" slug tuned coil forms 15/64" OD, shield can ½" x ½" x 1"; slug = carbonyl S.F. or equiv.

L_5, L_6 = 1½ turns No. 20 B.T., ¼" long, closewound, 10/32" slug tuned coil forms 15/64" OD, shield can ½" x ½" x 1"; slug-carbonyl S.F. or equiv.

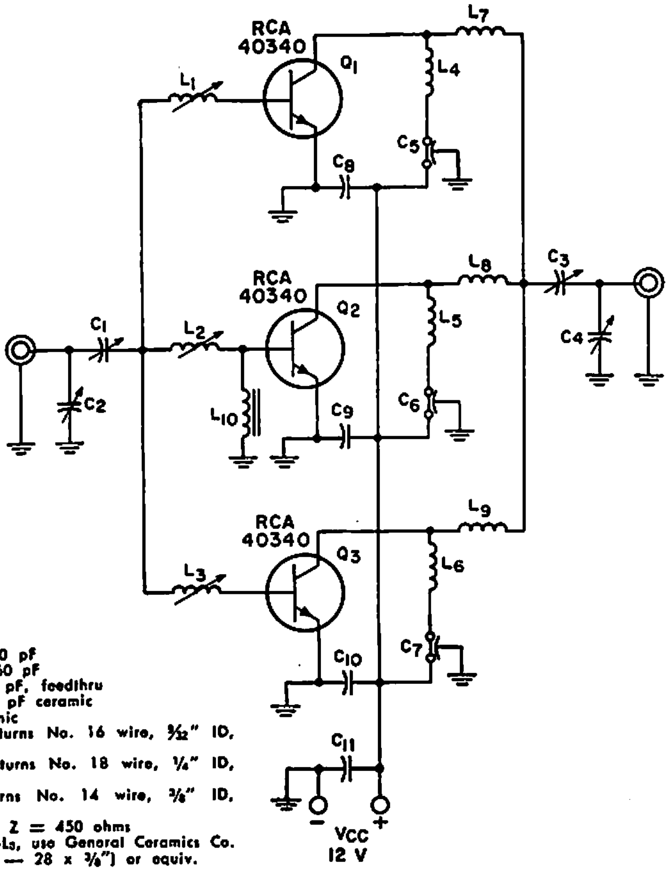
L_7 = 2½ turns No. 20 B.T., ¼" long, closewound, 10/32" slug tuned coil forms 15/64" OD, shield can ½" x ½" x 1"; slug = carbonyl S.F. or equiv.

L_8 = 2 turns No. 20 B.T., 3/16" D, 3/16" long

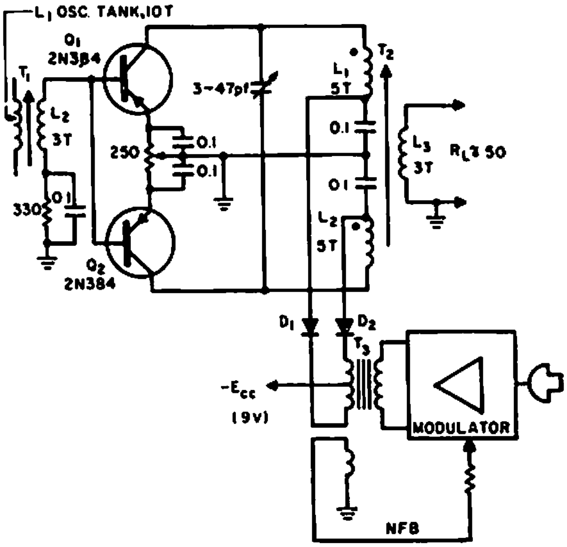
RFC = 4 turns No. 30 enamel wire, ferrite bead, Ferroxcube No. 56-590-65/4B or equiv.

156–174 MHZ MARINE-BAND MULTIPLIER-AMPLIFIER—Delivers 1 W to antenna (maximum power specified by FCC for harbor communications). Can be operated anywhere in band without retuning, simply by changing crystal frequency of exciter section (not shown). Consists of three frequency multiplier stages using 40637 transistors, followed by power amplifier stage.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 297.

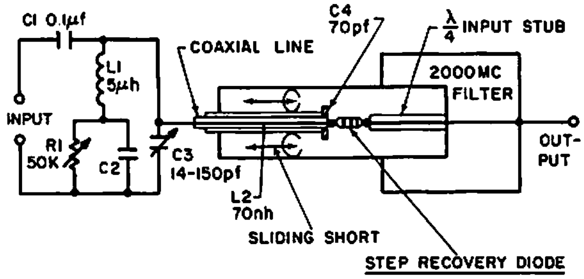
50 W AT 50 MHZ—Operates from 12-V auto storage battery, using three transistors in parallel and three chokes per stage for transient suppression.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 307.


RCA 40340
Q1
L7
L1
L4
C5
C8
RCA 40340
Q2
L8
C3
C1
L2
L5
C4
C2
L10
C6
C9
RCA 40340
Q3
L9
L3
L6
C7
C10
C11
−
VCC
+
12 V

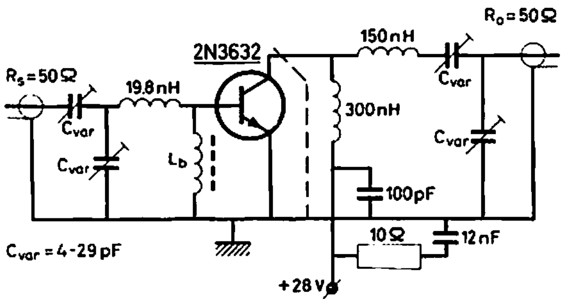
C_1, C_3 = 65 — 340 pF
C_2, C_4 = 100 — 560 pF
C_5, C_6, C_7 = 1000 pF, feedthru
C_8, C_9, C_{10} = 1800 pF ceramic
C_{11} = 0.2 pF ceramic
L_1, L_2, L_3 = 2-½ turns No. 16 wire, 9/32" ID, ¼" long
L_4, L_5, L_6 = 3-½ turns No. 18 wire, ¼" ID, 3/16" long
L_7, L_8, L_9 = 4 turns No. 14 wire, ⅜" ID, ½" long
L_{10} = ferrite choke, Z = 450 ohms
Note: For coils L_1—L_3, use General Ceramics Co. Q_2 material (¼" — 28 x ⅜") or equiv.


L1 OSC. TANK, 10T
Q1
2N384
T1
L2
3T
330
.01
250
0.1
0.1
3-47pf
Q2
2N384
L1
5T
T2
0.1
0.1
L2
5T
L3
3T
RL ≅ 50
D1
D2
T3
-Ecc
(9V)
MODULATOR
NFB

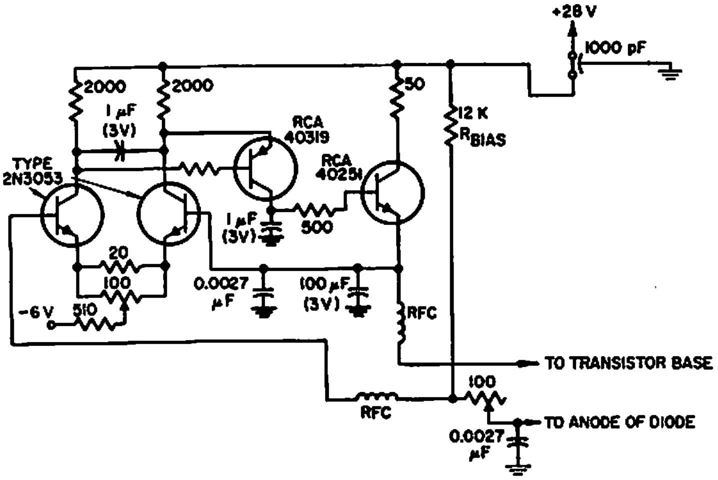
DOUBLE-SIDEBAND CB—Parallel-fed push-pull transistor output stage suppresses carrier of Citizens Band transmitter, giving greater operating range. Used in 100-mW 11-meter transceiver.—L. E. Geisler, Transistor Transmitter Has High-Level DSB Modulation, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 30.

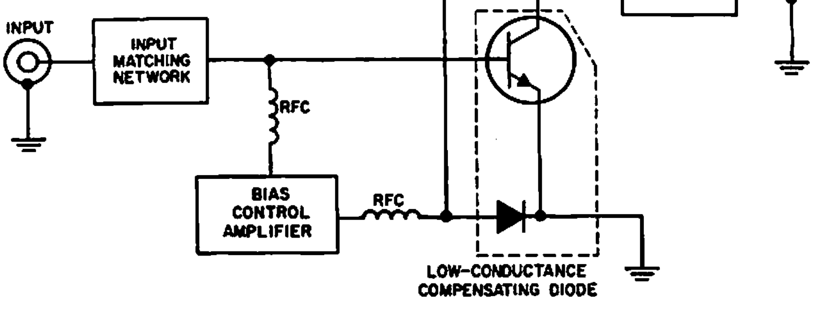

CI 0.1µf
INPUT
LI
5µh
RI
50K
C2
C3
14-150pf
COAXIAL LINE
C4
70pf
λ/4 INPUT STUB
2000MC
FILTER
OUT-
PUT
L2
70nh
SLIDING SHORT
STEP RECOVERY DIODE

S-BAND MULTIPLIER—Use of step recovery diode gives efficiency greater than 10%, which is better than with varactor diode as frequency multiplier. Article gives circuit design criteria. Output filter is six-resonator interdigital structure with 20-MHz bandwidth and 2-dB insertion loss. Input of 100 MHz is multiplied 20 times to give 2 GHz output.—R. Hall, Harmonic Generators: Is the Step Recovery Diode Best?, *Electronic Design*, Jan. 18, 1965, p 28–33.

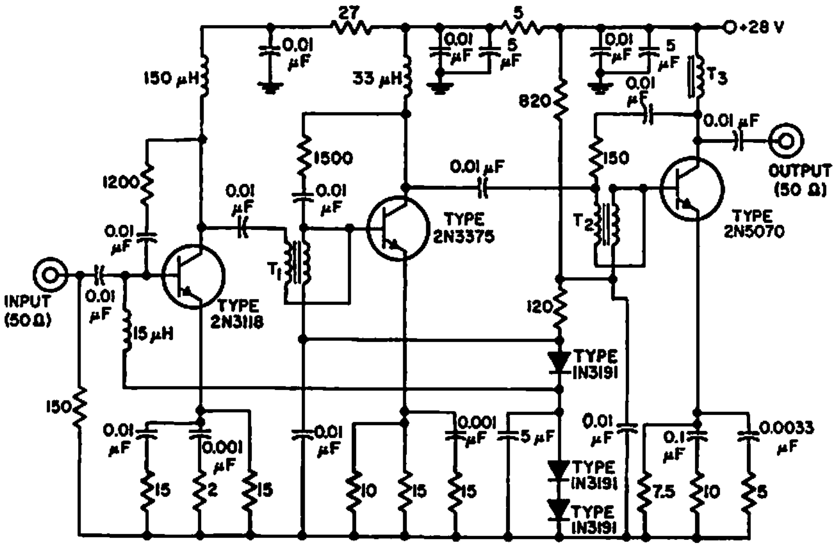

Rs=50Ω
Cvar
19.8nH
Cvar
Lb
2N3632
150nH
Cvar
R0=50Ω
300nH
Cvar
100pF
10Ω
12nF
Cvar = 4-29pF
+28V

175-MHZ POWER AMPLIFIER—Circuit is example of design procedure for optimizing input and output matching networks for r-f power transistor. Maximum power output is 13.5 W. Causes and cures for spurious oscillations are covered. Appendix gives derivations of design equations.—J. Mulder, On the Design of Transistor R. F. Power Amplifiers, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 27, No. 4, 1966–1967, p 155–171.


+28V
1000 pF
2000
2000
1µF
(3V)
TYPE
2N3053
RCA
40319
RCA
40251
50
12 K
RBIAS
1µF
(3V)
500
20
100
-6V
510
0.0027
µF
100µF
(3V)
RFC
TO TRANSISTOR BASE
RFC
100
TO ANODE OF DIODE
0.0027
µF


RFC
RBIAS
OUTPUT
OUTPUT
MATCHING
NETWORK
INPUT
INPUT
MATCHING
NETWORK
RFC
BIAS
CONTROL
AMPLIFIER
RFC
LOW-CONDUCTANCE
COMPENSATING DIODE

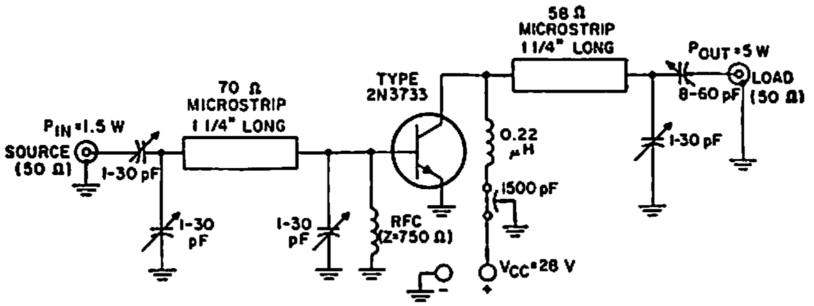
30-MHZ LINEAR AMPLIFIER—Output voltage of d-c differential amplifier serves as bias source for power transistor. Two additional stages provide current amplification, with negative feedback for stability. Uses RCA SSB developmental transistor-diode package (shown in accompanying block diagram) for temperature compensation, to give reliable operation over wide temperature range as class AB amplifier.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 318.


27
5
+28 V
0.01 µF
0.01 µF
5 µF
0.01 µF
5 µF
150 µH
33 µH
820
T3
0.01 µF
0.01 µF
OUTPUT (50 Ω)
1500
150
0.01 µF
1200
0.01 µF
0.01 µF
TYPE 2N3375
TYPE 2N5070
T2
0.01 µF
T1
INPUT (50Ω)
0.01 µF
TYPE 2N3118
15 µH
120
TYPE IN3191
150
0.01 µF
0.001 µF
0.01 µF
0.001 µF
5 µF
0.01 µF
0.1 µF
0.0033 µF
15
2
15
10
15
15
TYPE IN3191
TYPE IN3191
7.5
10
5

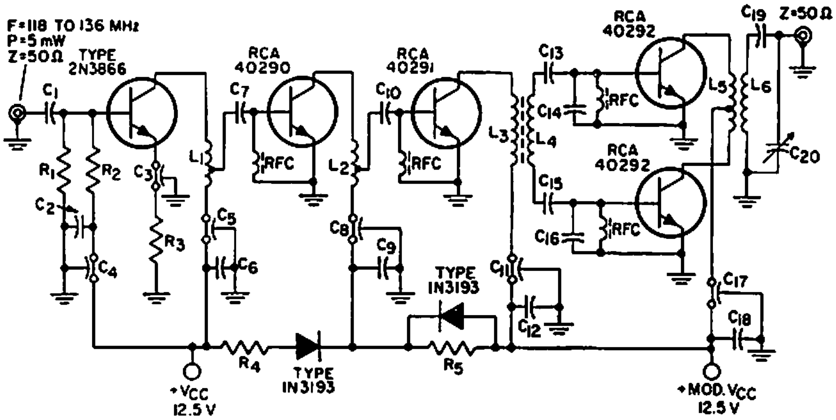
2–30 MHZ LINEAR POWER AMPLIFIER—Wideband amplifier has power gain of over 40 dB and delivers 5 W pep output for 28-V mobile applications.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 321.

T_1, T_2 = 18 turns twisted pair, No. 28 enamel wire on Q_1 CF 102 form

T_3 = 50 turns No. 30 enamel wire on CF 102 Q_1 form

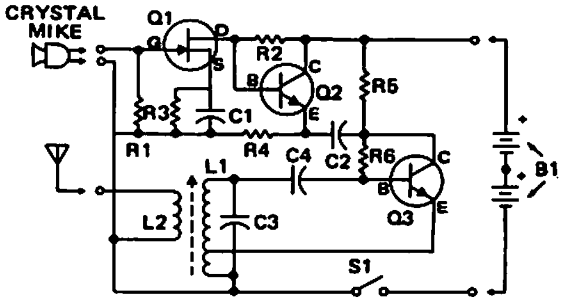

58 Ω MICROSTRIP 1 1/4" LONG
POUT = 5 W
LOAD (50 Ω)
8-60 pF
70 Ω MICROSTRIP 1 1/4" LONG
TYPE 2N3733
PIN = 1.5 W
SOURCE (50 Ω)
1-30 pF
0.22 µH
1-30 pF
1500 pF
1-30 pF
1-30 pF
RFC (Z=750 Ω)
VCC = 28 V
-
+

375-MHZ STRIPLINE AMPLIFIER—Delivers 5 W for military a-m voice communication systems. Transmission-line elements are constructed from 1/32-inch Teflon fiberglass microstrip board. Ferrite choke in transistor base return provides low-frequency stability.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 347.


F = 118 TO 136 MHz
P = 5 mW
Z = 50 Ω
TYPE 2N3866
RCA 40290
RCA 40291
RCA 40292
RCA 40292
C19
Z = 50 Ω
C1
C7
C10
C13
C14
RFC
L5
L6
L1
RFC
L2
RFC
L3
L4
C20
R1
R2
C3
C15
C16
RFC
C2
C5
C8
C9
R3
C6
C4
TYPE IN3193
C11
C12
C17
C18
R4
TYPE IN3193
R5
+VCC 12.5 V
+MOD. VCC 12.5 V

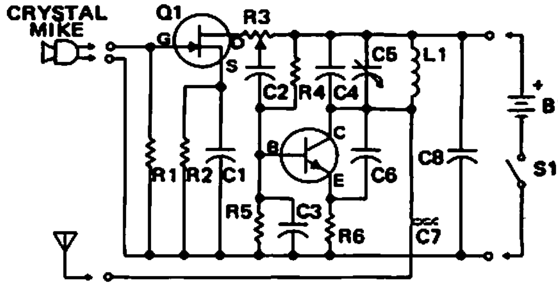
118–136 MHZ AIRCRAFT RADIO TRANSMITTER—Requires no retuning for band coverage. Push-pull output stage delivers 40 W pep. All stages are amplitude-modulated.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 329.

C_1 = 330 pF, Arco S.M. or equiv.
C_2 = 0.005 µF, ceramic
C_3, C_4, C_5, C_8, C_{11}, C_{17} = 1000 pF, feedthru
C_6, C_9, C_{12}, C_{18} = 0.05 µF, ceramic
C_7 = 50 pF, 5%, Arco S.M., or equiv.
C_{10}, C_{13}, C_{15} = 82 pF, 5%, Arco S.M., or equiv.
C_{14}, C_{16}, C_{19} = 150 pF, 5%, Arco S.M., or equiv.
C_{20} = Variable capacitor, 8-to-60 pF, Arco 404 or equiv.
L_1 = 7 turns No. 22 wire, 13/64" ID, 9/16" long, tapped at 1.5 turns
L_2 = 5½ turns No. 22 wire, 13/64" ID, close wound, tapped at 2 turns
L_3 = 6 turns No. 22 wire, 13/64" ID, interwind with L_4 on IRN-9 core material
L_4 = 4 turns No. 22 wire, 13/54" ID, interwind with L_3 on IRN-9 core material
L_5 = 5 turns No. 22 wire, 13/64" ID, center-tapped, interwind with L_6
L_6 = 5 turns No. 22 wire, 13/64" ID, interwind with L_5
RFC = 1 turn No. 28 wire, ferrite bead, Ferroxcube No. 56-590-65/48 or equiv.


CRYSTAL MIKE
Q1
G
D
S
R2
B
C
Q2
E
R5
R3
C1
R1
R4
C4
C2
R6
C
B
Q3
E
L1
L2
C3
S1
B1
+
+

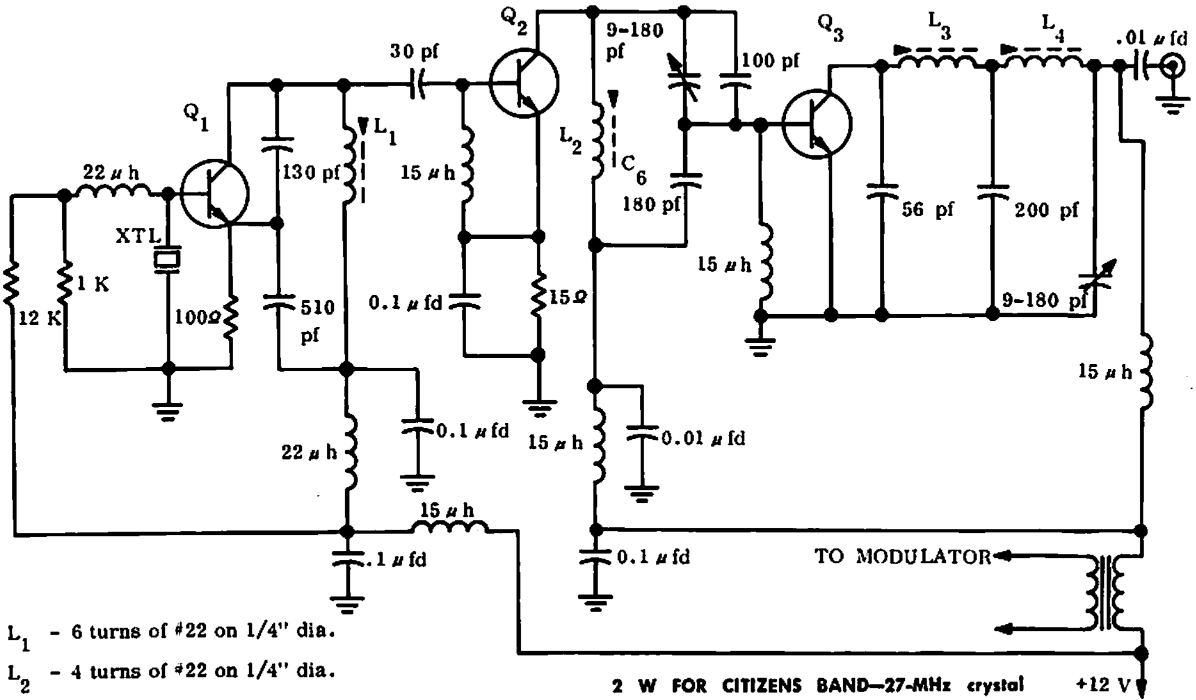
Q1	Field Effect Transistor	HEP 802
Q2,Q3	NPN Silicon Transistor	
R1	1,000,000 Ω Resistor ½ Watt 10%	
R2,R4	22,000 Ω Resistor ½ Watt 10%	
R3	4,700 Ω Resistor ½ Watt 10%	
R5	47,000 Ω Resistor ½ Watt 10%	
R6	470,000 Ω Resistor ½ Watt 10%	
C1,C2	10 µFD 12 Volt Electrolytic	
C3	220 PF Disc Ceramic	
C4	10 PF MICA	

A-M WIRELESS TRANSMITTER—High impedance of fet input stage of audio amplifier provides proper match with crystal mike. Driver Q2 modulates Hartley oscillator Q2 for feeding short antenna wire connected to four turns of hookup wire wound around adjustable ferrite antenna coil L1. Operates from two 9-V transistor radio batteries in series. Tune a-m radio to quiet spot, then adjust L1 until voice at mike is picked up. Range is one or two rooms in home.—"Calectro Handbook," GC Electronics, Rockford, Ill., FR-69-C, p 46.


CRYSTAL MIKE
Q1
G
D
S
R3
C2
R4
C4
C5
L1
+
B1
S1
R1
R2
C1
B
C
E
C6
C8
R5
C3
R6
C7

Q1	Transistor, FET, N Channel	HEP 802
Q2	NPN Silicon Transistor	HEP 55
R1	1 MEG Ω Resistor ½ Watt 10%	
R2,R5	4,700 Ω Resistor ½ Watt 10%	
R3	10,000 2 Trim Pot	
R4	10,000 Ω Resistor ½ Watt 10%	
R6	330 Ω Resistor ½ Watt 10%	
C1,C2	10 µFD 12V Electrolytic	
C3	0.01 µFD Disc Ceramic Capacitor	
C4	10 µFD MICA Capacitor	
C5	1.5-7.5 PF Variable Capacitor	
C6	10 PFD MCA Capacitor	

F-M WIRELESS TRANSMITTER—High impedance of fet input stage of audio amplifier provides proper match with crystal mike. Q1 frequency-modulates single-transistor oscillator tunable over 88—108 MHz f-m band. L1 is four turns of wire wound on pencil and spaced half-inch apart. C7 is two short pieces of insulated wire twisted together, C8 is 0.01-µF disc capacitor, and B1 is 9-V transistor radio battery. Normal setting of modulation control R3 is mid-position. Tune f-m receiver to quiet spot, then adjust C5 until voice at mike is heard.—"Calectro Handbook," GC Electronics, Rockford, Ill., FR-69-C, p 46.


Q_2
30 pf
9-180 pf
100 pf
Q_3
L_3
L_4
.01 µfd
Q_1
L_1
130 pf
15 µh
L_2
C_6
180 pf
22 µh
XTL
1 K
12 K
100Ω
510 pf
0.1 µfd
15Ω
15 µh
56 pf
200 pf
9-180 pf
15 µh
22 µh
0.1 µfd
15 µh
0.01 µfd
15 µh
.1 µfd
0.1 µfd
TO MODULATOR
+12 V

L_1 - 6 turns of #22 on 1/4" dia.

L_2 - 4 turns of #22 on 1/4" dia.

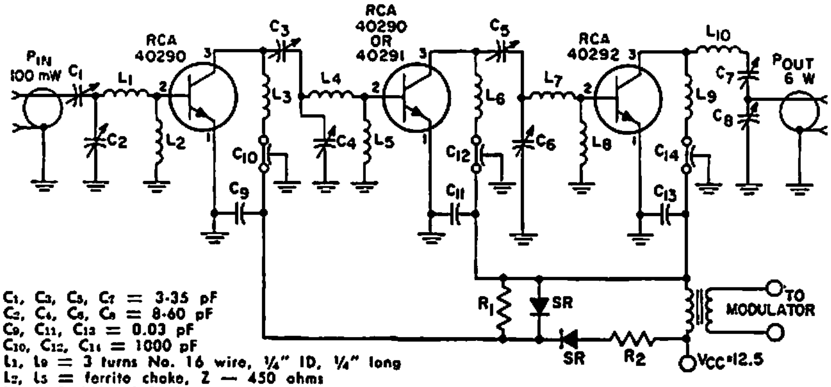
L_3 - 3 turns of #20 on 3/8" dia.

L_4 - 4 turns of #20 on 3/8" dia.

Q_1 & Q_2 Motorola 2N2951

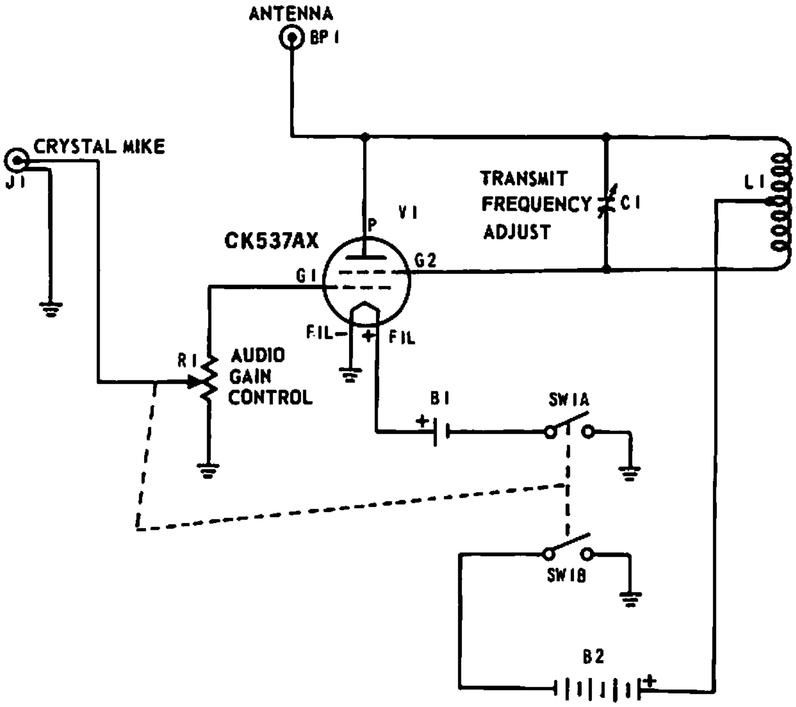
Q_3 Motorola 2N2950

2 W FOR CITIZENS BAND—27-MHz crystal oscillator feeds driver and single-transistor output stage. Requires 1.5 W audio input power to provide minimum of 80% modulation. Modulation distortion is less than 5%. —"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-2-2.

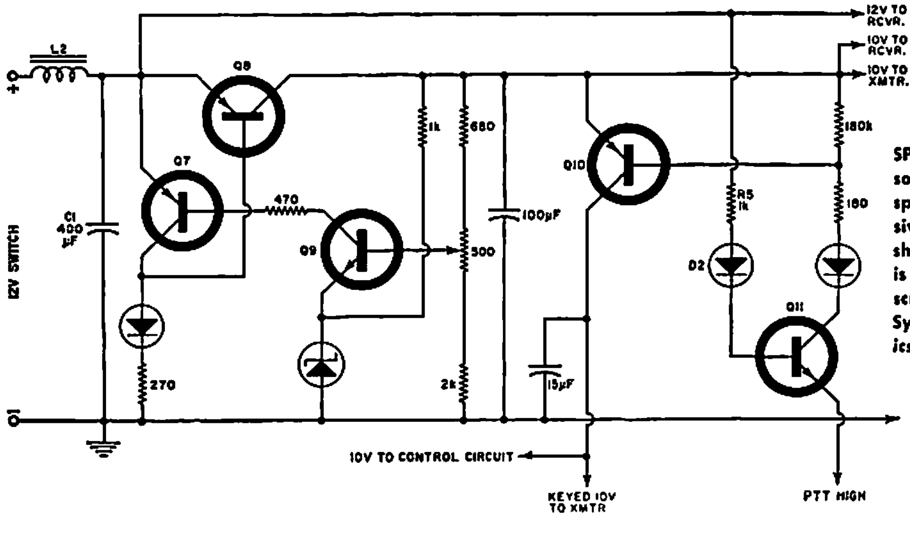

PIN
100 mW
C1
C2
L1
L2
RCA
40290
C3
L3
C10
C9
L4
C4
L5
RCA
40290
OR
40291
C5
L6
C12
C11
C6
L7
L8
RCA
40292
L10
C7
C8
L9
C14
C13
POUT
6 W
R1
SR
SR
R2
TO
MODULATOR
VCC=12.5

C_1, C_3, C_5, C_7 = 3-35 pF
C_2, C_4, C_6, C_8 = 8-60 pF
C_9, C_{11}, C_{13} = 0.03 pF
C_{10}, C_{12}, C_{14} = 1000 pF
L_1, L_9 = 3 turns No. 16 wire, ¼" ID, ¼" long
L_2, L_5 = ferrite choke, Z — 450 ohms
L_3 = rf choke, 1.5 µH
L_4, L_7 = 4 turns No. 16 wire, ¼" ID, ⅜" long
L_6 = rf choke, 1.0 µH
L_8 = wire-wound resistor, R = 2.4 ohms
L_{10} = 5 turns No. 16 wire, ⅜" ID, ½" long
R_1 = 220 ohms
R_2 = 180 ohms
SR = 1N2858A

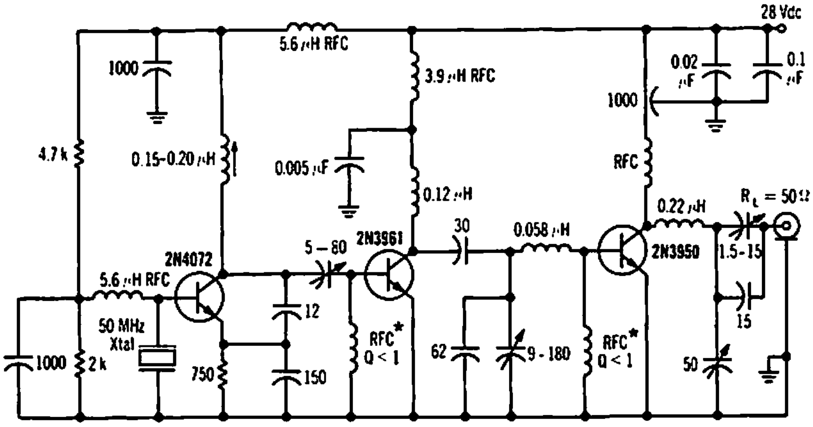
35-MHZ 6-W NARROW-BAND A-M TRANSMITTER—Modulator requires 6 W audio power, because transmitter has total of 12 W d-c input power from 12-V mobile storage battery. Developed for aircraft radio applications.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 327.


ANTENNA
BP 1
CRYSTAL MIKE
J1
CK537AX
P
V1
G1
G2
FIL−
+
FIL
TRANSMIT
FREQUENCY
ADJUST
C1
L1
R1
AUDIO
GAIN
CONTROL
B1
SW1A
SW1B
B2

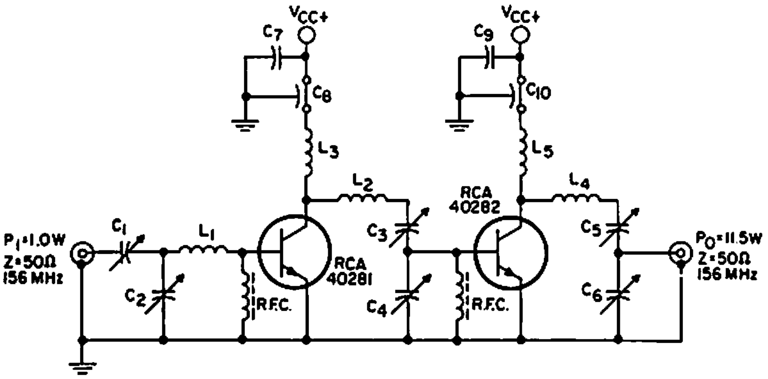
A-M WIRELESS MIKE—Can be operated legally if antenna is no longer than 10 ft. Tune radio to dead spot, then adjust C1 and R1 until voice at mike is heard. Use 1.25-V dry cell for B1 and 45-V or 90-V battery for V2. C1 is 150 pF, R1 750K, and L1 205 turns No. 24 enamel on ⅜-inch coil form.—R. M. Brown, "104 Simple One-Tube Projects," Tab Books, Blue Ridge Summit, Pa., 1969, p 102.


L2
+
12V SWITCH
C1
400
µF
Q8
Q7
470
Q9
270
1k
680
500
2k
100µF
15µF
Q10
R5
1k
D2
180k
180
Q11
12V TO
RCVR.
10V TO
RCVR.
10V TO
XMTR.
10V TO CONTROL CIRCUIT
KEYED 10V
TO XMTR
PTT HIGH

SPIKE REGULATOR—Used in G-E 450-MHz solid-state mobile radio to suppress voltage spikes caused by antenna mismatch, excessive temperature, high input voltage, or short on 12-V transmitter supply. Regulator is part of complete protection system described in article.—C. Smith, A Protection System for Solid-State Transmitters, *Electronics World*, Feb. 1969, p 38–39 and 77.

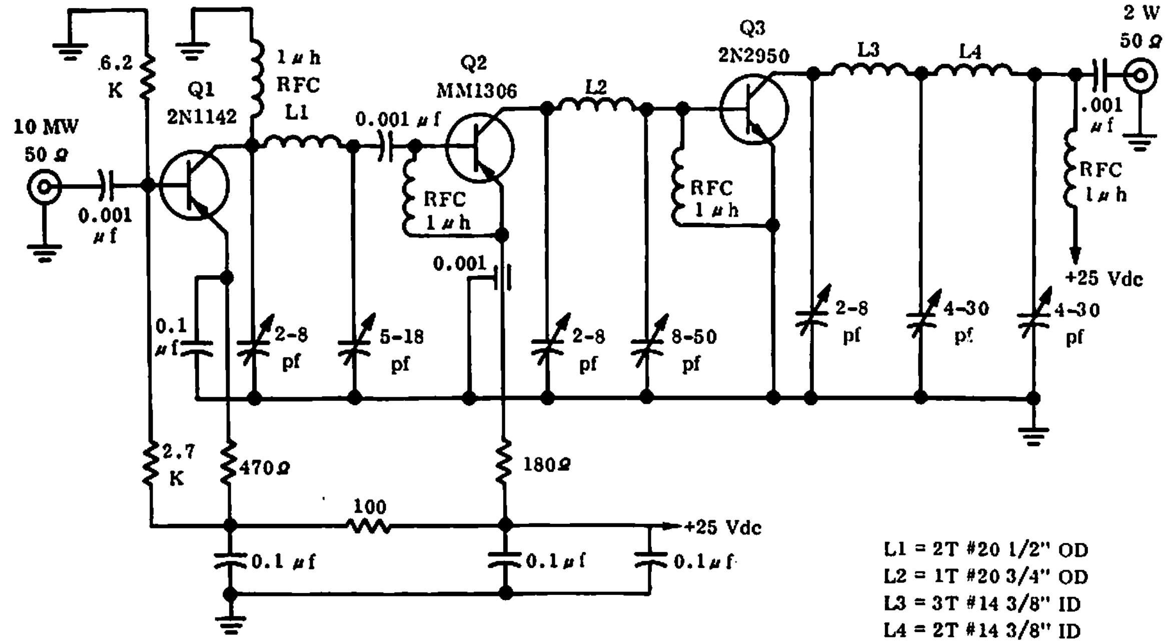

28 Vdc
1000
5.6 μH RFC
3.9 μH RFC
0.02 μF
0.1 μF
1000
4.7 k
0.15-0.20 μH
0.005 μF
RFC
0.12 μH
0.22 μH
R_L = 50Ω
30
0.058 μH
5 – 80
2N3961
2N3950
1.5-15
2N4072
5.6 μH RFC
12
15
50 MHz Xtal
RFC* Q < 1
62
9 - 180
RFC* Q < 1
1000
2 k
750
150
50

50-W 50-MHZ THREE-TRANSISTOR—Uses only three stages, one of which is low-level Colpitts crystal oscillator. Provides continuous power output, with 27 dB combined power gain for driver and final stages. Provisions for keying or frequency modulation may be added. Report gives design approach for optimizing performance of each stage. Circuit is suitable only for f-m or c-w, not a-m.—R. C. Hejhall, A 50 Watt 50 MHz Solid-State Transmitter, Motorola, Phoenix, Ariz., AN-246, 1967.


VCC+
C7
C8
L3
L2
VCC+
C9
C10
L5
L4
RCA 40282
P1=1.0W Z=50Ω 156 MHz
C1
L1
C2
R.F.C.
RCA 40281
C3
C4
R.F.C.
C5
C6
PO=11.5W Z=50Ω 156 MHz

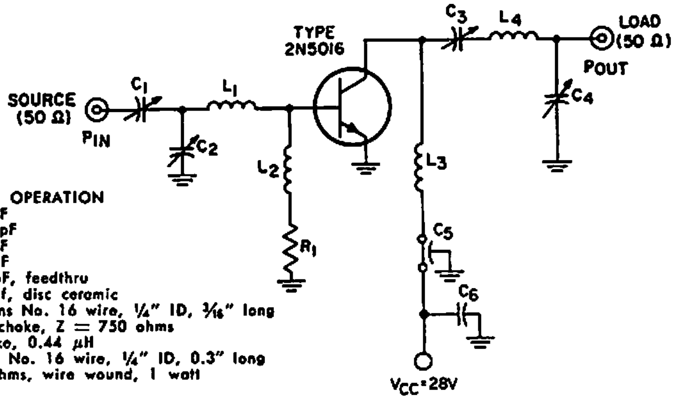
156–174 MHz MARINE-BAND POWER AMPLIFIER—With 1-W f-m power applied to input of driver, output stage delivers over 10 W to 50-ohm transmission line.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 298.

C_1, C_2, C_3, C_4, C_5, C_6, = Arco 404 or equiv.
C_7, C_9 = 0.022 μF, 25 V
C_8, C_{10} = 1000 pF, ceramic standoff
L_1, L_5 = 1 turn No. 20 wire, ¼" ID, 3/32" long
L_2, L_4 = 1½ turns No. 20 wire, ¼" ID, 3/32" long
L_3 = 2 turns No. 18 wire, ¼" ID, 5/16" long
RFC = 4 turns No. 30 wire, ferrite bead Ferroxcube No. 56-590-65/4B or equiv.


6.2 K
Q1 2N1142
1 μh RFC L1
Q2 MM1306
L2
Q3 2N2950
L3
L4
2 W 50 Ω
10 MW 50 Ω
0.001 μf
0.001 μf
RFC 1 μh
RFC 1 μh
.001 μf
RFC 1 μh
0.001
+25 Vdc
0.1 μf
2-8 pf
5-18 pf
2-8 pf
8-50 pf
2-8 pf
4-30 pf
4-30 pf
2.7 K
470Ω
180Ω
100
+25 Vdc
0.1 μf
0.1 μf
0.1 μf

L1 = 2T #20 1/2" OD
L2 = 1T #20 3/4" OD
L3 = 3T #14 3/8" ID
L4 = 2T #14 3/8" ID

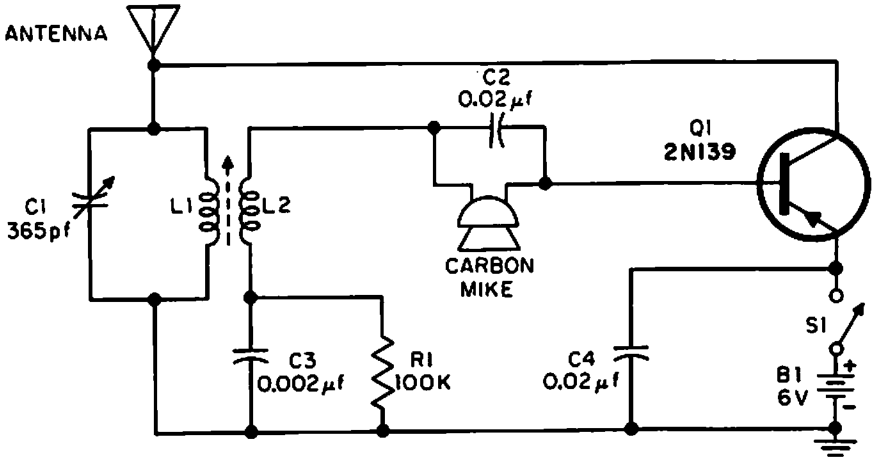
2-W 160-MHZ DRIVER AND FINAL—Three-transistor output circuit provides overall gain of 23 dB. Q1 operates class A and provides fair stability without neutralization. R-f choke that provides zero bias for Q2 should be as small as possible electrically to minimize possibility of circuit oscillation at some lower frequency.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-6-2.


TYPE
2N5016
SOURCE
(50 Ω)
PIN
C1
C2
L1
L2
R1
C3
L4
LOAD
(50 Ω)
POUT
C4
L3
C5
C6
VCC=28V

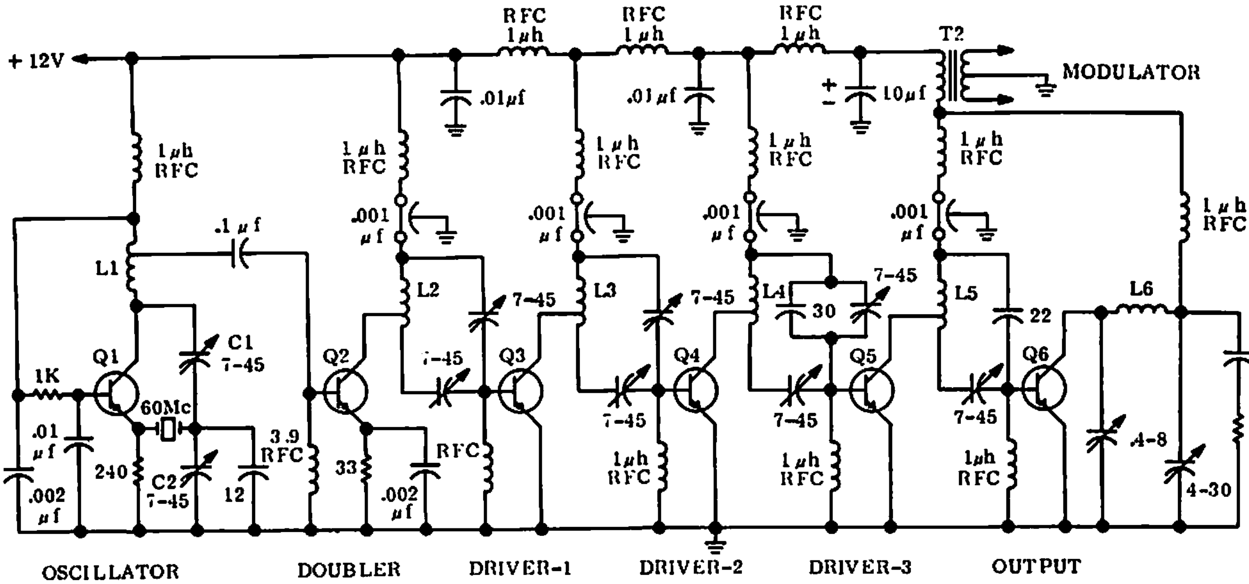
FOR 225-MHz OPERATION
C_1 = 4-40 pF
C_2 = 7-100 pF
C_3 = 3-35 pF
C_4 = 8-60 pF
C_5 = 1500 pF, feedthru
C_6 = 0.01 μf, disc ceramic
L_1 = 1.3 turns No. 16 wire, ¼" ID, 3/16" long
L_2 = ferrite choke, Z = 750 ohms
L_3 = rf choke, 0.44 μH
L_4 = 4 turns No. 16 wire, ¼" ID, 0.3" long
R_1 = 0.68 ohms, wire wound, 1 watt

400-MHZ POWER AMPLIFIER—Delivers over 15 W at 400 MHz and over 20 W at 225 MHz. T network matches 3-ohm input impedance of transistor to 50-ohm source impedance, and pi network matches output to 50-ohm load.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 348.

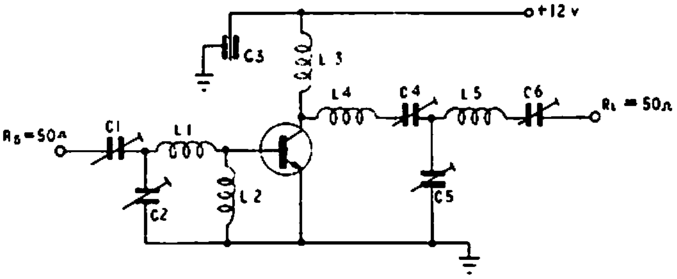
FOR 400-MHz OPERATION
C_1, C_3 = 1.5-20 pF
C_2, C_4 = 3-35 pF
C_5 = 1000 pF, feedthru
C_6 = 0.01 μF, disc ceramic
L_1 = 1.3 turns No. 16 wire, ¼" ID, ¼" long
L_2 = ferrite choke, 2 = 750 ohms (or 0.12-pH choke)
L_3 = rf choke, 0.13 μH
L_4 = 3 turns 1/32" x ⅛" copper ribbon, 3/16" ID, ½" long
R_1 = 0.68 ohms, wire wound, 1 watt


ANTENNA
C1
365pf
L1
L2
C2
0.02μf
CARBON
MIKE
Q1
2N139
C3
0.002μf
R1
100K
C4
0.02μf
S1
B1
6V
+
-

WIRELESS MIKE—Tune to dead spot at low end of a-m broadcast-band receiver. Antenna length is limited to 10 ft by law. If not heard, try reversing connections to L2. L1 is No. 7/41 Belden Litz wire wound closely in single layer to within ¼ inch of ends of 7-inch by 0.33-inch ferrite rod. L2 is 35 turns of No. 24 enameled wire wound directly over L1.—"A Modern Transistor Workbook," Radio Shack, Boston, Mass., 1965, p 13.

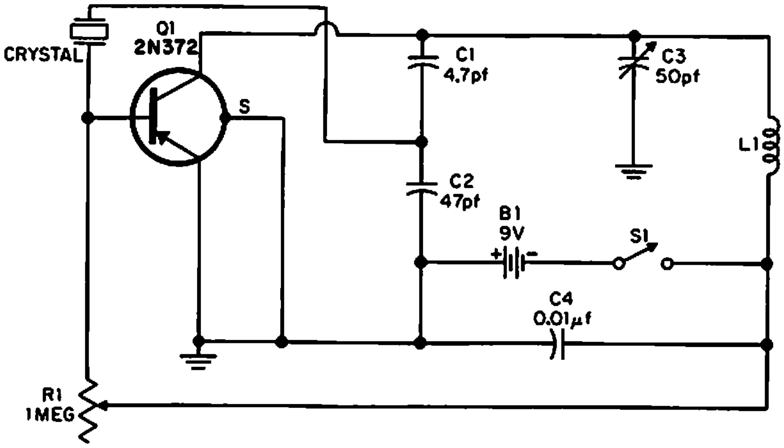

+12V
RFC
1μh
.01μf
10μf
T2
MODULATOR
1μh
RFC
.001
μf
.1μf
L1
L2
L3
L4
L5
L6
Q1
Q2
Q3
Q4
Q5
Q6
1K
C1
7-45
60Mc
C2
7-45
240
12
3.9
RFC
33
.002
μf
.01
μf
7-45
30
22
4-8
4-30
.001
μf
RL
50
OSCILLATOR
DOUBLER
DRIVER-1
DRIVER-2
DRIVER-3
OUTPUT

1.5-W 120-MHZ AIRCRAFT—Uses 60-MHz crystal oscillator to feed frequency-doubling amplifier stage Q2. Both driver and output stages are collector-modulated in order to obtain 100% modulation. Q5 and Q6 are 2N2950 and all other transistors are 2N2951. Book gives coil-winding data.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-5-2.

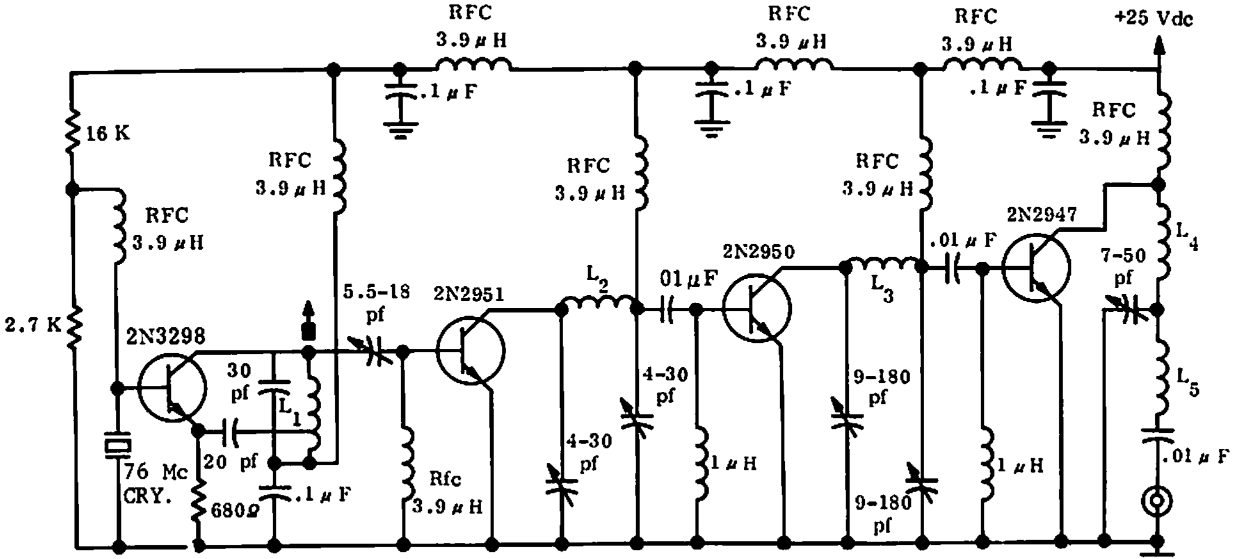

+12 v
C3
L3
L4
C4
L5
C6
R_L = 50Ω
R_S = 50Ω
C1
L1
L2
C2
C5

C_1, C_2, C_4 - C_6	3 - 30pF trimmer
C_3	1500pF feedthrough
L_1	4T, 6.3mm I.D. 1.2mm T.C.W. 10mm long
L_2	0.47µH Cambion Choke type 3640-13-2
L_3	0.15µH Cambion Choke type 3640-1-2
L_4, L_5	0.22µH Cambion Choke type 3640-5-2

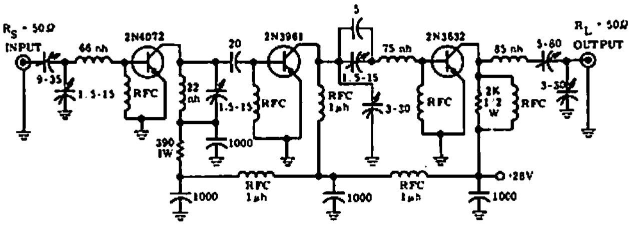
150-MHZ NARROW-BAND OUTPUT STAGE—For use in battery-operated portable transmitter where good gain and high efficiency are important. Uses ZT3866 uhf transistor in switching mode. Second harmonic suppression is excellent. Current drain is 155 mA. Report gives design equations.—A Low Power High Efficiency Output Stage Using ZT3866 Transistors, Ferranti Ltd., Oldham, Lancs., England, Application Note 37, Dec. 1968.


CRYSTAL
Q1
2N372
S
C1
4.7pf
C3
50pf
L1
C2
47pf
B1
9V
S1
C4
0.01µf
R1
1MEG

CB CHANNEL LOCATOR—When third-overtone Citizens-Band crystal for desired channel is inserted in oscillator, L1 will radiate that frequency to receiver for quick location of that channel. Adjust R1 initially, without crystal, until milliammeter in series with battery shows 0.2 mA, then insert crystal and adjust C3 for maximum signal at receiver. L1 is B&W 3003.—"A Modern Transistor Workbook,". Radio Shack, Boston, Mass., 1965, p 17.

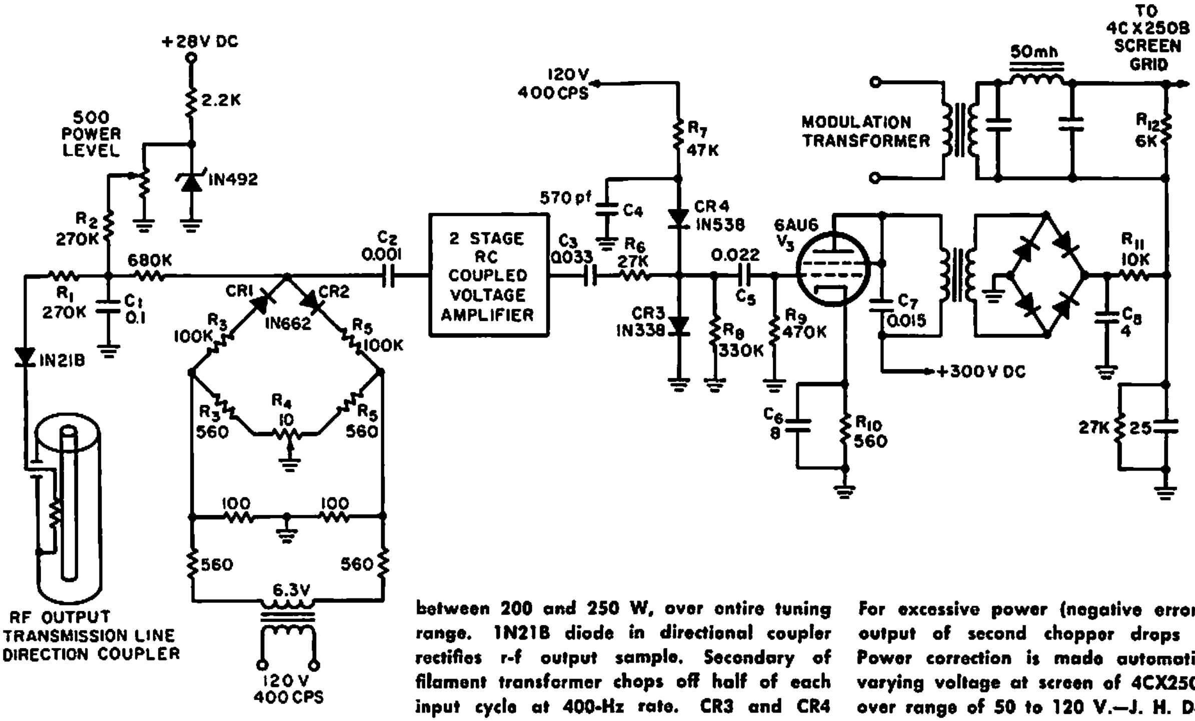

RFC
3.9 µH
RFC
3.9 µH
RFC
3.9 µH
+25 Vdc
.1 µ F
.1 µ F
.1 µ F
16 K
RFC
3.9 µ H
RFC
3.9 µ H
RFC
3.9 µ H
RFC
3.9 µ H
RFC
3.9 µ H
2.7 K
2N3298
30 pf
L_1
5.5-18 pf
2N2951
L_2
01 µF
2N2950
L_3
.01 µ F
2N2947
L_4
7-50 pf
L_5
20 pf
76 Mc CRY.
680Ω
.1 µ F
Rfc
3.9 µ H
4-30 pf
4-30 pf
1 µ H
9-180 pf
9-180 pf
1 µ H
.01 µ F
R_L = 50

10-W 76-MHz C-W—Operates from 25-V d-c supply and feeds into 50-ohm coaxial line. Requires 6-mW input power. Output stage draws 600 mA and driver stages 166 mA. Book gives coil-winding data.—"Circuits Manual," Motorola, Phoenix, Ariz., 1965, p 12-4-2.


R_S = 50Ω
INPUT
9-35
66 nh
1.5-15
2N4072
RFC
22 nh
390 1W
1000
20
1.5-15
2N3961
RFC
5
1.5-15
RFC 1µh
3-30
75 nh
2N3632
RFC
2K 1/2 W
RFC
85 nh
5-80
3-50
R_L = 50Ω
OUTPUT
+28V
1000
RFC 1µh
1000
RFC 1µh
1000

L_1 - 66 nh, 6 Turns #18 Tinned Wire, 3/32" I.D. 1/2" L.
L_2 - 22 nh, 2 Turns #18 Tinned Wire, 3/32" I.D. 1/4" L.
L_3 - 75 nh, 4 Turns #14 Tinned Wire, 1/4" I.D. 3/8" L.
L_4 - 85 nh, 3 Turns #14 Tinned Wire, 3/8" I.D. 3/8" L.

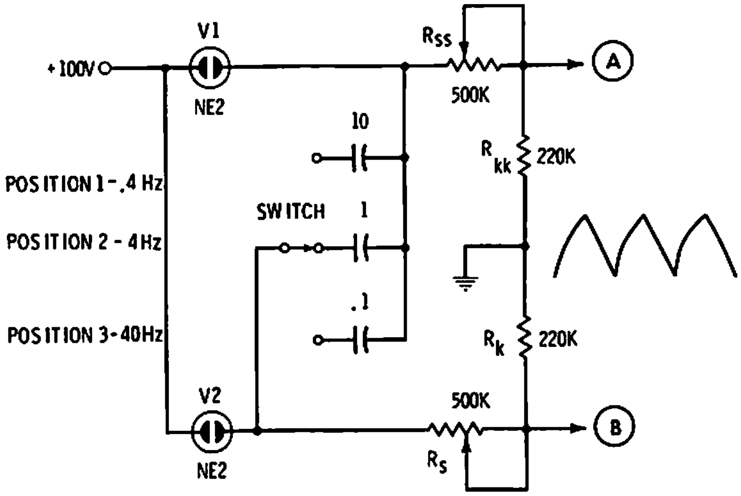
15 W at 160 MHZ—Provides 30.5 dB power gain with only three transistor stages. Report shows how input-output admittance data in network design is used to optimize performance of each stage. Addition of appropriate oscillator, buffer, and multiplier stages would give complete f-m or c-w transmitter. Not intended for a-m operation. Requires 13-mW power input.—R. Hejhall, A 160 MHz 15-Watt Solid-State Power Amplifier, Motorola, Phoenix, Ariz., AN-214, 1967.


+28V DC
2.2K
500 POWER LEVEL
IN492
R_2 270K
680K
R_1 270K
C_1 0.1
IN21B
CR1
CR2
IN662
R_3 100K
R_5 100K
R_3 560
R_4 10
R_5 560
100
100
560
560
6.3V
120 V 400 CPS
RF OUTPUT TRANSMISSION LINE DIRECTION COUPLER
C_2 0.001
2 STAGE RC COUPLED VOLTAGE AMPLIFIER
120V 400CPS
570 pf
C_4
C_3 0.033
R_6 27K
R_7 47K
CR4 IN538
CR3 IN338
R_8 330K
0.022
C_5
R_9 470K
6AU6 V_3
C_7 0.015
+300V DC
C_6 8
R_{10} 560
MODULATION TRANSFORMER
50mh
TO 4CX250B SCREEN GRID
R_{12} 6K
R_{11} 10K
C_8 4
27K
25

R-F POWER OUTPUT CONTROL—Used in servo-tuned a-m fsk 225–399.95 MHz transmitter to maintain power within 10% of preset value, between 200 and 250 W, over entire tuning range. 1N21B diode in directional coupler rectifies r-f output sample. Secondary of filament transformer chops off half of each input cycle at 400-Hz rate. CR3 and CR4 form second chopper—a shunt gate that alternately blocks and passes when input error signal is positive to indicate low power. For excessive power (negative error signal), output of second chopper drops to zero. Power correction is made automatically by varying voltage at screen of 4CX250B driver over range of 50 to 120 V.—J. H. Davis and B. van Sutphin, Automatic Carrier-Level System Controls 250-Watt Transmitter, *Electronic Design*, March 16, 1964, p 78–81.

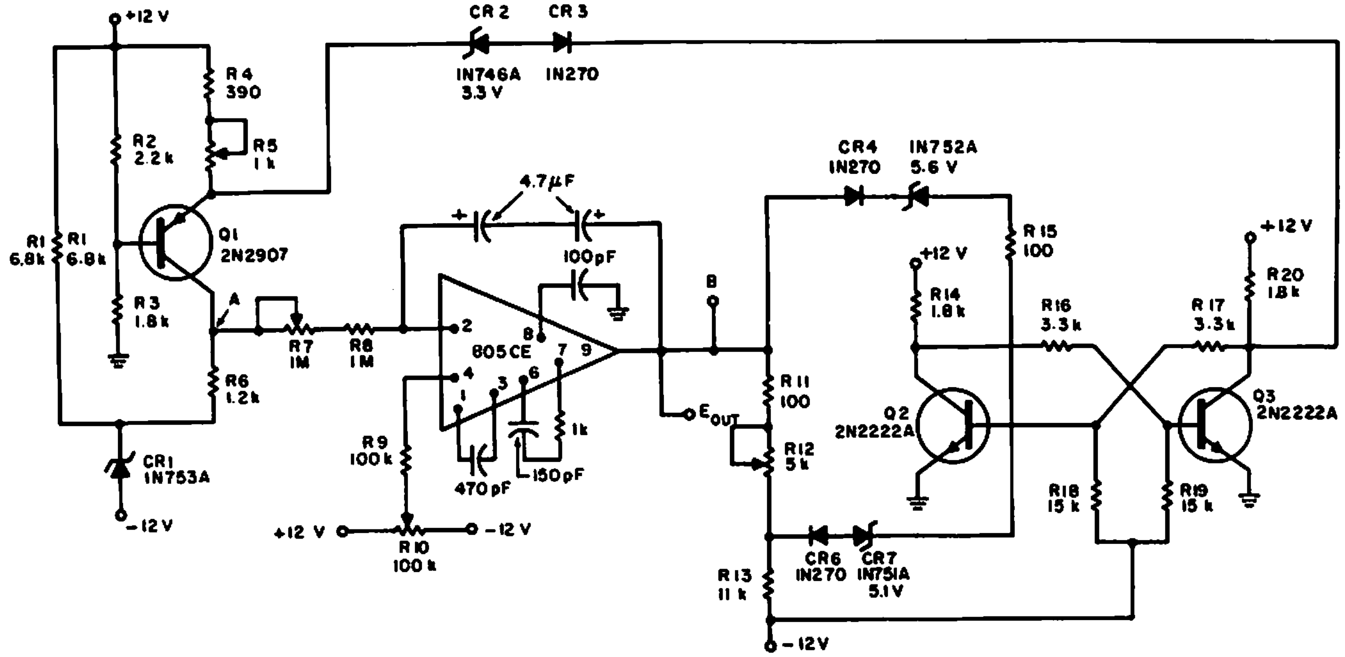
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 92
Triangular-Wave Generator Circuits



V1
+100V
NE2
Rss
500K
A
10
Rkk
220K
POSITION 1-.4 Hz
SWITCH
1
POSITION 2 - 4Hz
.1
POSITION 3-40Hz
Rk
220K
V2
500K
B
NE2
Rs

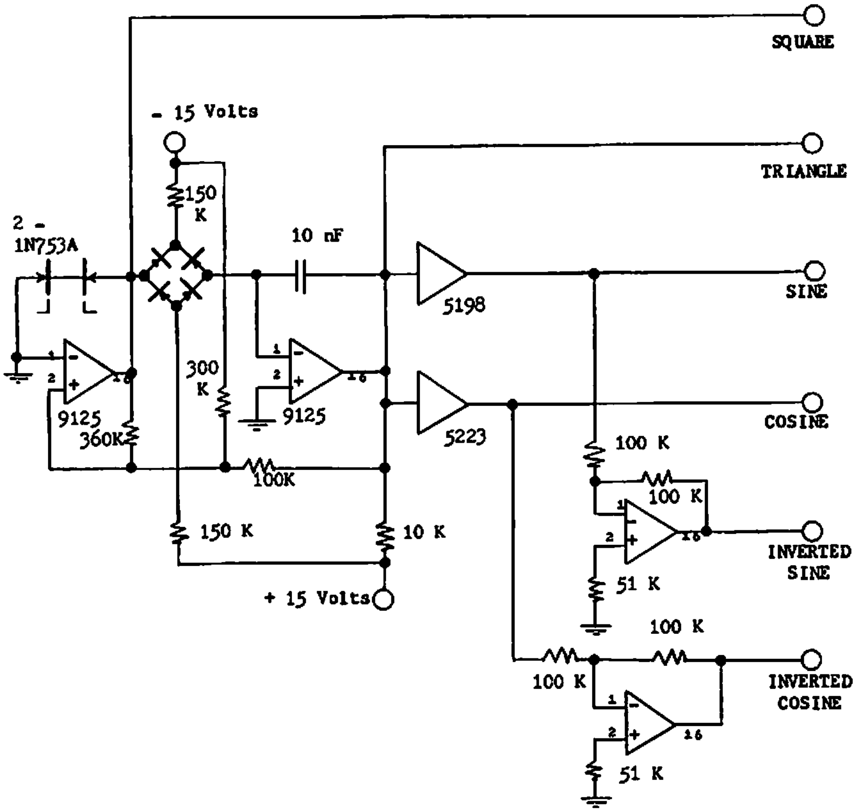
LOW-FREQUENCY TRIANGULAR-PULSE NEON—May be used as time base for any slow-scan device requiring equal trace and retrace time. 500K controls may be ganged for frequency control, or isolated for linearity adjustment.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 47.



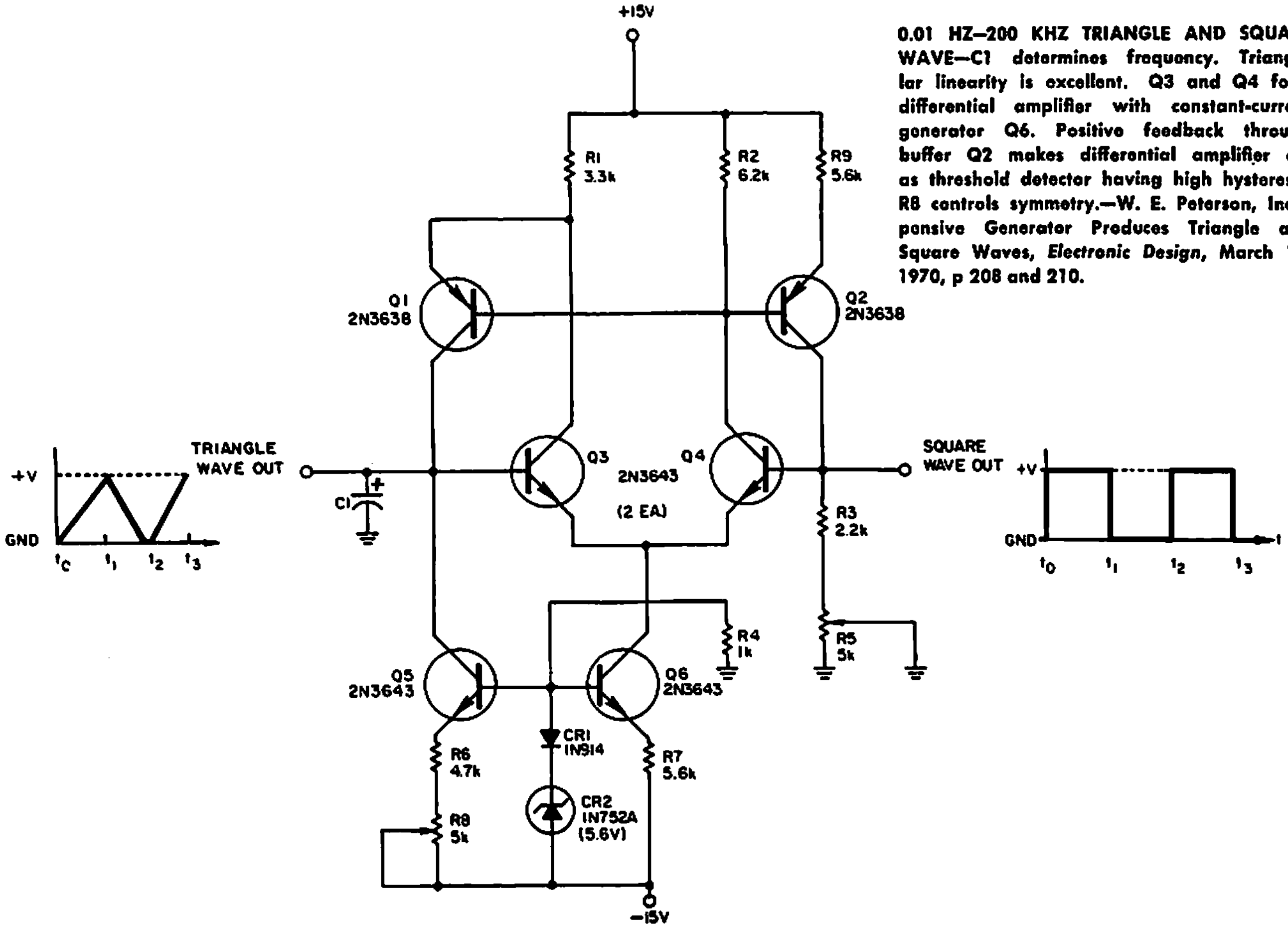
+12 V
R4
390
R5
1 k
R2
2.2 k
R1
6.8k
R1
6.8k
Q1
2N2907
R3
1.8 k
A
R6
1.2 k
CR1
1N753A
-12 V
CR 2
CR 3
1N746A
3.3 V
1N270
4.7μF
100pF
R7
1M
R8
1M
2
8
805CE
7
9
4
1
3
6
1k
470 pF
150 pF
R9
100 k
+12 V
R10
100 k
-12 V
B
E_OUT
CR4
1N270
1N752A
5.6 V
R15
100
+12 V
R14
1.8 k
R11
100
Q2
2N2222A
R12
5 k
CR6
1N270
CR7
1N751A
5.1V
R13
11 k
-12V
R16
3.3 k
R17
3.3 k
+12 V
R20
1.8 k
Q3
2N2222A
R18
15 k
R19
15 k

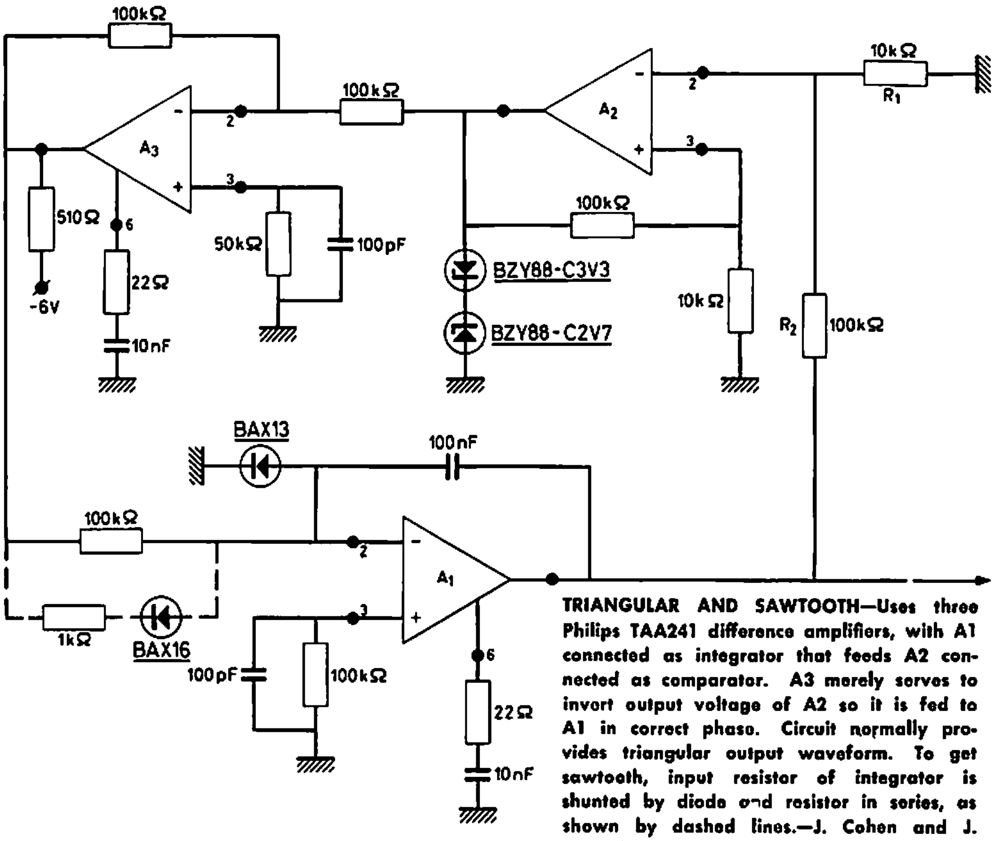
SUBAUDIO TRIANGULAR WAVES—With values shown, output can be adjusted down to 0.05 Hz with R7. Wave shape is good.—N. M. Nekomoto, LF Triangular Wave Generator Has Just a Few Components, *Electronic Design*, Nov. 22, 1967, p 105.

UNIVERSAL WAVEFORM GENERATOR—Combination of six OEI IC modules provides choice of six different output waveforms, with frequency determined by 10-nF capacitor and 150K resistors in oscillator using first 9125 opamp as switch with hysteresis and second as integrator driven by current having polarity determined by switch and diode bridge. All waveforms are symmetrical about common output except triangle. Diodes are 1N914 or similar.—A Square/Triangle/Sine/Cosine Waveform Generator, Optical Electronics, Tucson, Ariz., No. 10116.

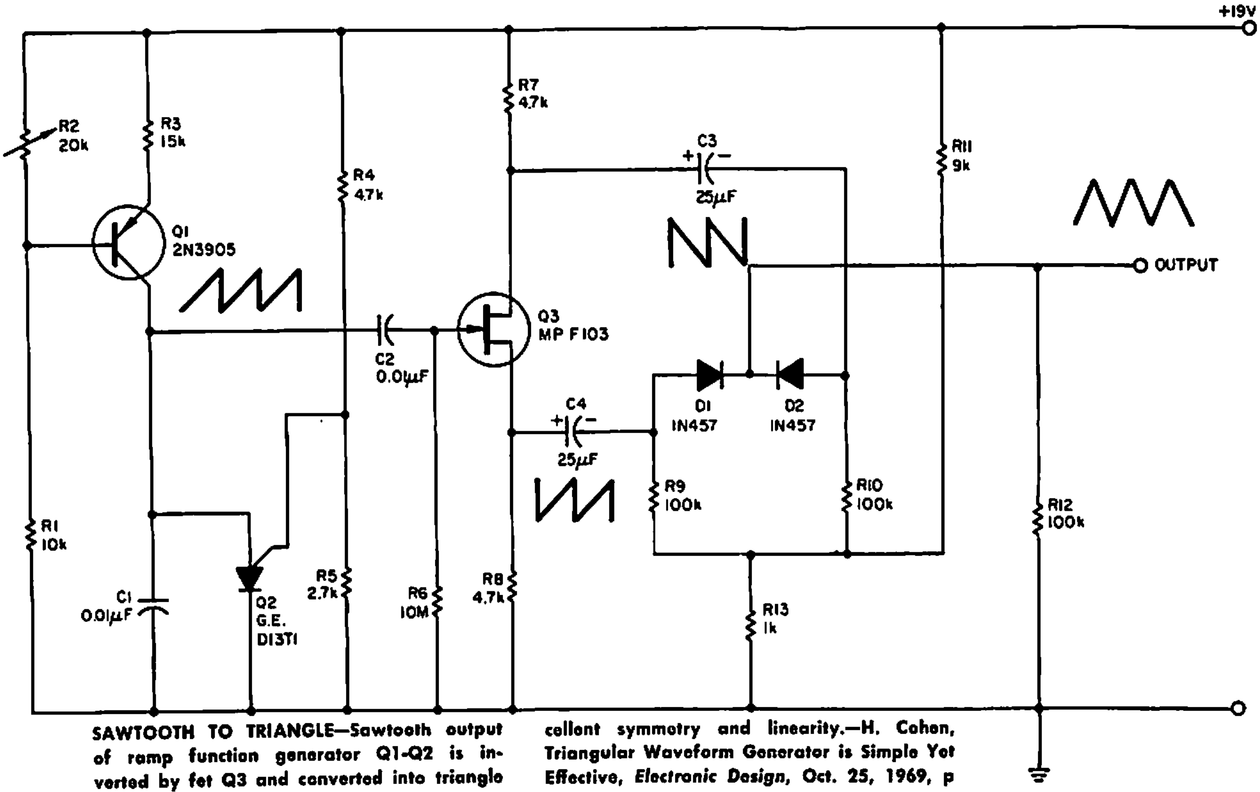

SQUARE
- 15 Volts
TRIANGLE
2 - 1N753A
150 K
10 nF
SINE
5198
9125
300 K
9125
5223
COSINE
360K
100K
100 K
100 K
150 K
10 K
INVERTED SINE
+ 15 Volts
51 K
100 K
100 K
INVERTED COSINE
51 K

0.01 HZ–200 KHZ TRIANGLE AND SQUARE WAVE—C1 determines frequency. Triangular linearity is excellent. Q3 and Q4 form differential amplifier with constant-current generator Q6. Positive feedback through buffer Q2 makes differential amplifier act as threshold detector having high hysteresis. R8 controls symmetry.—W. E. Peterson, Inexpensive Generator Produces Triangle and Square Waves, *Electronic Design*, March 15, 1970, p 208 and 210.

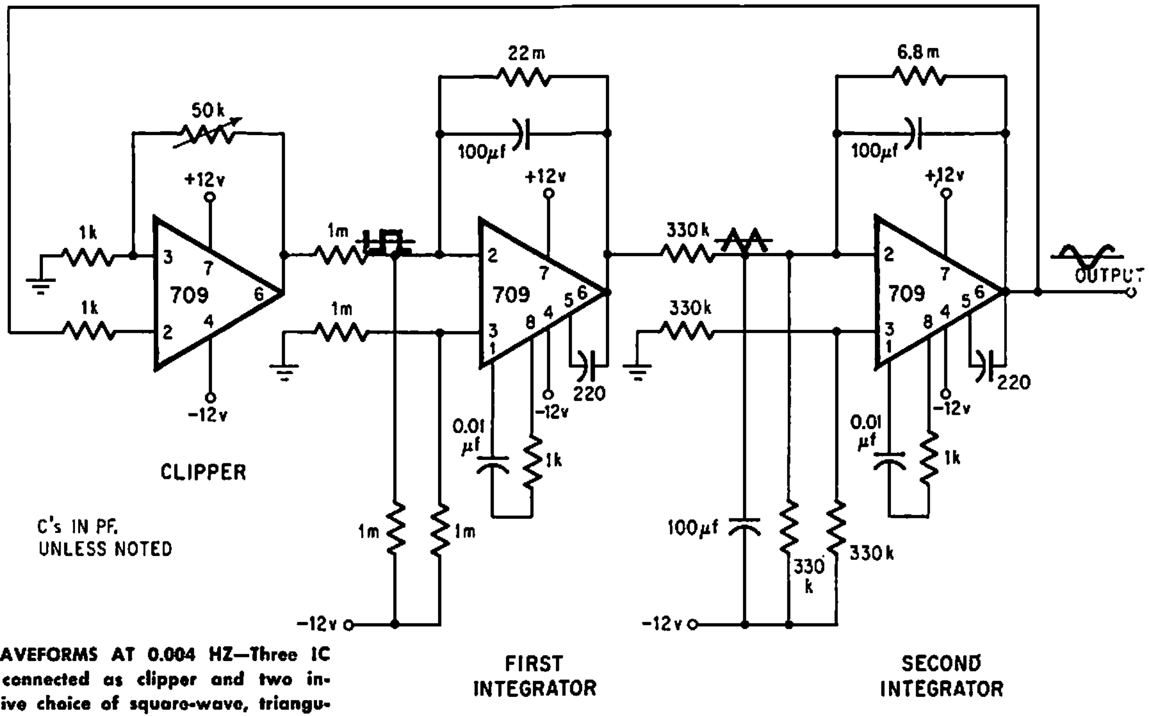

+15V
R1 3.3k
R2 6.2k
R9 5.6k
Q1 2N3638
Q2 2N3638
+V
GND
t_c t_1 t_2 t_3
TRIANGLE WAVE OUT
C1
Q3
2N3643
(2 EA)
Q4
SQUARE WAVE OUT
+V
GND
t_0 t_1 t_2 t_3
t
R3 2.2k
R4 1k
R5 5k
Q5 2N3643
Q6 2N3643
CR1 1N914
R6 4.7k
R7 5.6k
CR2 1N752A (5.6V)
R8 5k
-15V


100kΩ
10kΩ
R₁
A₃
A₂
2
3
100kΩ
510Ω
6
22Ω
-6V
10nF
50kΩ
100pF
100kΩ
BZY88-C3V3
BZY88-C2V7
10kΩ
R₂
100kΩ
BAX13
100nF
100kΩ
A₁
1kΩ
BAX16
100pF
100kΩ
22Ω
10nF

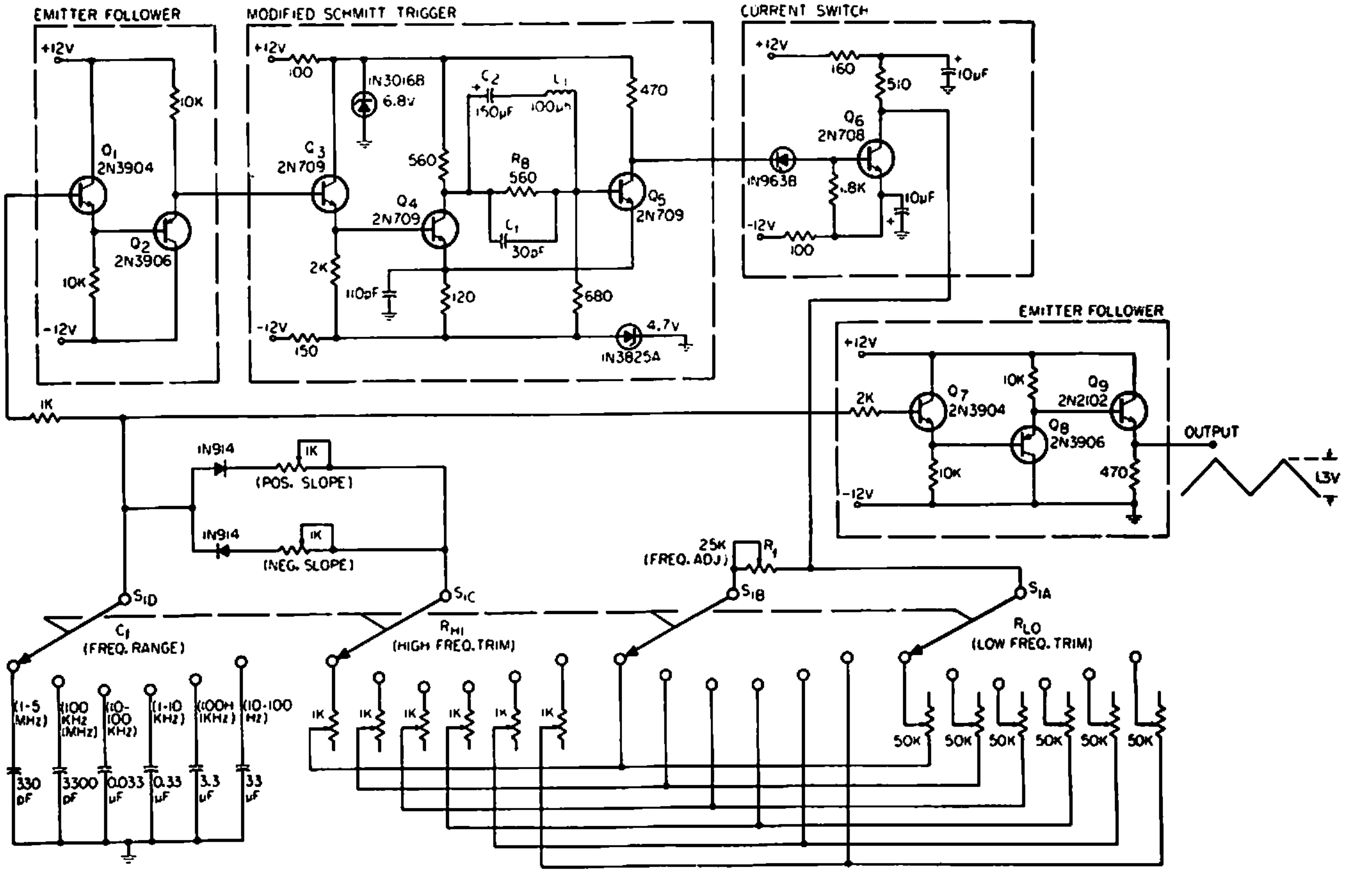
TRIANGULAR AND SAWTOOTH—Uses three Philips TAA241 difference amplifiers, with A1 connected as integrator that feeds A2 connected as comparator. A3 merely serves to invert output voltage of A2 so it is fed to A1 in correct phase. Circuit normally provides triangular output waveform. To get sawtooth, input resistor of integrator is shunted by diode and resistor in series, as shown by dashed lines.—J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.


+19V
R2
20k
R3
15k
R7
4.7k
C3
25μF
R11
9k
R4
4.7k
Q1
2N3905
OUTPUT
Q3
MP F103
C2
0.01μF
C4
25μF
D1
IN457
D2
IN457
R9
100k
R10
100k
R12
100k
R1
10k
C1
0.01μF
Q2
G.E.
D13T1
R5
2.7k
R6
10M
R8
4.7k
R13
1k

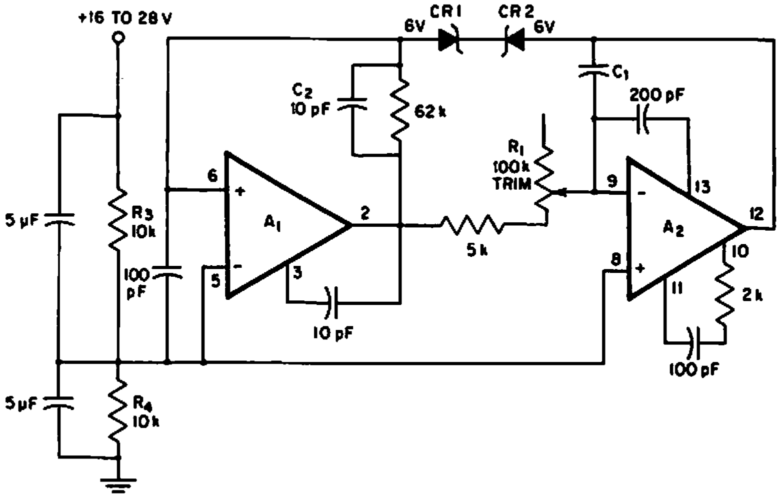
SAWTOOTH TO TRIANGLE—Sawtooth output of ramp function generator Q1-Q2 is inverted by fet Q3 and converted into triangle waveform by D1 and D2. Output has excellent symmetry and linearity.—H. Cohen, Triangular Waveform Generator is Simple Yet Effective, *Electronic Design*, Oct. 25, 1969, p 111 and 113.


22m
100µf
+12v
6.8m
100µf
+12v
50k
+12v
1k
1k
3
2
7
4
6
709
-12v
1m
1m
709
2
3
1
7
8
4
5
6
220
0.01 µf
-12v
1k
330k
330k
709
220
0.01 µf
-12v
1k
OUTPUT
CLIPPER
C's IN PF.
UNLESS NOTED
1m
1m
-12v
100µf
330 k
330k
-12v
FIRST INTEGRATOR
SECOND INTEGRATOR

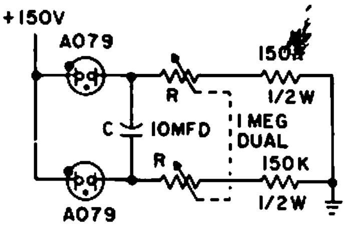
THREE WAVEFORMS AT 0.004 HZ—Three IC opamps, connected as clipper and two inverters, give choice of square-wave, triangular-wave, and parabolic waveform approximating sine wave, for universal subaudio generator. Pot controls output amplitude.—A. D. Delagrange, Low Frequency Waveform Generator Uses 3 Op Amps, *Electronics*, April 14, 1969, p 98.


EMITTER FOLLOWER
+12V
10K
Q1 2N3904
Q2 2N3906
10K
-12V
MODIFIED SCHMITT TRIGGER
+12V
100
1N3016B 6.8V
C2 150µF
L1 100µH
470
Q3 2N709
560
R8 560
Q4 2N709
C1 30pF
Q5 2N709
2K
110pF
120
680
-12V
150
4.7V 1N3825A
CURRENT SWITCH
+12V
160
510
10µF
Q6 2N708
1N963B
1.8K
10µF
-12V
100
EMITTER FOLLOWER
+12V
2K
Q7 2N3904
10K
Q9 2N2102
Q8 2N3906
10K
470
-12V
OUTPUT
1.3V
1K
1N914
1K
(POS. SLOPE)
1N914
1K
(NEG. SLOPE)
25K (FREQ. ADJ)
R1
S1D
S1C
S1B
S1A
C1 (FREQ. RANGE)
RHI (HIGH FREQ. TRIM)
RLO (LOW FREQ. TRIM)
(1-5 MHz)
(100 KHz (MHz)
(10-100 KHz)
(1-10 KHz)
(100H 1KHz)
(10-100 Hz)
330 pF
3300 pF
0.033 µF
0.33 µF
3.3 µF
33 µF
1K
1K
1K
1K
1K
1K
50K
50K
50K
50K
50K
50K

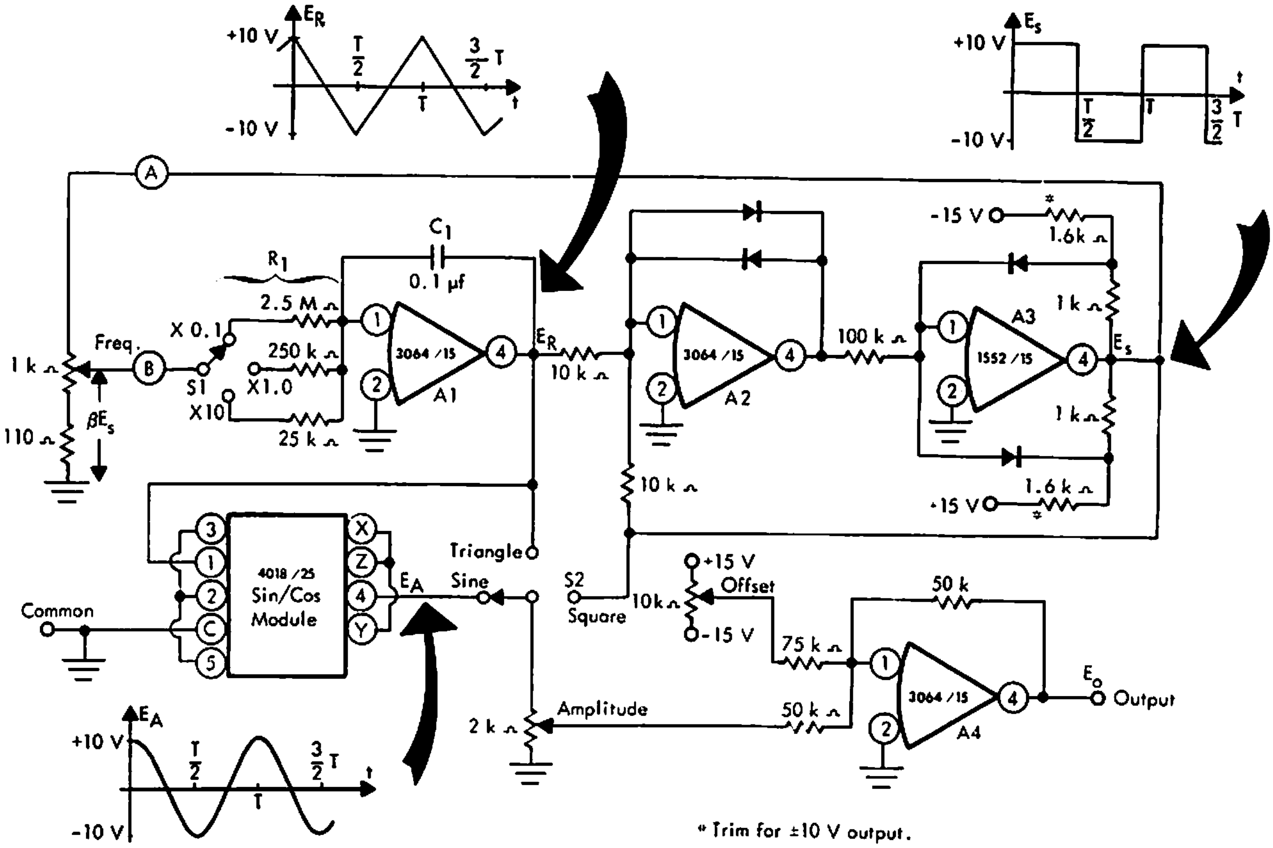
10 HZ–5 MHZ AT STABILIZED 1 V—Reduces true triangular wave with 1% linearity over entire range. S1 gives choice of six frequency bands, with Rf providing tuning in each band. Hyperbolic resistance curve for Rf gives straight-line relation between frequency and shaft rotation.—J. P. Bolton and B. E. Packham, Wide-Range Triangular-Wave Generator, *EEE*, March 1967, p 96 and 98.


+16 TO 28 V
CR1
CR2
6V
6V
C1
200 pF
C2
10 pF
62 k
R1
100 k
TRIM
5 µF
R3
10k
100
pF
A1
A2
5 k
10 pF
2 k
100 pF
R4
10k
6
5
2
3
9
8
13
12
10
11

TRIANGLE-SQUARE WITH ONE IC—Uses Burroughs dual 1709 opamp package MC-1437P, with opamp A1 serving as level-detecting switching amplifier for generating square waves, and opamp A2 connected as integrator for generating triangular waves with excellent linearity. C1 determines frequency range, which is 8 to 120 kHz for 500 pF and 400 to 10,000 Hz for 0.01 μF. Output has constant amplitude to over 50 kHz.—J. F. Kingsbury, Single IC Forms Wide-Range Triangle/Square-Wave Generator, *EEE*, Oct. 1969, p 109–110.

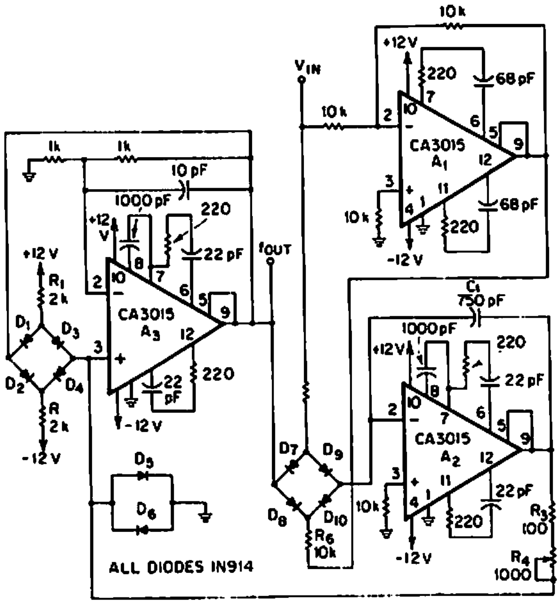

+150V
A079
A079
R
R
C
10MFD
1 MEG
DUAL
150K
1/2W
150K
1/2W

0.005–0.5 HZ TRIANGULAR—Upper frequency limit of dual astable low-subaudio oscillator is set by ionization time of neons. Lower frequency depends on leakage resistance of C, which should be high-quality paper or mylar.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 37.

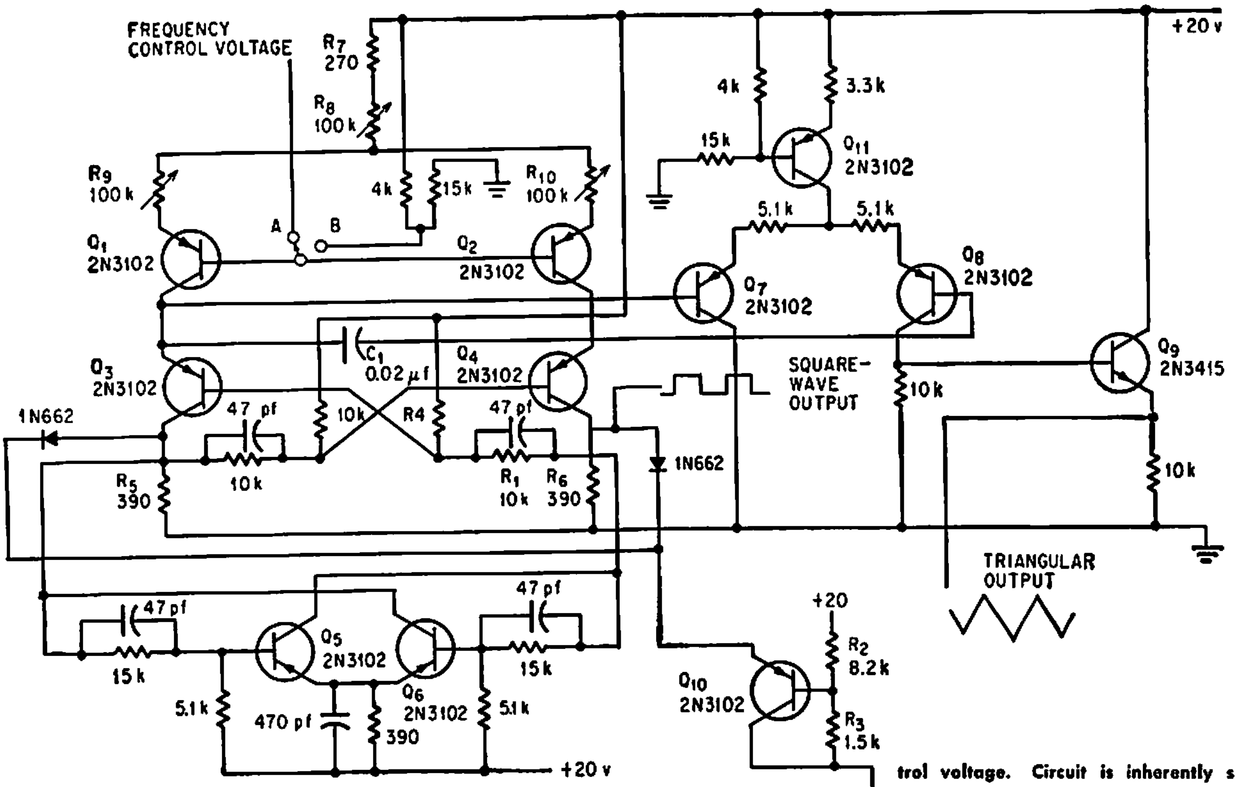

E_R
+10 V
-10 V
T/2
T
3/2 T
t
E_S
+10 V
-10 V
A
B
Freq.
1 k
110
βE_s
R1
2.5 M
250 k
25 k
X 0.1
X1.0
X10
S1
C1
0.1 µf
3064/15
A1
E_R
10 k
3064/15
A2
100 k
1552/15
A3
-15 V
1.6k
1 k
E_s
1 k
1.6 k
+15 V
10 k
4018/25
Sin/Cos
Module
Common
E_A
Triangle
Sine
S2
Square
+15 V
Offset
10k
-15 V
75 k
50 k
3064/15
A4
E_o
Output
2 k
Amplitude
50 k
E_A
+10 V
-10 V

* Trim for ±10 V output.

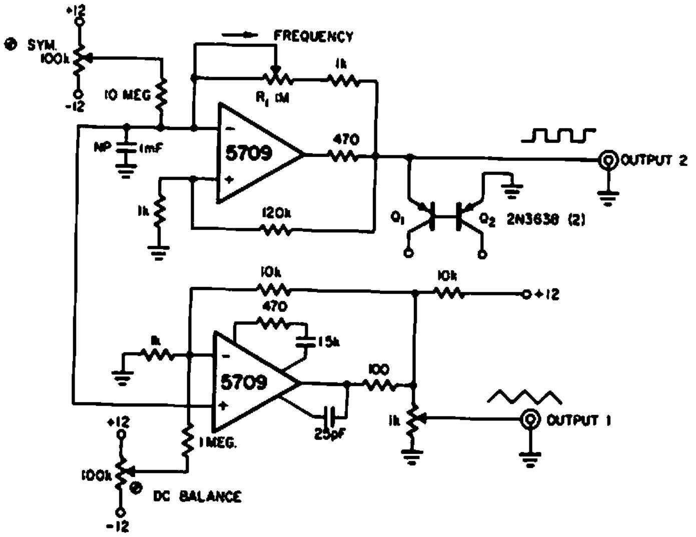
0.1–100 HZ SINE-SQUARE-TRIANGULAR—Combination of opamps with Burr-Brown 4018-25 sine-cosine module gives accurate and stable low-frequency function generator having choice of three output waveforms, as required for testing electrical or hydraulic servos, low-pass active filters, and other low-frequency devices. Adjustments of frequency, amplitude, and offset are independent.—Sine/Cosine Function Generator, Burr-Brown Research, Tucson, Ariz., PDS-210, 1968, p 6.


10k
+12V
220
68pF
VIN
10k
2
10
7
6
5
9
CA3015
A1
12
3
11
4
1
10k
68pF
220
-12V
1k
1k
10pF
1000pF
220
+12 V
22pF
fOUT
+12V
R1
2k
D1
D3
2
10
8
7
6
5
9
CA3015
A3
12
3
22 pF
220
D2
D4
R
2k
-12V
-12V
C1
750pF
1000pF
220
+12V
22pF
8
2
10
7
6
5
9
CA3015
A2
12
D7
D9
3
11
22pF
10k
4
1
220
R3
100
D8
D10
R6
10k
-12V
R4
1000
D5
D6
ALL DIODES IN914

40–70 KHZ TRIANGULAR AND SQUARE WAVES—Output frequency range of almost one octave is covered by control voltages of 4 to 7 V d-c with better than 0.5% linearity. C1 determines nominal center frequency, with values from 2 μF to 60 pF giving frequencies from 30 Hz to 750 kHz respectively. Produces triangular wave at output of opamp A2 (terminal 9 of A2) and square wave at output of A3. Amplitude of square wave is 3 V p-p and rise time 100 ns.—D. M. Stewart, Linear VCO Generates Sawtooth and Square Waveforms, *EEE*, March 1969, p 86.

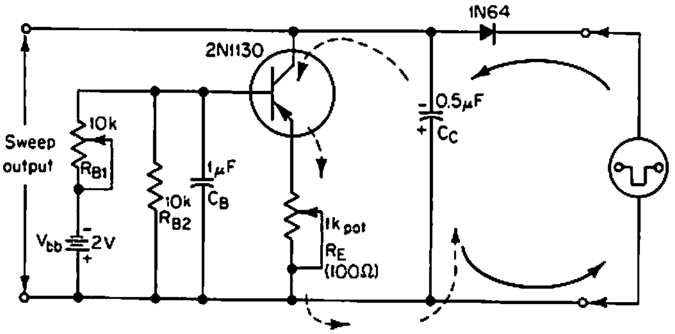

FREQUENCY CONTROL VOLTAGE
R7 270
R8 100k
+20 v
4k
3.3k
15k
Q11 2N3102
R9 100k
4k
15k
R10 100k
5.1k
5.1k
A
B
Q1 2N3102
Q2 2N3102
Q7 2N3102
Q8 2N3102
C1 0.02 μf
Q3 2N3102
Q4 2N3102
SQUARE-WAVE OUTPUT
10k
Q9 2N3415
1N662
47 pf
10k
R4
47 pf
1N662
R5 390
10k
R1 10k
R6 390
10k
TRIANGULAR OUTPUT
47 pf
47 pf
+20
15k
Q5 2N3102
15k
R2 8.2k
Q10 2N3102
5.1k
470 pf
Q6 2N3102
390
5.1k
R3 1.5k
+20 v

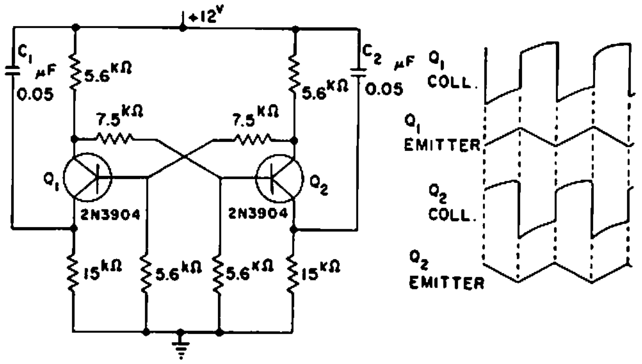
TRIANGULAR AND SQUARE WAVEFORMS—D-c amplifier Q7-Q8-Q9-Q11 added to modified astable mvbr Q1-Q2-Q5-Q6 gives choice of waveforms, with rise and fall times of 80 ns. Both outputs can be linearly varied over frequency range of 25 to 1 by external control voltage. Circuit is inherently self-starting.—C. Marosi, Voltage-Controlled Multi Produces Triangular Output, *Electronics*, Oct. 31, 1966, p 72–73.


+12
SYM.
100k
-12
10 MEG
FREQUENCY
R1 1M
1k
NP
1mF
5709
470
OUTPUT 2
1k
120k
Q1
Q2 2N3638 (2)
10k
10k
+12
470
15k
1k
5709
100
25pF
1k
OUTPUT 1
+12
1MEG.
100k
DC BALANCE
-12

TRIANGLE OR SQUARE-WAVE—Gives choice of outputs. Symmetry is better than 1% from 30 Hz to 25 kHz. R1 should be log taper.—"Linear Applications," Signetics, Sunnyvale, Cal.

VOLTAGE SWEEP GENERATOR—Input pulse must be negative. Frequency range is 5,000 to 10,000 pps with values shown for CC, going down to minimum of 500 pps for 2 μF and up to maximum of 200,000 pps for 0.001 μF. Output waveform is constant-voltage triangular.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 274.

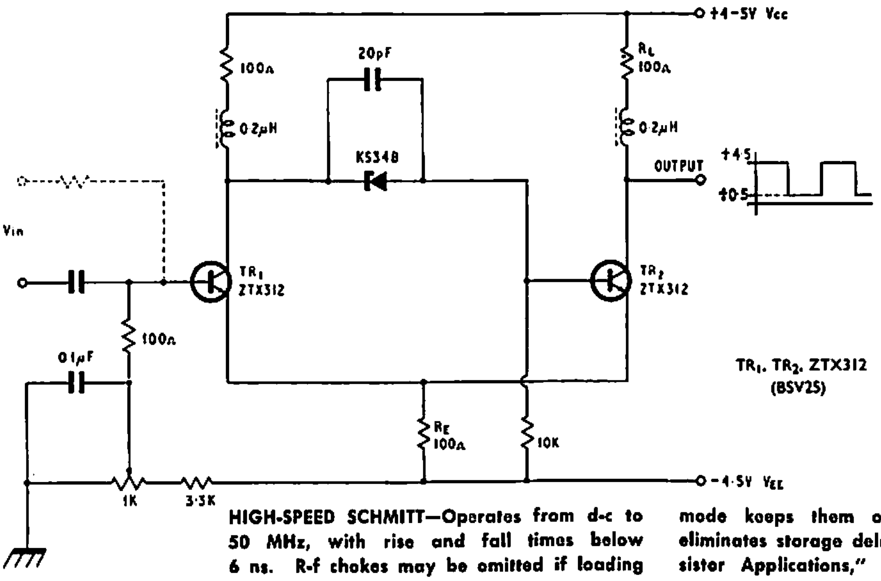

1N64
2N1130
Sweep output
10k
RB1
Vbb 2V
10k
RB2
1μF
CB
1k pot
RE
(100Ω)
0.5μF
CC


+12V
C1 μF 0.05
5.6kΩ
C2 μF 0.05
5.6kΩ
7.5kΩ
7.5kΩ
Q1
Q2
2N3904
2N3904
15kΩ
5.6kΩ
5.6kΩ
15kΩ
Q1 COLL.
Q1 EMITTER
Q2 COLL.
Q2 EMITTER

NEW TRIANGLE GENERATOR—Modification of astable mvbr, using two resistors in place of direct coupling, generates triangular waves automatically at transistor emitters.—S. Chang, A New Astable Multivibrator Generating Triangular Waves, *Proc. IEEE*, June 1968, p 1103.

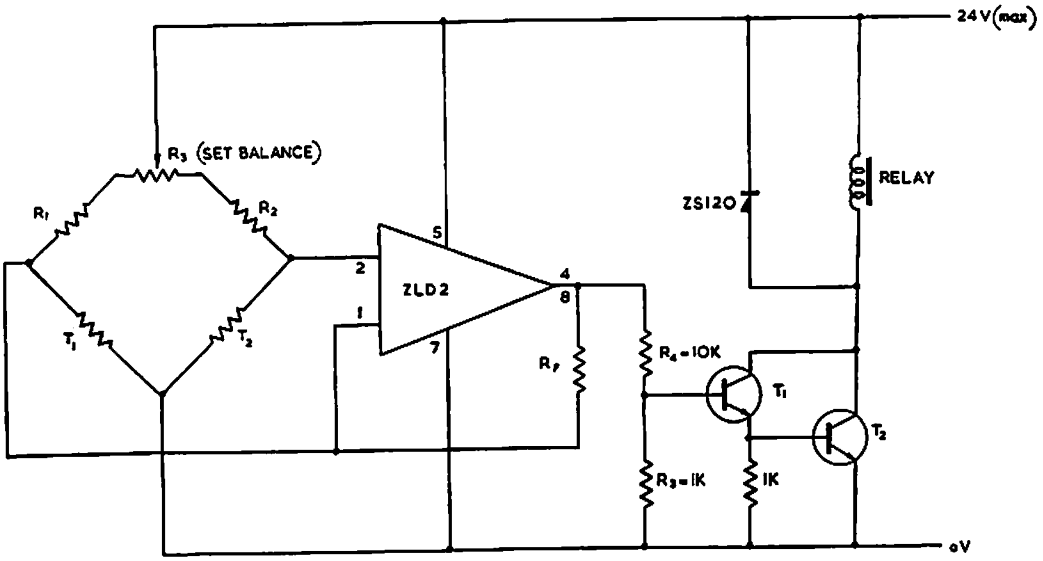
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 93
Trigger Circuits

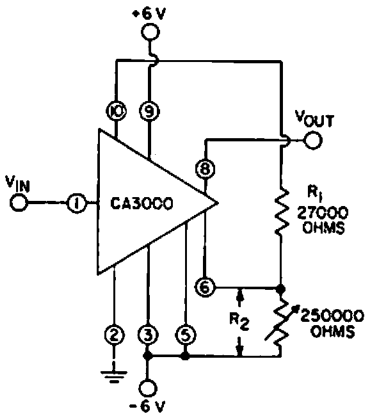

+4·5V Vcc
100Ω
20pF
R_L 100Ω
0·2μH
0·2μH
KS348
OUTPUT
+4·5
+0·5
Vin
TR_1 ZTX312
TR_2 ZTX312
100Ω
0·1μF
R_E 100Ω
10K
1K
3·3K
−4·5V V_{EE}

TR_1, TR_2, ZTX312 (BSV25)

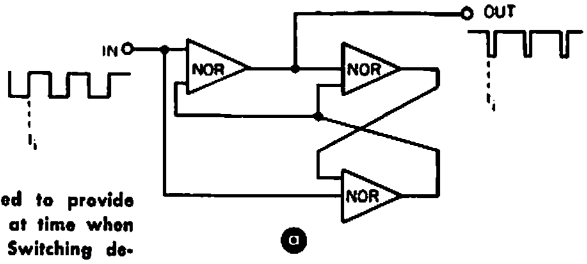
HIGH-SPEED SCHMITT—Operates from d-c to 50 MHz, with rise and fall times below 6 ns. R-f chokes may be omitted if loading is light. Operating transistors in current mode keeps them out of saturation and eliminates storage delay times.—"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 20.


24V(max)
R_3 (SET BALANCE)
R_1
R_2
T_1
T_2
5
2
ZLD2
1
7
4
8
R_F
ZS120
RELAY
R_4=10K
T_1
T_2
R_3=1K
1K
0V

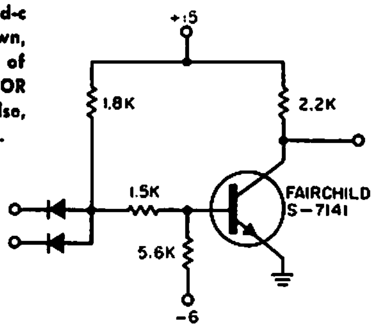
TRIGGER PREVENTS RELAY CHATTER—Two transistors are inserted between IC differential amplifier and relay to introduce enough trigger action to prevent chatter of relay when input is changing very slowly, as when comparing temperatures at two different locations with thermistors T1 and T2 in bridge circuit. Bridge resistors R1 and R2 should have low temperature coefficients. Value of feedback resistor RF is determined by maximum hysteresis that can be tolerated. —Microlin Amplifiers ZLD2S and ZLD2T, Ferranti Ltd., Oldham, Lancs., England, Report 11, 1967, p 13.


+6 V
⑩
⑨
VOUT
VIN
①
CA3000
⑧
R1
27000 OHMS
⑥
R2
250000 OHMS
②
③
⑤
-6 V

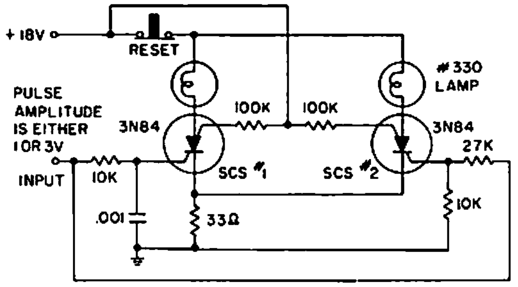
IC SCHMITT—Only two resistors need be added to IC d-c amplifier to give stable and predictable operation as Schmitt trigger. Book gives design equations.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 129.


IN
NOR
NOR
NOR
OUT
ti
ti
a

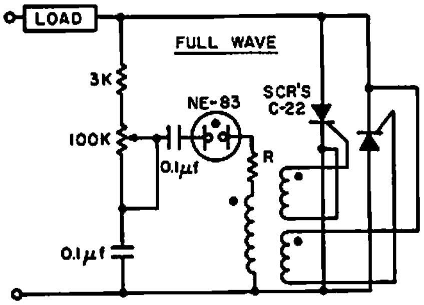
THREE NOR'S GIVE SPIKE—Used to provide trigger pulse in digital system at time when clock pulse is not available. Switching delay times of logic elements are used to generate narrow output pulse whenever d-c level of input changes. With values shown, output pulse width is three times that of individual NOR gate.—D. R. Hobaugh, NOR Gates Generate Non-Clocked Output Pulse, *Electronic Design*, Dec. 20, 1965, p 50–51.


+5
1.8K
2.2K
1.5K
FAIRCHILD S-7141
5.6K
-6

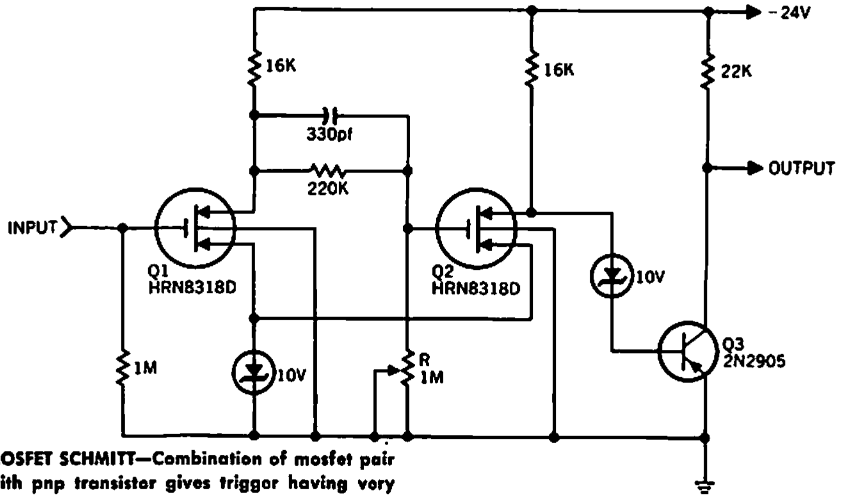
NOR CIRCUIT


+18V
RESET
#330 LAMP
PULSE AMPLITUDE IS EITHER 1 OR 3V
INPUT
3N84
100K
100K
3N84
27K
10K
SCS #1
SCS #2
.001
33Ω
10K

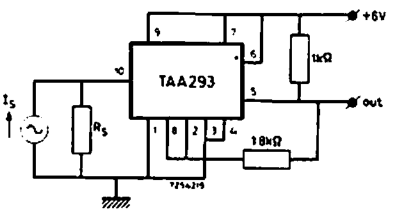
VOLTAGE-LEVEL INDICATOR LAMPS—Pulse amplitude of 1 V triggers SCS-1 and turns on associated incandescent lamp without affecting other lamp. 3-V pulse is delayed by R-C integrating network for SCS-1 and therefore triggers SCS-2 first. This raises common emitter voltage, preventing SCS-1 from triggering, so only right-hand lamp comes on to indicate presence of 3-V pulse.—Planar Silicon Controlled Switch 3N84/3N85, General Electric, Syracuse, N.Y., No. 65.18, 1964.


LOAD
FULL WAVE
3K
NE-83
SCR'S C-22
100K
0.1μf
R
0.1μf

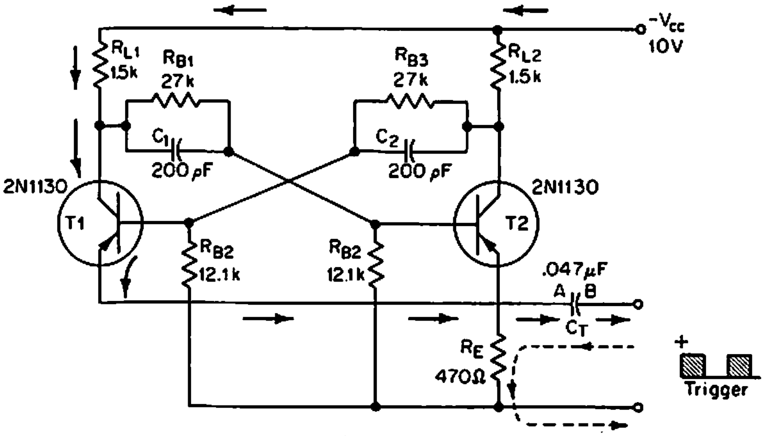
FULL-WAVE NEON—Neon provides triggering of scr when voltage across the two capacitors reaches its breakdown voltage in range of 60 to 100 V. Will control scr from full off up to 95% of total rms load voltage. Pulse transformer fires scrs alternately. Neon gives visual indication that one of scrs is receiving triggering pulse.—C. R. Dougherty, Neon Trigger Circuits for SCR's, *Electronic Design*, Jan. 6, 1964, p 78.


-24V
16K
16K
22K
330pf
220K
OUTPUT
INPUT
Q1 HRN8318D
Q2 HRN8318D
10V
Q3 2N2905
1M
10V
R 1M

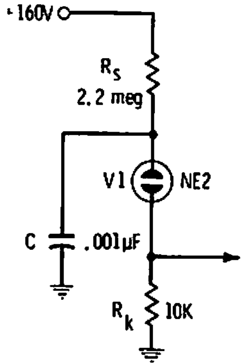
MOSFET SCHMITT—Combination of mosfet pair with pnp transistor gives trigger having very high input impedance, low output impedance, and good temperature stability. Zeners used for generating reference voltage and shifting level can be changed to allow for different detection levels. Adjust R so Q1 is nonconducting and Q2 is fully on; input signal about 3 V more negative than zener reference voltage will then operate trigger.—C. R. Perkins, "Application of MOSFET Devices to Electronic Circuits," Hughes, Newport Beach, Cal., 1968, p 34.


+6V
9
7
6
10
TAA293
1kΩ
5
out
I_S
R_S
1
8
2
3
4
18kΩ
7Z54219

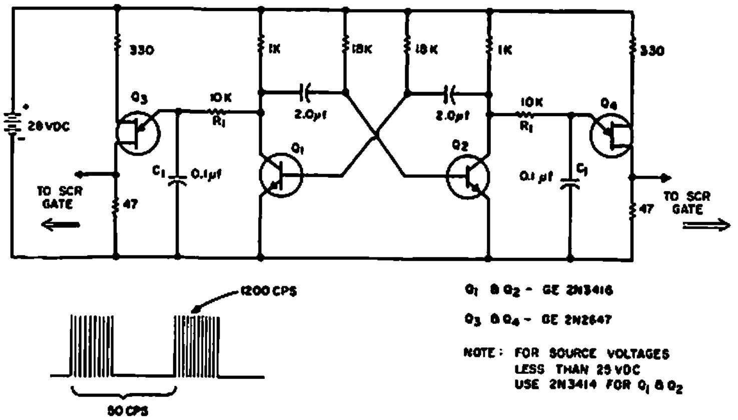
CURRENT-OPERATED SCHMITT IC—Uses Philips TAA293 general-purpose amplifier. With zero input current, output is about 4 V. At about 26 μA input, circuit switches to low state.—The TAA293 as a Schmitt Trigger and Multivibrator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 25, 1968.


$-V_{CC}$
10V
R_{L1}
1.5k
R_{B1}
27k
C_1
200pF
R_{B3}
27k
C_2
200pF
R_{L2}
1.5k
2N1130
T1
R_{B2}
12.1k
R_{B2}
12.1k
2N1130
T2
.047μF
A
B
C_T
R_E
470Ω
+
Trigger

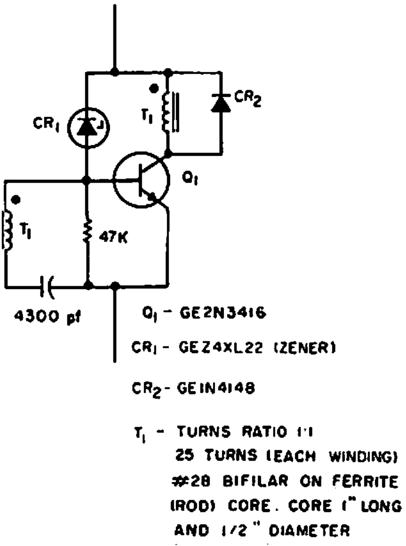
EMITTER-TRIGGERED MVBR—Circuit is basically emitter-triggered flip-flop, developed for use with ring counters, shift registers, and other counters. Often called complemented flip-flop. Most effective at lower trigger frequencies. Book gives design criteria and equations.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 238.


+160V
R_S
2.2 meg
V1
NE2
C
.001μF
R_k
10K

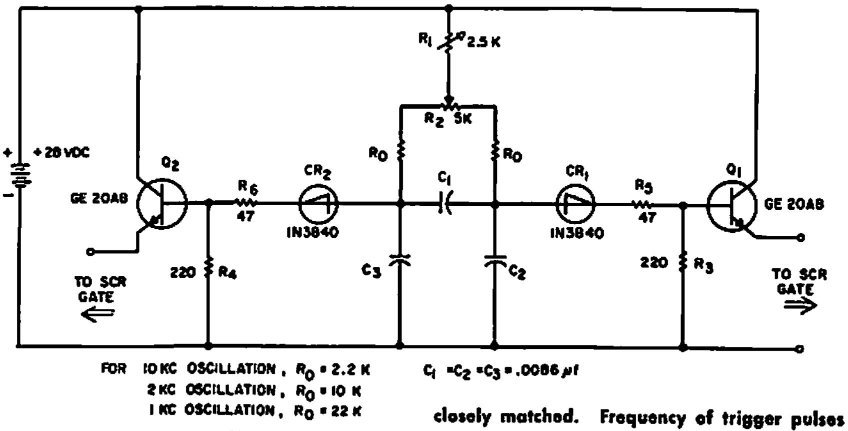
2,400-HZ NEON—Trigger pulse reaches maximum amplitude of 5 V p-p in less than 10 μs. Value of 10K resistor may be varied for different pulse height.—W. G. Miller, "Using and Understanding Miniature Neon Lamps," H. W. Sams & Co., Indianapolis, Ind., 1969, p 40.


330
1K
18K
18K
1K
330
28VDC
Q_3
10K
R_1
2.0μf
2.0μf
10K
R_1
Q_4
Q_1
Q_2
C_1
0.1μf
0.1μf
C_1
TO SCR GATE
47
47
TO SCR GATE
1200 CPS
60 CPS
Q_1 & Q_2 - GE 2N3416
Q_3 & Q_4 - GE 2N2647
NOTE: FOR SOURCE VOLTAGES LESS THAN 25 VDC USE 2N3414 FOR Q_1 & Q_2

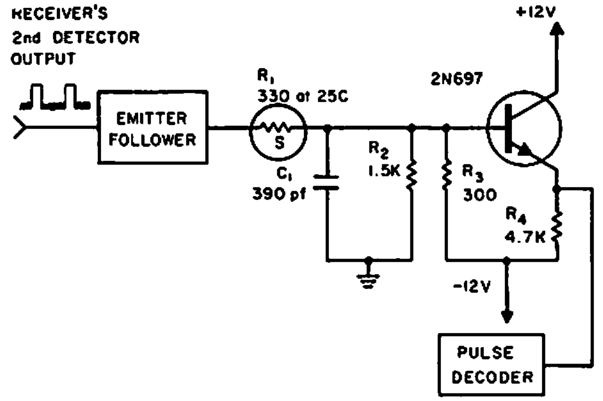
PULSE TRAIN GENERATOR—Used to maintain triggering of scr during major portion or all of conduction period. Transistor mvbr provides alternate driving voltages to ujt oscillators. Pulse frequency within train of pulses is determined by R1C1 time constant, and is 1,200 Hz for values shown. Frequency of flip-flop Q1-Q2 determines frequency of scr output.—J. C. Hey, Simple Circuits for Triggering SCR's Into Fast-Rising Load Currents, General Electric, Syracuse, N.Y., No. 200.41, 1965, p 6.


CR_1
T_1
CR_2
Q_1
T_1
47K
4300 pf
Q_1 - GE2N3416
CR_1 - GEZ4XL22 (ZENER)
CR_2 - GE1N4148
T_1 - TURNS RATIO 1:1
25 TURNS (EACH WINDING)
#28 BIFILAR ON FERRITE
(ROD) CORE. CORE 1" LONG
AND 1/2" DIAMETER

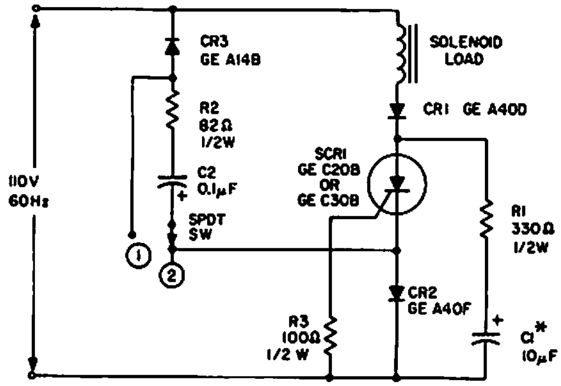
TRIGGER-DIODE EQUIVALENT—Developed for applications where driving voltage for trigger is too low for available trigger diodes. Uses low-cost components.—J. C. Hey, Simple Circuits for Triggering SCR's Into Fast-Rising Load Currents, General Electric, Syracuse, N.Y., No. 200.41, 1965, p 4.


R_1
2.5K
R_2 5K
+
+28VDC
-
Q_2
GE 20AB
R_O
R_O
R_6
47
CR_2
IN3840
C_1
CR_1
IN3840
R_5
47
Q_1
GE 20AB
TO SCR GATE
220
R_4
C_3
C_2
220
R_3
TO SCR GATE
FOR 10KC OSCILLATION, R_O = 2.2 K
2KC OSCILLATION, R_O = 10 K
1KC OSCILLATION, R_O = 22 K
C_1 = C_2 = C_3 = .0086μf

FLIP-FLOP TRIGGER FOR TWO SCR's—Provides alternate output pulses as required for two-scr inverter circuits. R1 adjusts frequency. R2 adjusts symmetry. Capacitors should be closely matched. Frequency of trigger pulses depends on value of resistors RO.—J. C. Hey, Simple Circuits for Triggering SCR's Into Fast-Rising Load Currents, General Electric, Syracuse, N.Y., No. 200.41, 1965, p 3.

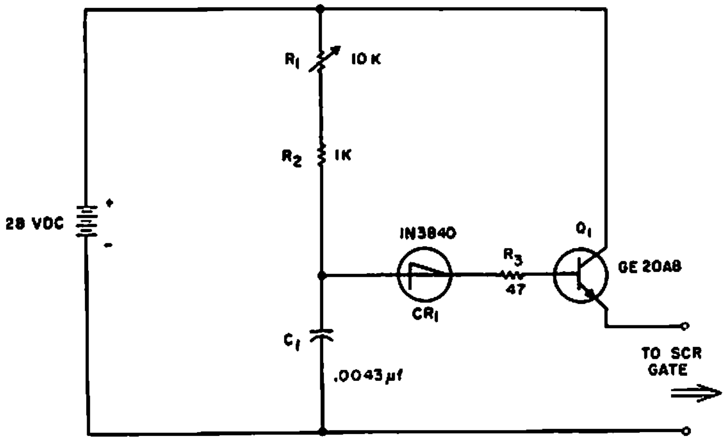

RECEIVER'S 2nd DETECTOR OUTPUT
EMITTER FOLLOWER
R_1 330 at 25C
S
C_1 390 pf
R_2 1.5K
R_3 300
R_4 4.7K
2N697
+12V
-12V
PULSE DECODER

SUPPRESSING NOISE TRIGGERING—Insertion of low-pass filter at second detector output of pulse-decoding receiver, using temperature-sensing Sensistor as resistive element R1, improves trigger sensitivity by making bandwidth decrease with increasing temperature. At −40 C, 3-dB bandwidth is 3.9 MHz, as compared to 2.7 MHz at 50 C.—C. Samocki, Temperature Varies Bandwidth to Improve Trigger Sensitivity, *Electronic Design*, Jan. 4, 1965, p 77–78.

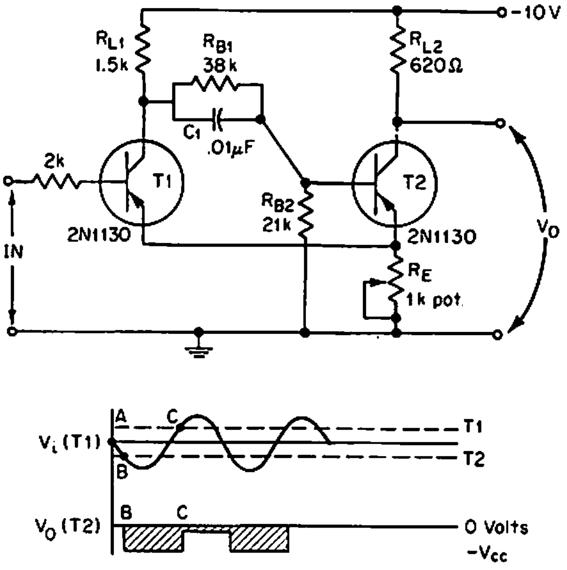

CR3 GE A14B
R2 82Ω 1/2W
C2 0.1μF
SPDT SW
①
②
110V 60Hz
SOLENOID LOAD
CR1 GE A40D
SCR1 GE C20B OR GE C30B
R1 330Ω 1/2W
CR2 GE A40F
R3 100Ω 1/2 W
C1* 10μF

*TIME CONSTANT OF C1 R1 MAY NEED TAILORING DEPENDING ON HOLDING CURRENT OF SCR1.

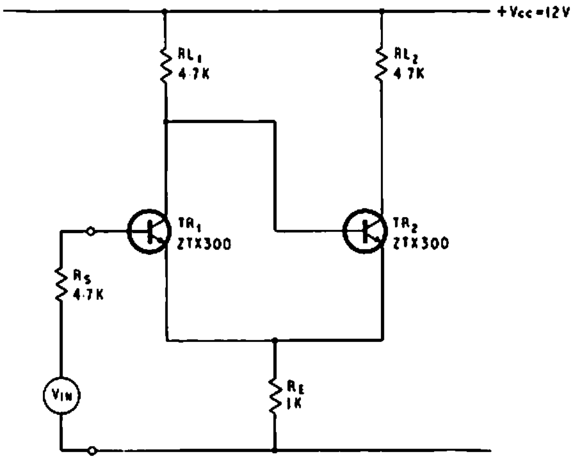
POSITIVE HALF-CYCLE SCR TRIGGER—When pushbutton switch SW is moved from 1 to 2, scr will trigger near beginning of next positive half-cycle and stay on only for balance of that half-cycle. Switch may be closed randomly at any time during the two preceding half-cycles. Scr will not trigger again until SW is opened and then reclosed. This type of one-shot logic is used in some test equipment supplies and for solenoid drives of electronic hammers and stapling guns, where load current must flow only for one half-cycle. —"SCR Manual," 4th Edition, General Electric, 1967, p 151–152.


28 VDC
R_1 10 K
R_2 1K
1N3840
CR_1
R_3 47
Q_1
GE 20A8
C_1 .0043μf
TO SCR GATE

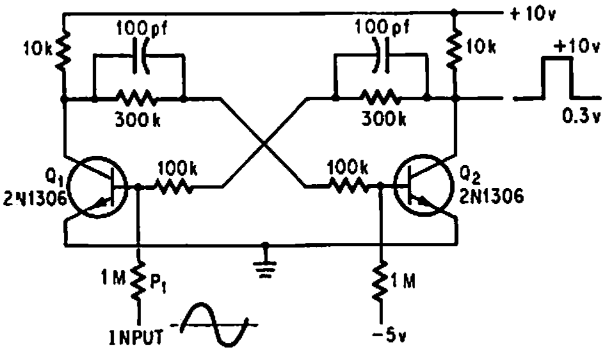
SIMPLE SCR TRIGGER—C1 charges through R1-R2 to 25-V breakover of 1N3840 trigger diode, then discharges through diode into base of power transistor Q1 to make it produce high-current output pulse of about 20 V for applying to gate of scr as trigger. Stray circuit inductances must be minimized to give required current rise of 10 A per μs. Repetition rate of trigger pulses is adjusted with R1.—J. C. Hoy, Simple Circuits for Triggering SCR's Into Fast-Rising Load Currents, General Electric, Syracuse, N.Y., No. 200.41, 1965, p 3.


-10V
R_{L1} 1.5k
R_{B1} 38k
C_1 .01μF
R_{L2} 620Ω
2k
T1
2N1130
IN
R_{B2} 21k
T2
2N1130
R_E 1k pot
V_O
V_i (T1)
A
C
B
T1
T2
V_O (T2)
B
C
0 Volts
$-V_{cc}$

BASIC SCHMITT—Chief uses are converting sine wave into rectangular wave, reshaping distorted rectangular waves, and detecting presence of signals. Book gives design criteria.—A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 244.

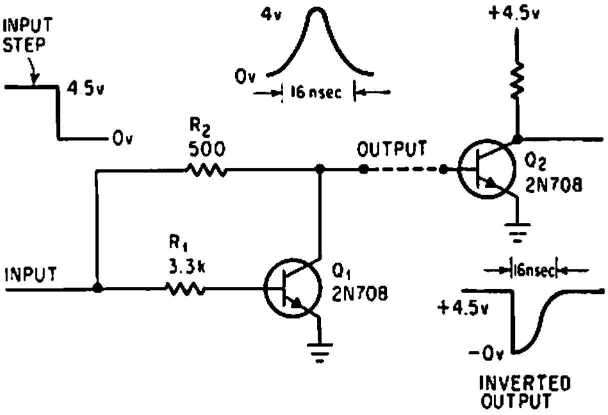

+Vcc=12V
RL1 4·7K
RL2 4·7K
TR1 ZTX300
TR2 ZTX300
Rs 4·7K
VIN
RE 1K

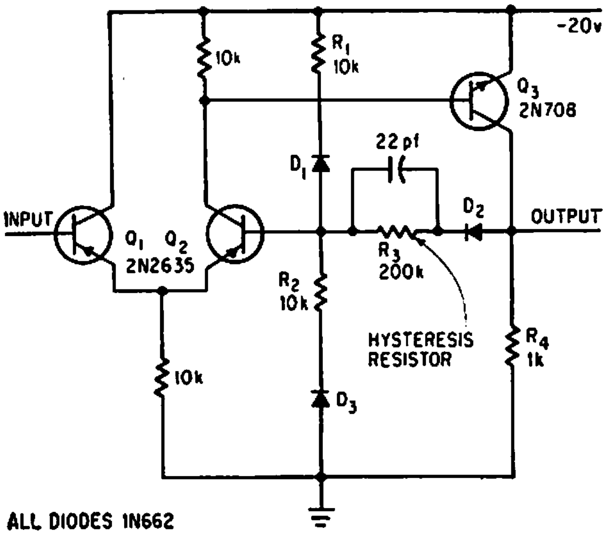
LEVEL-OPERATED SWITCH—Feedback through common emitter resistor of Schmitt trigger makes circuit switch rapidly from on to off and vice versa. Design equations are given. —"E-Line Transistor Applications," Ferranti Ltd., Oldham, Lancs., England, 1969, p 19.


+10v
10k
100pf
300k
100pf
10k
+10v
300k
0.3v
Q1 2N1306
100k
100k
Q2 2N1306
1M
P1
1M
INPUT
-5v

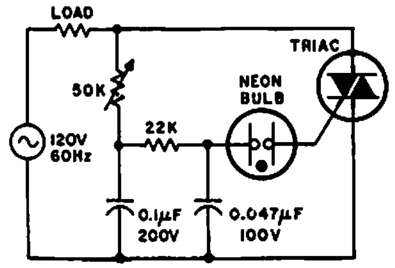
ADJUSTABLE HYSTERESIS—Potentiometer P1 at input of conventional flip-flop determines threshold level at which input signal turns Q1 on and Q1 off to generate output step. Ideal for generating square pulses from sine waves or for providing binary output from transducer. Setting of P1 also controls amount of hysteresis, for preventing chatter in trigger circuit as it changes state if 60-Hz hum is picked up by sensing transducer.—D. Schoon, Potentiometer Turns Flip-flop Into An Adjustable Trigger, *Electronics*, Sept. 4, 1967, p 95–96.

SPIKE GENERATOR—Simple capacitorless circuit differentiates leading edge of rectangular input pulse, to produce fixed-width triggering spikes about 16 ns wide. Can be built with RTL IC's.—G. A. May, Differentiating Pulse Former Requires No Capacitors, *Electronics*, May 1, 1967, p 70–71.

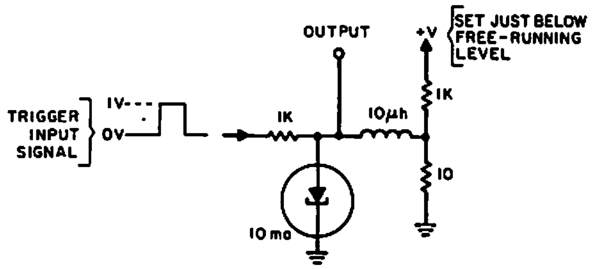

INPUT STEP
4.5v
0v
4v
0v
16nsec
+4.5v
R2 500
OUTPUT
Q2 2N708
R1 3.3k
INPUT
Q1 2N708
16nsec
+4.5v
-0v
INVERTED OUTPUT


-20v
10k
R1 10k
Q3 2N708
22pf
D1
D2
INPUT
Q1 Q2 2N2635
R3 200k
OUTPUT
R2 10k
HYSTERESIS RESISTOR
R4 1k
10k
D3
ALL DIODES 1N662

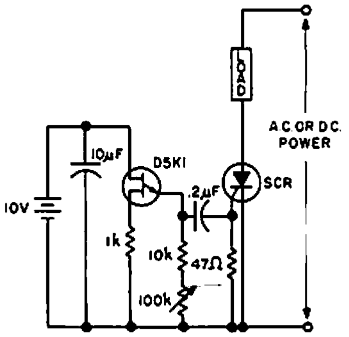
HIGH-IMPEDANCE SCHMITT—Input impedance is over 2,000 ohms, about 200 times greater than conventional Schmitt, as required for squaring low-power information signals. Trip points and hysteresis of circuit remain stable and predictable over wide temperature range. Q1 and Q2 form current-mode switch controlling Q3.—G. Moresi, Differential Schmitt Trigger with 200-K Input Impedance, *Electronics*, Jan. 23, 1967, p 90–91.


LOAD
TRIAC
50K
NEON
BULB
22K
120V
60Hz
0.1μF
200V
0.047μF
100V

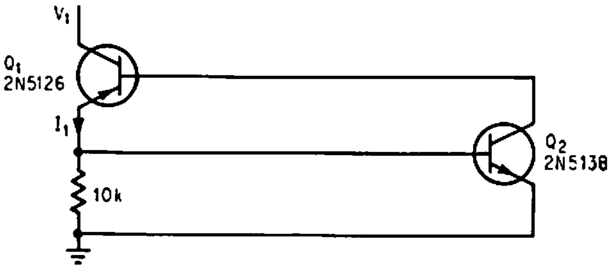
NEON TRIGGER FOR TRIAC—Choice of triac depends on load. For maximum precision of triggering, neon should be shielded against radiation.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 237.


OUTPUT
+V
SET JUST BELOW
FREE-RUNNING
LEVEL
TRIGGER
INPUT
SIGNAL
1V
0V
1K
10μh
1K
10
10 ma

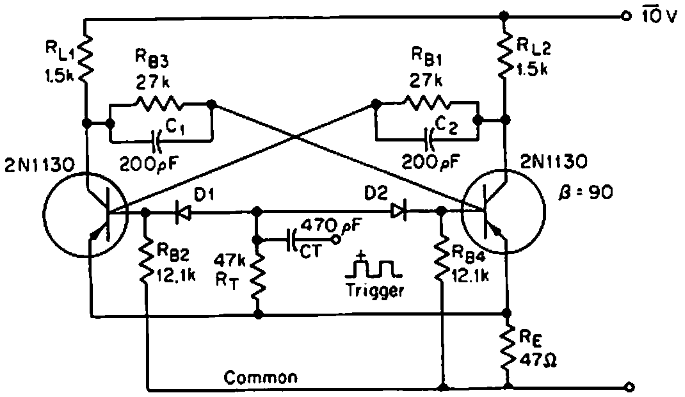
TUNNEL-DIODE TRIGGER—Simple one-shot mvbr is triggered by 1-V pulse. One drawback, however, is varying response to different trigger signals because of manner in which one-shot recovers triggering sensitivity. Article presents pseudo-Schmitt circuit that eliminates these uncertainties in trigger logic. —H. A. Zimmerman, Pseudo-Schmitt Eliminates Uncertainties in Trigger Logic, *Electronic Design*, Nov. 22, 1965, p 30–35.


LOAD
A.C. OR D.C.
POWER
10μF
D5K1
.2μF
SCR
10V
1k
10k
47Ω
100k

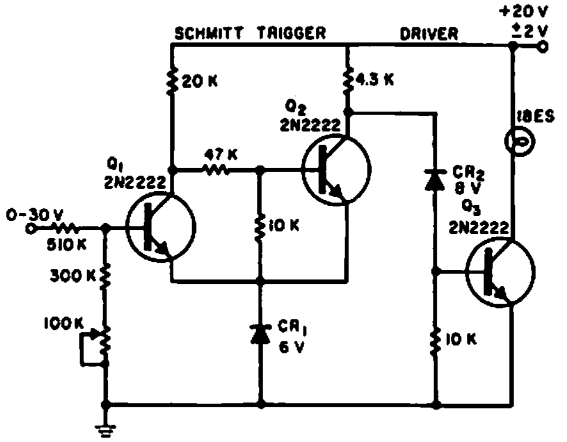
POSITIVE-SUPPLY UJT-SCR—Trigger current flows through 10-V supply, with 10-μF capacitor assuring low supply impedance and adequate trigger current. Choice of scr depends on load current.—Silicon Complementary Unijunction Transistor D5K1, General Electric, Syracuse, N.Y., No. 60.15, 1967.


V₁
Q₁
2N5126
I₁
Q₂
2N5138
10k

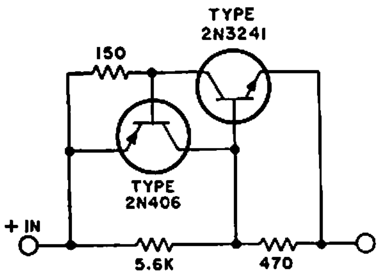
EFFICIENT TRIGGER—Three parts minimize cost while giving good temperature stability, rapid switching, and efficient energy transfer. Utilizes reverse breakdown characteristic of emitter-base junction to set triggering level accurately. Ideal for use as thyristor gate-drive trigger in phase controls.—R. B. Hood, Transistor Breakdown Yields Inexpensive Thyristor Trigger, *Electronics*, Sept. 4, 1967, p 96.


10V
RL1
1.5k
RB3
27k
C1
200pF
RB1
27k
C2
200pF
RL2
1.5k
2N1130
2N1130
β = 90
D1
D2
470pF
CT
RB2
12.1k
47k
RT
Trigger
RB4
12.1k
RE
47Ω
Common

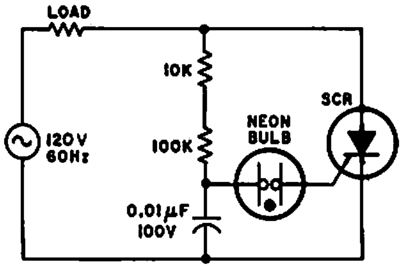
BASE-TRIGGERED FLIP-FLOP—Switching action occurs only on positive excursions of input trigger applied to base, so output frequency is half that of input to complemented flip-flop (4,000 pps for input of 8,000 pps with values shown), and circuit acts as frequency divider. —A. C. Gillie, "Pulse and Logic Circuits," McGraw-Hill, N.Y., 1968, p 240.


+20 V
±2 V
SCHMITT TRIGGER
DRIVER
20 K
4.3 K
Q₂
2N2222
18ES
47 K
Q₁
2N2222
CR₂
8 V
Q₃
2N2222
0-30 V
510 K
10 K
300 K
100 K
CR₁
6 V
10 K

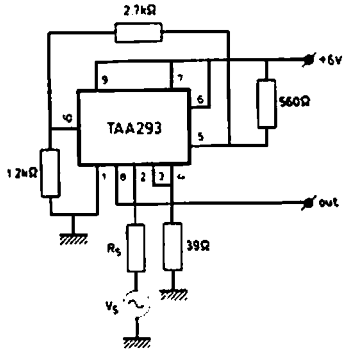
ZENER IMPROVES TRIGGERING ACCURACY—Replacement of feedback resistor with 6-V zener CR1 in Schmitt trigger narrows range between turn-on and turn-off voltages from 4 V to about 0.3 V.—R. E. Risely, Zener Diode Reduces Schmitt Trigger Hysteresis, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 93.


TYPE
2N3241
150
TYPE
2N406
+ IN
5.6K
470

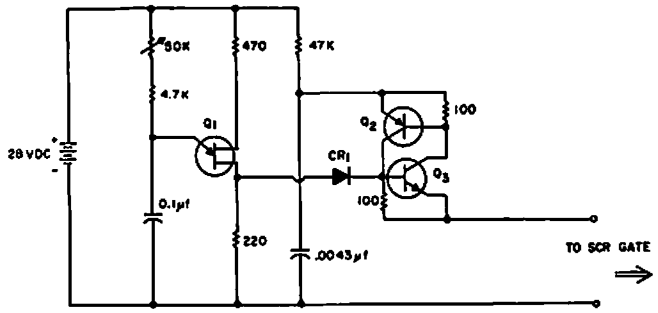
TWO TRANSISTORS EQUAL ONE DIODE—Regenerative action of circuit, when either transistor begins to conduct, causes switching comparable to avalanching in trigger diode. With proper biasing, circuit will trigger at 15 V or less.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 240.


LOAD
120V
60Hz
10K
100K
NEON
BULB
SCR
0.01μF
100V

NEON TRIGGER FOR SCR—Possible drawback is effect of radiation on breakdown point of neon. For precise control, neon should be shielded or specially treated for radiation. Low cost and long life are offsetting advantages.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 237.

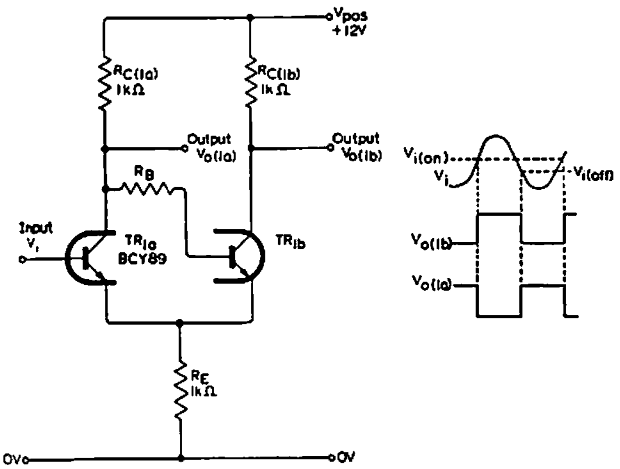

2.7kΩ
+6V
9
7
6
10
TAA293
5
560Ω
1.2kΩ
1
8
2
3
4
out
R_s
39Ω
V_s

VOLTAGE-OPERATED SCHMITT IC—Uses Philips TAA293 general-purpose amplifier connected as emitter-coupled Schmitt followed by output amplifier. Output voltage is 5 to 6 V p-p depending on saturation voltage of output transistor. Rise time is about 200 ns and fall time 40 ns.—The TAA293 as a Schmitt Trigger and Multivibrator, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 25, 1968.

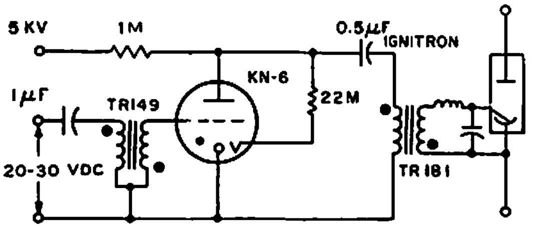

50K
470
47K
4.7K
Q1
28 VDC
+
-
Q_2
100
CR1
Q_3
100
0.1μf
220
.0043μf
TO SCR GATE

CR1 – GE 1N4154
Q1 – GE 2N2646
Q2 – 2N3638 (FOR SUPPLY VOLTAGE LESS THAN 25 VDC)
– 2N3133 (FOR SUPPLY VOLTAGE UP TO 35 VDC
Q3 – 2N3414 (FOR SUPPLY VOLTAGE LESS THAN 25VDC)
– 2N3416 (FOR SUPPLY VOLTAGE UP TO 35 VDC)

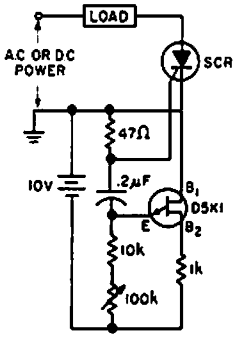
REGENERATIVE TRANSISTOR PAIR AS SCR TRIGGER—Can be used when trigger-circuit driving voltage is too low for available trigger diodes. Ujt Q1 provides external sync pulse at desired triggering frequency.—J. C. Hey, Simple Circuits for Triggering SCR's Into Fast-Rising Load Currents, General Electric, Syracuse, N.Y., No. 200.41, 1965, p 5.


Vpos
+12V
$R_{C(Ia)}$
1kΩ
$R_{C(Ib)}$
1kΩ
Output
$V_{o(Ia)}$
Output
$V_{o(Ib)}$
$V_{i(on)}$
V_i
$V_{i(off)}$
R_B
Input
V_i
TR_{Ia}
BCY89
TR_{Ib}
$V_{o(Ib)}$
$V_{o(Ia)}$
R_E
1kΩ
0V
0V

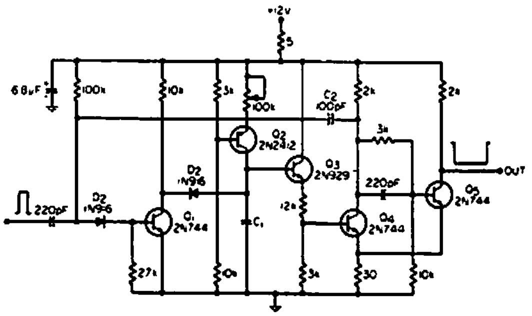
STABLE SCHMITT—Close thermal coupling of transistor pair results in trigger (input) voltages more stable over entire frequency range than separate transistors.—"Circuits Using Low-Drift Transistor Pairs," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Application Book, 1968, p 25.


5 KV
1M
0.5μF
IGNITRON
KN-6
1μF
TR149
22M
20-30 VDC
TR 181

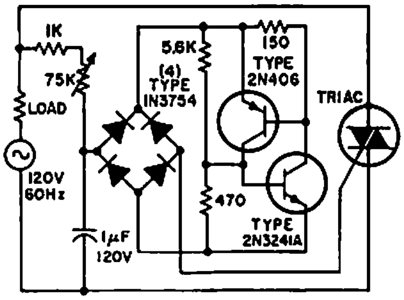
KRYTRON-TRIGGERED IGNITION—Four-element cold-cathode gas-filled switch tube produces high peak current for short duration through pulse transformer, for triggering industrial ignition.—Krytrons—Cold Cathode Switch Tubes, EG&G, Boston, Mass., KR-100, 1968.


LOAD
AC OR DC POWER
SCR
47Ω
10V
.2μF
B1
D5K1
E
B2
10k
1k
100k

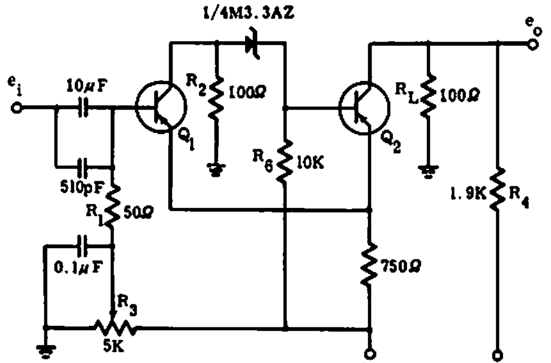
NEGATIVE-SUPPLY UJT-SCR—Complementary ujt makes triggering of scr easier than with positive supply. Choice of scr depends on load current.—Silicon Complementary Unijunction Transistor D5K1, General Electric, Syracuse, N.Y., No. 60.15, 1967.


+12V
5
68μF
100k
10k
3k
100k
C2
100pF
2k
2k
Q2
2N2412
3k
Q3
2N929
OUT
220pF
D2
1N916
D2
1N916
220pF
Q1
2N744
C1
12k
Q4
2N744
Q5
2N744
27k
10k
3k
30
10k

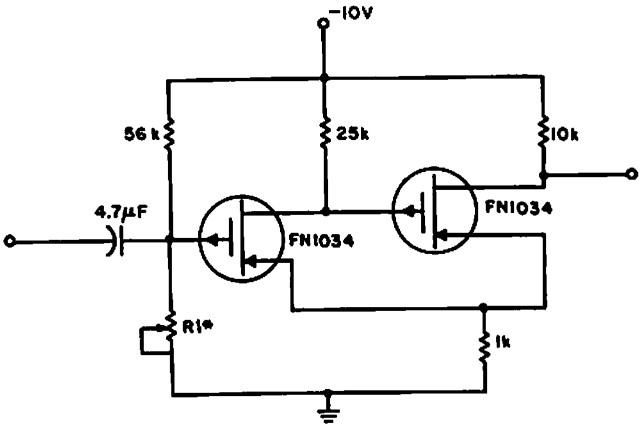
MULTI-SHOT TRIGGER—Period of output pulse depends on number of input trigger pulses occurring while circuit is active. Uses Schmitt trigger Q4-Q5. Article gives design equations.—R. S. Hughes, Multi-Shot Trigger Circuit, *EEE*, June 1967, p 138–139.


1K
75K
LOAD
120V
60Hz
5.6K
(4) TYPE 1N3754
150
TYPE 2N406
TRIAC
470
TYPE 2N3241A
1μF
120V

TWO-TRANSISTOR SCR TRIGGER—Two-transistor circuit, with regenerative action comparable to avalanching in trigger diode, can deliver trigger currents up to 1 A, more than enough for triggering all RCA thyristors. —"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 240.

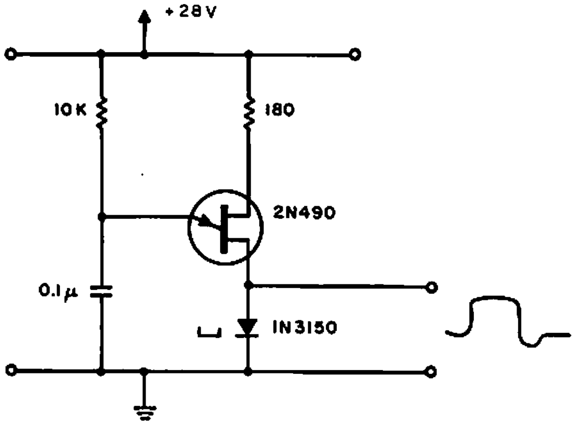

1/4M3.3AZ
e_o
e_i
10μF
R_2
100Ω
Q_1
R_L
100Ω
Q_2
R_6
10K
510pF
R_1
50Ω
1.9K
R_4
0.1μF
750Ω
R_3
5K
+20v
-20v

CURRENT-MODE SCHMITT—50-HMz trigger is inverter modification in which input reference voltage of one stage depends on collector voltage of preceding stage. Bias pot serves as sensitivity-symmetry control. R4 supplies constant current into 100-ohm output load, so output levels are shifted to +1 V and −1 V from levels of 0 and −2 V which would otherwise result. With 2N2258 transistors, rise and fall times are 2 and 3 ns respectively.—"High Speed Switching Transistor Handbook," Motorola, Phoenix, Ariz., 1969, p 283.

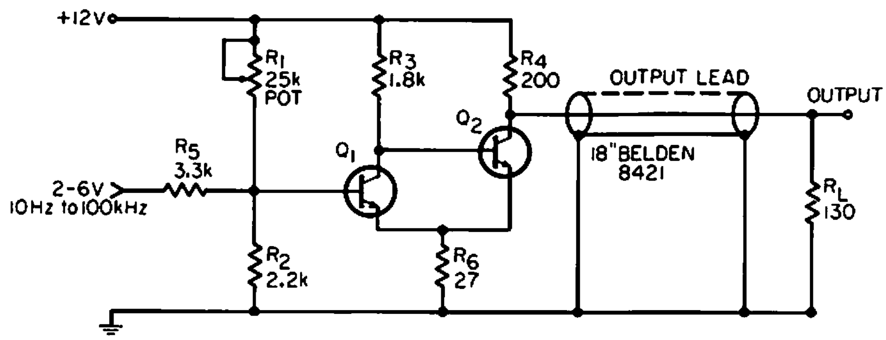

−10V
56k
25k
10k
4.7μF
FN1034
FN1034
R1*
1k

*R1 = 18k FOR $V_{TRIGGER}$ = −1V

BETTER SCHMITT—Two mosfet's provide higher trigger speed, higher input inmpedance, and better temperature stability than transistor version. R1 sets trigger level in range from −2 V to +2 V.—S. Biron, Two MOS-FETs and Resistors Make Better Schmitt Trigger, *Electronic Design*, May 10, 1967, p 92.

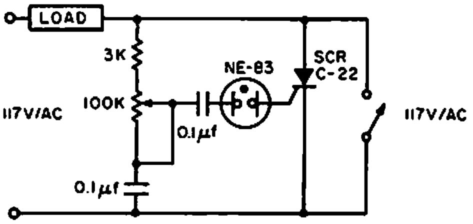

+28V
10K
180
2N490
0.1μ
1N3150

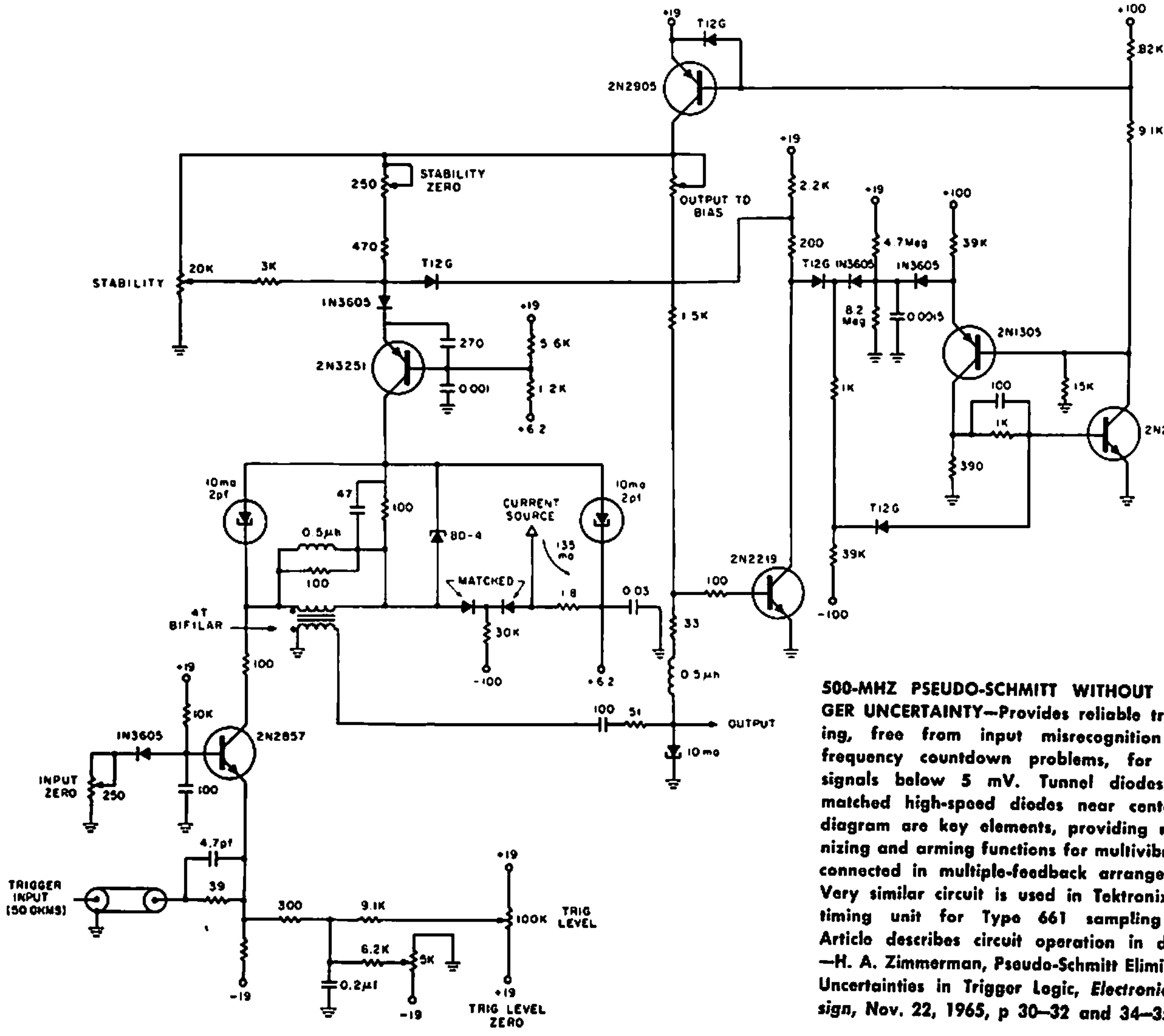
1-NS RISE TIME—Simple modification of ujt relaxation oscillator, driving tunnel diode, serves as fast trigger generator that can deliver high enough output current to simplify amplification and shaping of output waveform.—E. Elad, Tunnel Diode and UJT Produce Ultra-Fast Trigger Output, *Electronic Design*, June 7, 1965, p 40–41.


+12V
R1
25k
POT
R3
1.8k
R4
200
OUTPUT LEAD
OUTPUT
Q2
Q1
R5
3.3k
2-6V
10Hz to 100kHz
18" BELDEN
8421
RL
130
R2
2.2k
R6
27

10 HZ–100 KHZ FAST-RISE SCHMITT—Requires no capacitors, and transistors may be low-cost types such as 2N4418, 2N4275, or MPS2369. Waveform is excellent at all frequencies without adjustment of component values, and both rise and fall times are less than 12 ns. May be used for sine-square wave conversion.—J. H. Cono, Simplified Schmitt Yields Fast Rise Time, *EEE*, April 1968, p 108.

HALF-WAVE NEON—Controls scr from full off up to 95% of half-wave rms output voltage. Closing switch applies full power. Neon also provides visual indication that scr is receiving triggering pulse.—C. R. Dougherty, Neon Trigger Circuits for SCR's, *Electronic Design*, Jan. 6, 1964, p. 78.


LOAD
3K
NE-83
SCR
C-22
117V/AC
100K
0.1μf
117V/AC
0.1μf

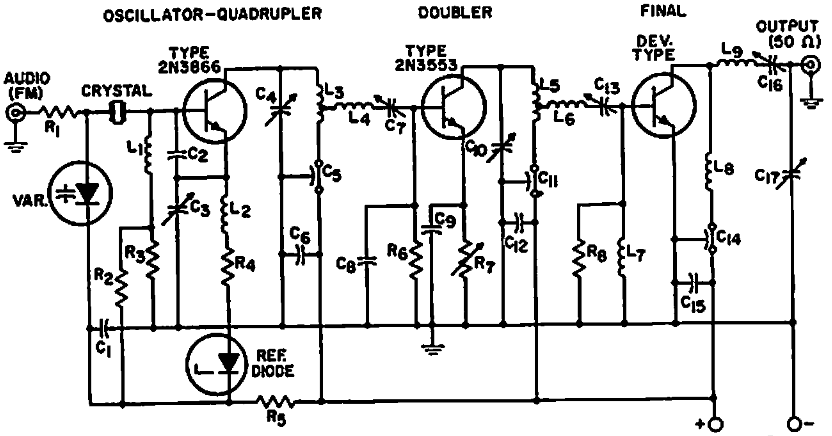

+19
T12G
2N2905
+100
82K
91K
250
STABILITY ZERO
OUTPUT TO BIAS
+19
2.2K
+19
+100
470
200
4.7Meg
39K
STABILITY
20K
3K
T12G
T12G
1N3605
1N3605
1N3605
8.2 Meg
0.0015
1.5K
+19
270
5.6K
2N3251
0.001
1.2K
+6.2
2N1305
1K
100
15K
1K
2N2501
390
10ma 2pf
47
100
CURRENT SOURCE
10ma 2pf
0.5μh
80-4
135 ma
T12G
39K
100
MATCHED
1.8
0.03
100
2N2219
-100
4T BIFILAR
30K
33
-100
+6.2
100
0.5μh
+19
10K
100
51
OUTPUT
1N3605
2N2857
10ma
INPUT ZERO
250
100
4.7pf
+19
TRIGGER INPUT (50 OHMS)
39
300
9.1K
100K
TRIG LEVEL
6.2K
5K
-19
0.2μf
-19
+19
TRIG LEVEL ZERO

500-MHZ PSEUDO-SCHMITT WITHOUT TRIGGER UNCERTAINTY—Provides reliable triggering, free from input misrecognition and frequency countdown problems, for input signals below 5 mV. Tunnel diodes and matched high-speed diodes near center of diagram are key elements, providing recognizing and arming functions for multivibrators connected in multiple-feedback arrangement. Very similar circuit is used in Tektronix 5T3 timing unit for Type 661 sampling cro. Article describes circuit operation in detail. —H. A. Zimmerman, Pseudo-Schmitt Eliminates Uncertainties in Trigger Logic, *Electronic Design*, Nov. 22, 1965, p 30–32 and 34–35.

CHAPTER 94

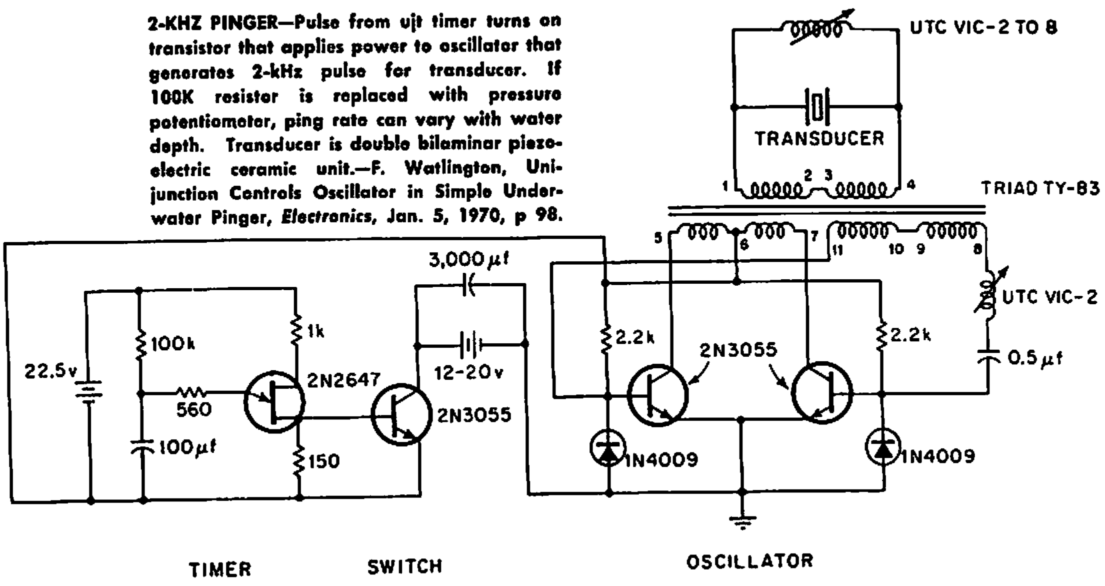
Ultrasonic Circuits

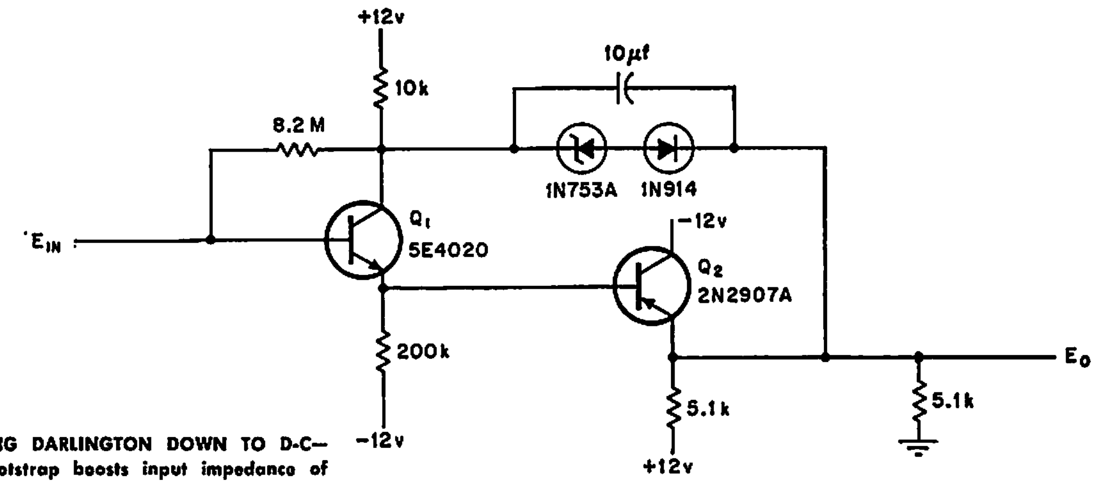
1.5-W SONOBUOY TRANSMITTER—Used with underwater hydrophone to pick up sounds of enemy submarine. Crystal oscillator frequency is 165 MHz. Over-all efficiency is greater than 50% with 12–15 V battery supply. Final stage is straight-through class C amplifier using RCA developmental transistor; if power output of 0.5 W is sufficient, 2N4427 may be used instead.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 344.


OSCILLATOR-QUADRUPLER
DOUBLER
FINAL
OUTPUT (50 Ω)
AUDIO (FM)
CRYSTAL
TYPE 2N3866
TYPE 2N3553
DEV. TYPE
VAR.
REF. DIODE
R1 R2 R3 R4 R5 R6 R7 R8
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15 C16 C17
L1 L2 L3 L4 L5 L6 L7 L8 L9
+ −
VCC • 15 V

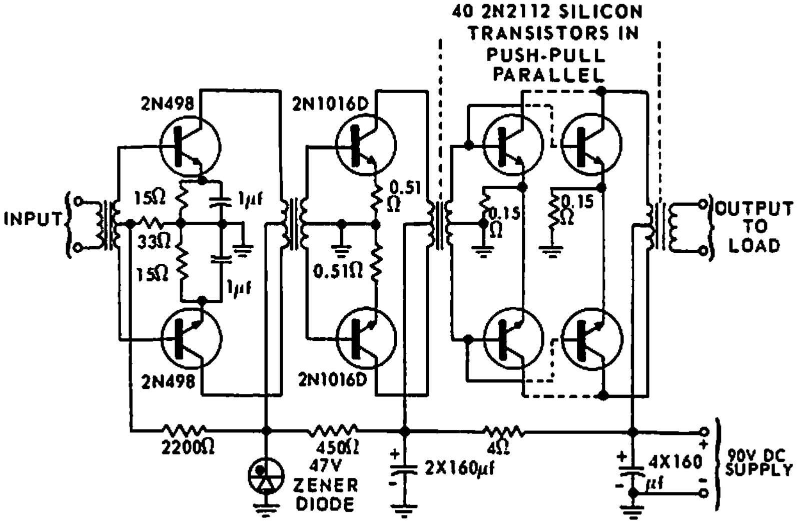
C_1 = 0.05 µF
C_2 = 75 pF
C_3 = 32-250 pF
C_4, C_{10}, C_{16}, C_{17} = 3-35 pF
C_5 = 2200 pF, feedthru
C_6, C_{12}, C_{15} = 0.01 µF
C_7 = 14-150 pF
C_8 = 50 pF
C_9 = 500 pF
C_{11}, C_{14} = 1500 pF, feedthru
C_{13} = 8-60 pF
L_1 = 22 µH
L_2 = 5.5 µH
L_3 = 3 turns No. 16 wire, ¼" ID x ½" long
L_4 = 5 turns No. 22 wire, 5/16" ID (close wound)
L_5 = 2-¼ turns No. 16 wire, ¼" ID x ⅜" long
L_6 = 2-¼ turns No. 18 wire, 7/32" ID (close wound)
L_7, L_8 = 1.0 µH
L_9 = 5 turns No. 16 wire, ¼" ID x ⅜" long
R_1 = 1000 ohms
R_2 = 1200 ohms
R_3 = 47 ohms
R_4 = 10 ohms
R_5 = 100 ohms
R_6 = 51 ohms
R_7 = potentiometer, 50 ohms
R_8 = 100 ohms
Var = varactor
Ref. Diode = 12-volt zener diode

2-KHZ PINGER—Pulse from ujt timer turns on transistor that applies power to oscillator that generates 2-kHz pulse for transducer. If 100K resistor is replaced with pressure potentiometer, ping rate can vary with water depth. Transducer is double bilaminar piezoelectric ceramic unit.—F. Watlington, Unijunction Controls Oscillator in Simple Underwater Pinger, *Electronics*, Jan. 5, 1970, p 98.

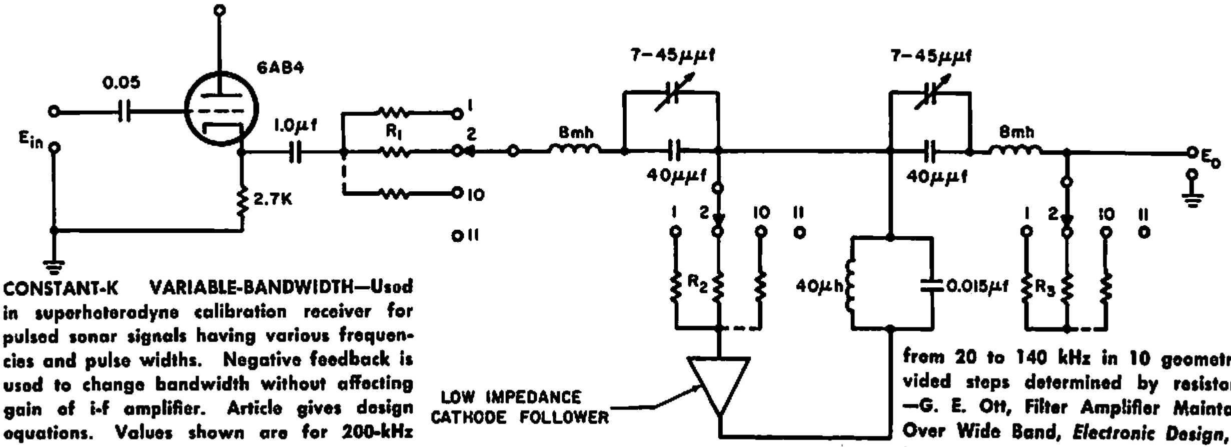

UTC VIC-2 TO 8
TRANSDUCER
TRIAD TY-83
1 2 3 4 5 6 7 8 9 10 11
UTC VIC-2
0.5 µf
3,000 µf
22.5v
100k
1k
560
2N2647
100 µf
150
2N3055
12-20v
2.2k
2N3055
2.2k
1N4009
1N4009
TIMER
SWITCH
OSCILLATOR


+12v
10k
8.2 M
10μf
1N753A
1N914
EIN
Q1
5E4020
−12v
Q2
2N2907A
200k
E0
5.1k
5.1k
−12v
+12v

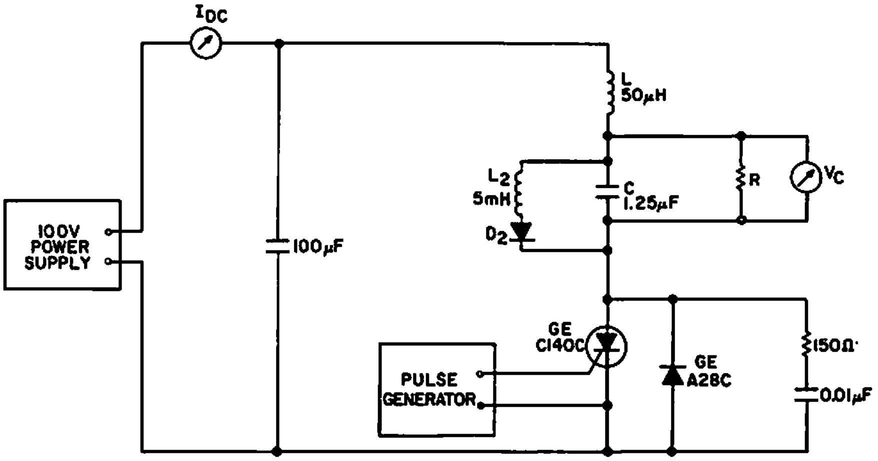
EXTENDING DARLINGTON DOWN TO D-C—Zener bootstrap boosts input impedance of Darlington to 30 meg and assures operation down to d-c signals. Useful as isolation amplifier for applications such as medical sensors and hydrophone transducers. If super-beta transistor such as MC1556 is used for Q1, input resistance is over 100 meg.—R. J. Turner, Zener in Bootstrap Extends Amplifier's Range to D-C, *Electronics*, March 16, 1970, p 88.


40 2N2112 SILICON TRANSISTORS IN PUSH-PULL PARALLEL
2N498
2N1016D
INPUT
15Ω
1μf
33Ω
15Ω
1μf
0.51 Ω
0.51Ω
0.15 Ω
0.15 Ω
OUTPUT TO LOAD
2N498
2N1016D
2200Ω
450Ω
47V ZENER DIODE
2X160μf
4Ω
4X160 μf
90V DC SUPPLY
+
−

10-KW AMPLIFIER—All-transistor amplifier provides better than 50% efficiency in generating 10-kW pulses 250-ms wide with 10% duty cycle, over frequency range of 2 to 12 kHz. When driving crystal for ceramic transducers, tuning reactors are required for power factor correction so amplifier sees resistive load at transmitted frequency. Pulse-shaping network is necessary to prevent dangerous transients at start and finish of keying.—"Silicon Power Transistor Handbook," Westinghouse, Youngwood, Pa., p 6-6.

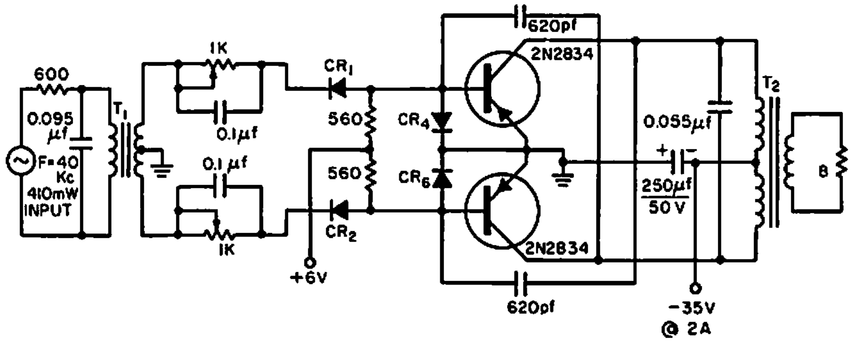

+300v
6AB4
0.05
Ein
1.0μf
R1
1
2
10
11
2.7K
7−45μμf
8mh
40μμf
1
2
10
11
R2
40μh
0.015μf
7−45μμf
8mh
40μμf
1
2
10
11
R3
E0
LOW IMPEDANCE CATHODE FOLLOWER

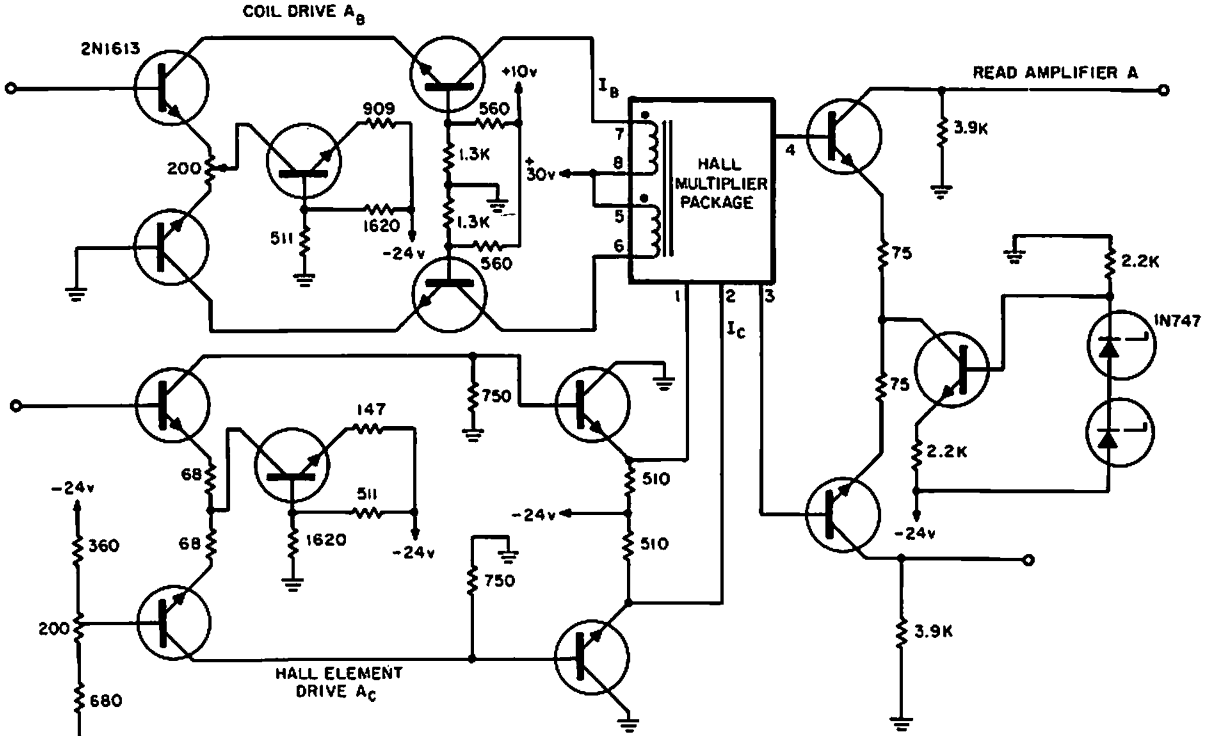
CONSTANT-K VARIABLE-BANDWIDTH—Used in superheterodyne calibration receiver for pulsed sonar signals having various frequencies and pulse widths. Negative feedback is used to change bandwidth without affecting gain of i-f amplifier. Article gives design equations. Values shown are for 200-kHz center frequency, with bandwidth varying from 20 to 140 kHz in 10 geometrically divided steps determined by resistor values.—G. E. Ott, Filter Amplifier Maintains Gain Over Wide Band, *Electronic Design*, Oct. 11, 1965, p 58–61.


I_{DC}
100V POWER SUPPLY
100μF
L 50μH
L2 5mH
D2
C 1.25μF
R
V_C
GE C140C
GE A28C
PULSE GENERATOR
150Ω
0.01μF

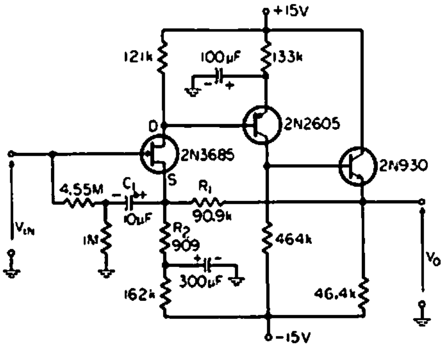
SINGLE-SCR ULTRASONIC INVERTER—Can be driven over frequency range of about 400 to 30,000 Hz by external pulse generator. For values shown, will deliver 500 W at 10,000 Hz from 100 V d-c for ultrasonic cleaning, welding, and mixing applications, induction heating, sonar, fluorescent-lamp dimmers, and d-c/d-c converters. Article gives complete design procedure for adapting circuit to any specific application.—N. Mapham, A Low-Cost, Ultrasonic-Frequency Inverter Using a Single SCR, General Electric, Syracuse, N.Y., No. 671.2, 1966, p 10.

50 W AT 40 KHZ—Power transistors in tuned class C power amplifier achieve 88% efficiency. Can be used for ultrasonic cleaners and fathometers. Power gain is 21 dB. Article gives transformer winding data.—50-W Ultrasonic Amplifier, *Electronic Design*, March 2, 1964, p 58.

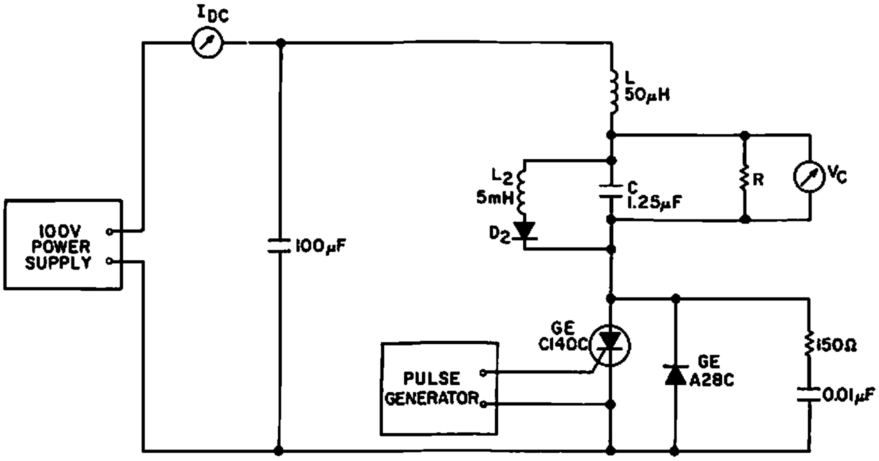

600
0.095 μf
F=40 Kc
410mW INPUT
T_1
1K
0.1μf
0.1 μf
1K
CR_1
560
560
CR_2
+6V
CR_4
CR_6
620pf
2N2834
2N2834
620pf
0.055μf
250μf 50V
T_2
8
-35V @ 2A


COIL DRIVE A_B
2N1613
200
909
560
+10v
1.3K
1.3K
+30v
1620
511
-24v
560
I_B
7
8
5
6
HALL MULTIPLIER PACKAGE
1
2
3
4
I_C
READ AMPLIFIER A
3.9K
75
75
2.2K
2.2K
IN747
-24v
3.9K
147
750
68
68
511
1620
-24v
510
510
-24v
750
-24v
360
200
680
HALL ELEMENT DRIVE A_C

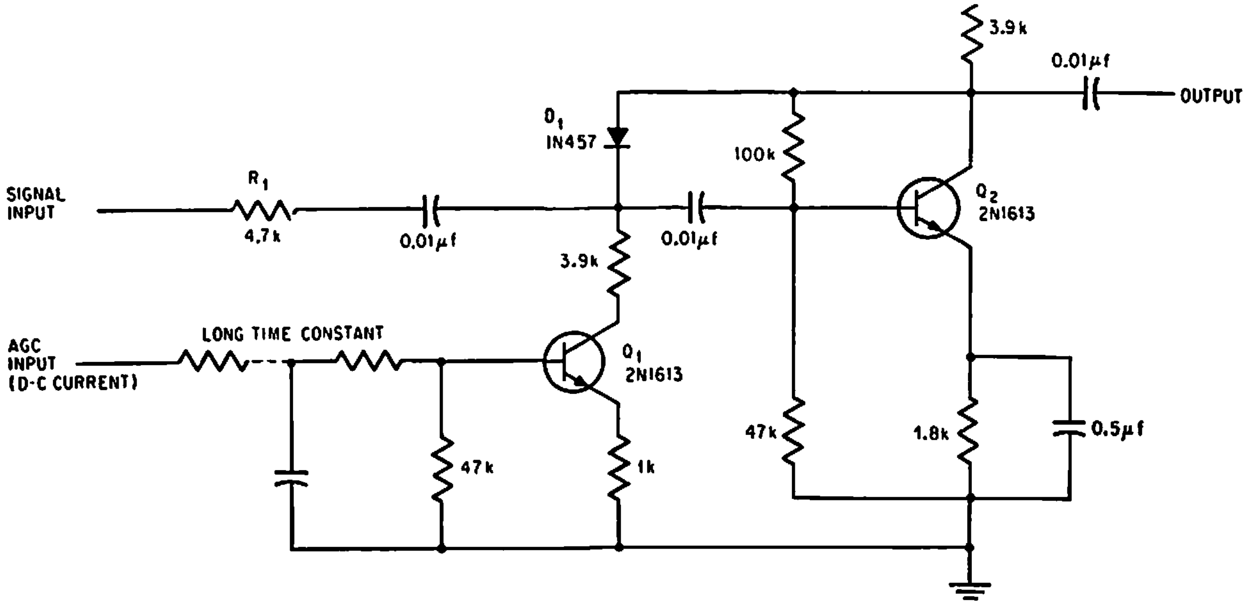
POLAR DISPLAY—Drive and read amplifier circuits shown are for Hall multiplier, two of which are used to transform rectangular coordinates to polar for crt display. Applications include direction-finding, sonar, and ppi radar systems. Both drives are differential amplifiers. Hall multiplier is Helipot model 700 Hallefox.—G. H. Smerage, Hall-Effect Multiplier Simplifies Polar Display, *Electronic Design*, March 29, 1965, p 24, 26, 28–29.


+15V
121k
100µF
133k
D
2N2605
2N3685
2N930
S
4.55M
C1
R1
10µF
90.9k
VIN
1M
R2
909
464k
300µF
162k
46.4k
VO
-15V

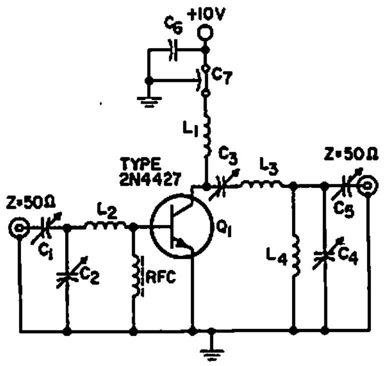
HYDROPHONE PREAMP—Low-noise circuit provides 40 dB gain from 10 to 10,000 Hz when used with 330-pF hydrophone.—W. F. Blodgett, Low-Noise Preamplifier Uses FET, *EEE*, May 1967, p 182.


IDC
L
50µH
L2
5mH
D2
C
1.25µF
R
VC
100V
POWER
SUPPLY
100µF
GE
C140C
GE
A28C
150Ω
0.01µF
PULSE
GENERATOR

BASIC SOLID-STATE INVERTER—Can generate kilowatts of power over frequency range of 400 Hz to 30 kHz for ultrasonic and other applications, with good waveform and good regulation over wide range of loads and phase angles. Requires only single scr, minimizing cost of trigger circuitry. Can handle reactive loads. Applications include ultrasonic cleaning, mixing, and welding with either magnetostrictive or electrostrictive transducers, induction heating, sonar, d-c/d-c converters, regulated d-c power supplies, and high-frequency supplies for fluorescent lamps and fluorescent dimmers. Operates from 100—120 V d-c supply. Frequency is determined by external pulse generators. Article gives design procedure and equations. —N. Mapham, A Low Cost, Ultrasonic Frequency Inverter Using a Single SCR, General Electric, Syracuse, N.Y., No. 200.49, 1967, p 10.

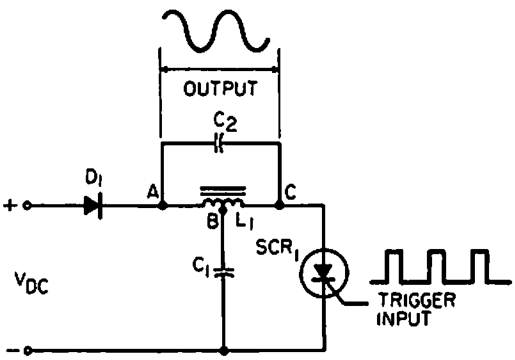

3.9k
0.01µf
OUTPUT
D1
IN457
100k
SIGNAL
INPUT
R1
4.7k
0.01µf
0.01µf
Q2
2N1613
3.9k
AGC
INPUT
(D-C CURRENT)
LONG TIME CONSTANT
Q1
2N1613
47k
1.8k
0.5µf
47k
1k

WIDE-RANGE AGC FOR SONAR—Accepts much greater range of input signal levels than conventional agc circuits while holding undistorted output between 0.5 and 1.5 V for inputs from 0.5 mV to 0.5 V. Frequency range is 20 Hz to 100 kHz. Designed for use in low-cost pleasure-craft sonar.—M. F. Feller, AGC Amplifier Handles 60-DB Range, *Electronics*, Nov. 28, 1966, p 81—82.

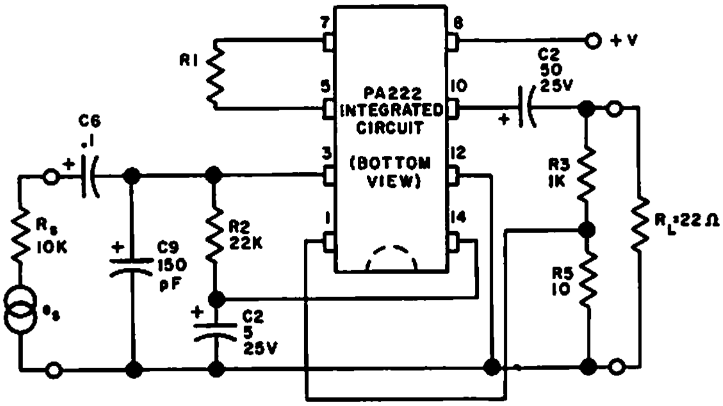

C_6
+10V
C_7
L_1
C_3
L_3
Z=50Ω
TYPE 2N4427
Q_1
Z=50Ω
L_2
C_1
C_2
RFC
L_4
C_4
C_5

C_1, C_2, C_4, C_5 = 7-to-100 pF Arco 423 or equiv.
C_3 = 14-to-150 pF, Arco 424, or equiv.
C_6 = 0.01 μF, 50 V
C_7 = 1000 pF, feedthru
L_1 = 0.75 μH
L_2 = 1 turn No. 18 wire, 5/32" ID
L_3 = 1½ turns No. 18 wire, ¼" ID
L_4 = 1¼ turns No. 18 wire, 3/16" ID
RFC = 450 ohms, ferrite

175-MHZ SONOBUOY OUTPUT STAGE—Straight-through class C power output stage delivers 500 mW for 60 mW drive power.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 345.


OUTPUT
C_2
D_1
A
C
B
L_1
SCR_1
C_1
+
V_{DC}
−
TRIGGER INPUT

100 W AT 1–20 KHZ WITH SCR—Simple scr circuit has better than 90% efficiency in generating ultrasonic sine-wave output at frequency of input trigger which can be simple mvbr or ujt oscillator. If 60-Hz line voltage is used in place of d-c supply, will give bursts of ultrasonic power. Values of components are not critical, even though they determine operating frequency.—H. R. Camenzind, Seesaw Circuit Gives Sine-Wave Power, *EEE*, Dec. 1966, p 119–120.

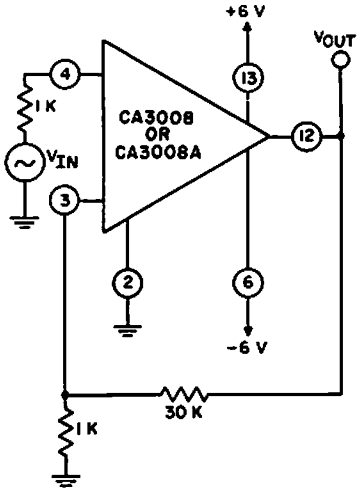

R1
7
8
+V
C2 50 25V
5
10
PA222 INTEGRATED CIRCUIT (BOTTOM VIEW)
C6 .1
3
12
R3 1K
1
14
R_s 10K
C9 150 pF
R2 22K
R5 10
R_L=22Ω
e_s
C2 5 25V
+

50–100,000 HZ IC AMPLIFIER—Input resistance is about 22K. Distortion level at output is 3% at about 1 W. R1 is selected to adjust no-signal current drain, and can be 68K, 100K, or 150K.—Integrated Circuit Audio Amplifier PA222, General Electric, Syracuse, N.Y., No. 85.20, 1967.

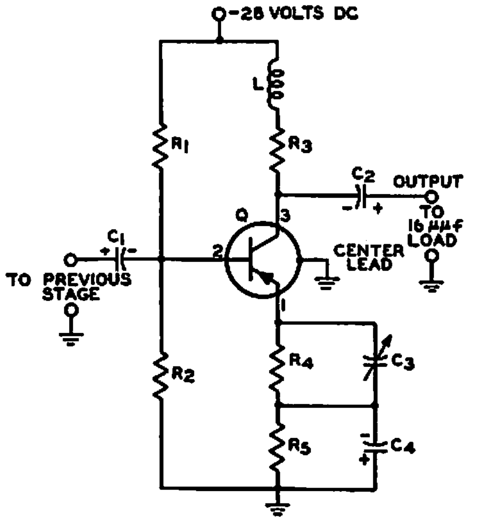
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 95

Video Circuits

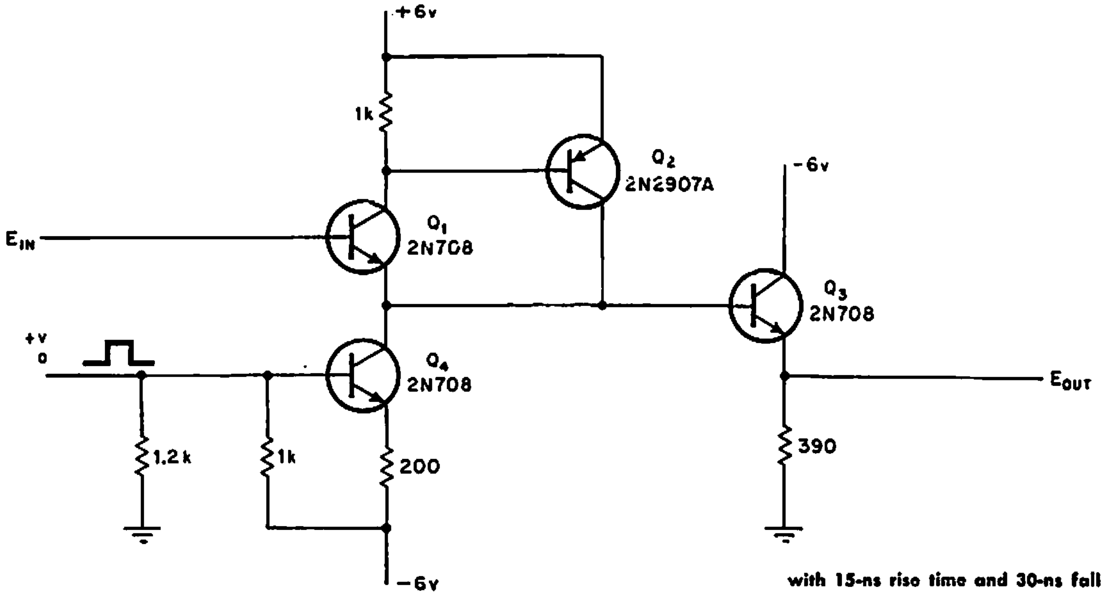

+6 V
VOUT
4
1 K
CA3008
OR
CA3008A
13
12
VIN
3
2
6
-6 V
30 K
1 K

30-DB NONINVERTING WITHOUT PHASE COMPENSATION—IC opamp with only three external resistors provides flat response to 2 MHz, with gain then increasing to peak at 4.5 MHz before dropping down to zero above 10 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 247.

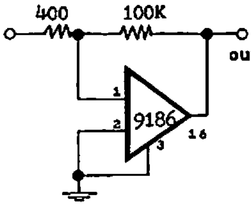

-28 VOLTS DC
L
R1
R3
C2
OUTPUT
TO
16 µµf
LOAD
Q
3
C1
2
CENTER
LEAD
TO PREVIOUS
STAGE
1
R4
C3
R2
R5
C4

$C_1 = 25\ \mu F$
$C_2 = 25\ \mu F$
$C_3 = 100$ to 300 pF
$C_4 = 100\ \mu F$
$L = 30\ \mu H$
$R_1 = 20000$
$R_2 = 3600$
$R_3 = 2000$
$R_4 = 62$
$R_5 = 620$

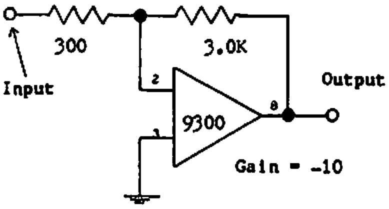
LOW-LEVEL VIDEO AMPLIFIER—Uses 2N274 pnp transistor having cutoff frequency of 30 MHz. At 12.5 MHz, input resistance is 150 ohms, output resistance 4,000 ohms, and power gain up to 27 dB.—"Transistor Manual," RCA, Harrison, N.J., SC-13, p 130.


+6v
1k
Q2
2N2907A
-6v
EIN
Q1
2N708
Q3
2N708
+v
0
Q4
2N708
EOUT
1.2k
1k
200
390
-6v

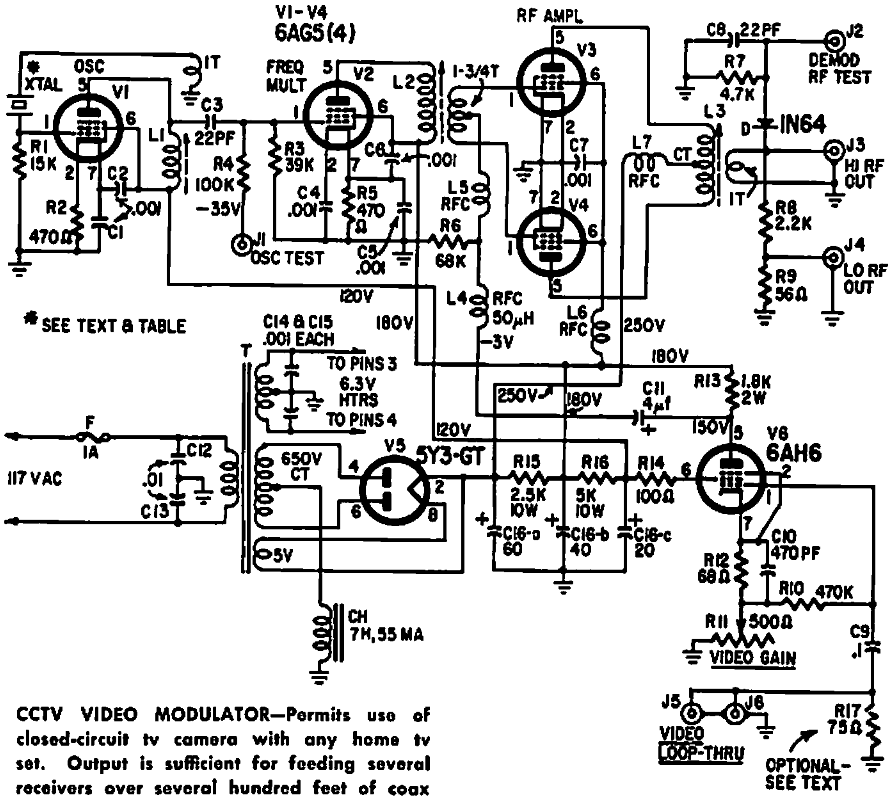
UNITY-GAIN BUFFER—Voltage gain is between 0.995 and 0.999 over entire temperature range of −30 to +160 F and input impedance is high, as required in radar video processors. Can be used to sample d-c level of integrator and transfer analog pulse to output decision circuits such as Schmitt trigger. Will handle input pulses with 15-ns rise time and 30-ns fall time. Q1 and Q2 cancel d-c offset at input.—R. J. Turner, Buffer Amp Provides Stability Over Wide Temperature Range, *Electronics*, Nov. 24, 1969, p 107.


400
100K
out
9186
1
2
3
16

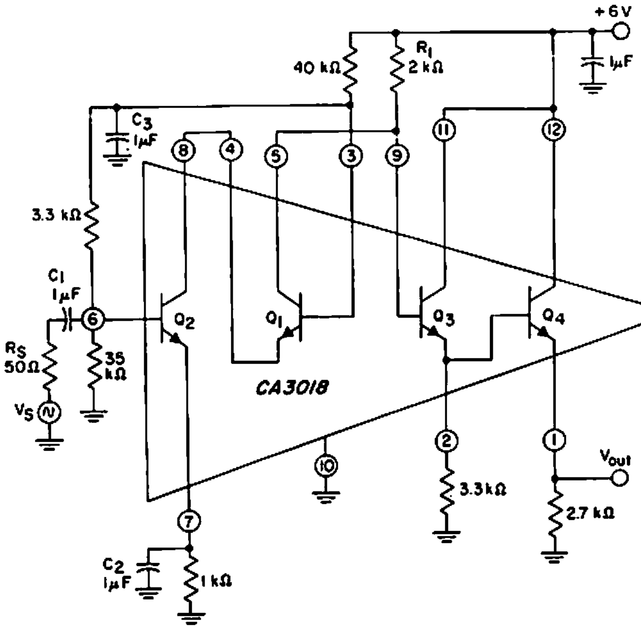
7-MHZ WITH 250 GAIN—OEI Model 9186 opamp in two-resistor configuration shows low noise and good stability without external phase compensation, with closed-loop gain level of 250 from d-c to 7 MHz.—Three Inverting Amplifiers Using the 9186, Optical Electronics, Tucson, Ariz., No. 10124.


300
3.0K
Input
Output
2
1
8
9300
Gain = -10

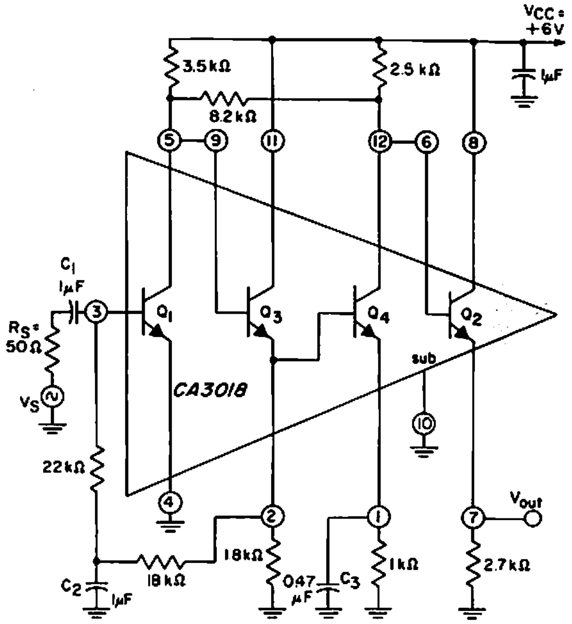
INVERTING WITH GAIN OF 10—Uses OEI 9300 opamp having 6 dB/octave rolloff up to 100 MHz. IC requires +6 V and −6V supplies. Rise and fall times are 30 ns for 1 V output. Use metal-film resistors to prevent overshoot and ringing.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


V1-V4
6AG5(4)
* XTAL
OSC
V1
1T
C3
22PF
R1
15K
R2
470Ω
C2
.001
C1
L1
R4
100K
-35V
J1
OSC TEST
FREQ MULT
V2
R3
39K
C4
.001
R5
470Ω
C6
.001
C5
.001
L2
1-3/4T
L5
RFC
R6
68K
L4
RFC
50μH
-3V
RF AMPL
V3
V4
C7
.001
L7
RFC
CT
L3
L6
RFC
250V
180V
120V
C8 22PF
R7
4.7K
J2
DEMOD
RF TEST
D
1N64
J3
HI RF
OUT
1T
R8
2.2K
R9
56Ω
J4
LO RF
OUT
* SEE TEXT & TABLE
C14 & C15
.001 EACH
T
TO PINS 3
6.3V
HTRS
TO PINS 4
F
1A
117 VAC
C12
.01
C13
650V
CT
5V
V5
5Y3-GT
CH
7H,55 MA
250V
180V
C11
4μf
150V
R13
1.8K
2W
R15
2.5K
10W
R16
5K
10W
R14
100Ω
C16-a
60
C16-b
40
C16-c
20
V6
6AH6
C10
470PF
R12
68Ω
R10
470K
R11
500Ω
VIDEO GAIN
C9
.1
J5
J6
VIDEO
LOOP-THRU
R17
75Ω
OPTIONAL-
SEE TEXT

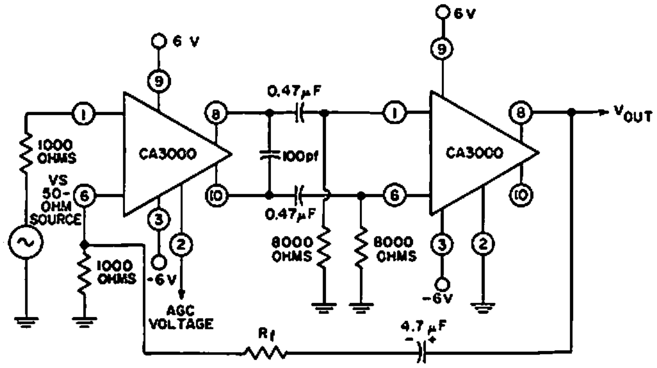
CCTV VIDEO MODULATOR—Permits use of closed-circuit tv camera with any home tv set. Output is sufficient for feeding several receivers over several hundred feet of coax cable. Article gives coil turns data and crystal frequency for each channel. For channel 10, use 48.312-MHz crystal, with 11 turns for L1, 4 for L2, and 5½ for L3. Camera should provide about 1 V p-p and negative-going sync.—E. T. Hansen, Build a Video Modulator for CCTV, *Radio-Electronics*, Jan. 1966, p 52–54.


+6V
1μF
40 kΩ
R_1
2 kΩ
C_3
1μF
8
4
5
3
9
11
12
3.3 kΩ
C_1
1μF
6
R_S
50Ω
35 kΩ
V_S
Q_2
Q_1
Q_3
Q_4
CA3018
10
2
1
3.3kΩ
2.7 kΩ
V_{out}
7
C_2
1μF
1 kΩ

CASCODE VIDEO AMPLIFIER—Frequency response is flat within 3 dB between 6 kHz and 11 MHz, using four-transistor IC connected as shown. Mid-frequency voltage gain is 37 dB, and useful dynamic input range is 40 μV to 16.6 mV p-p.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 311.


VCC = +6V
1μF
3.5 kΩ
8.2 kΩ
2.5 kΩ
5
9
11
12
6
8
C_1
1μF
3
R_S = 50Ω
V_S
Q_1
Q_3
Q_4
Q_2
CA3018
sub
10
4
22kΩ
2
1
7
V_{out}
18kΩ
18 kΩ
.047 μF
C_3
1kΩ
2.7kΩ
C_2
1μF

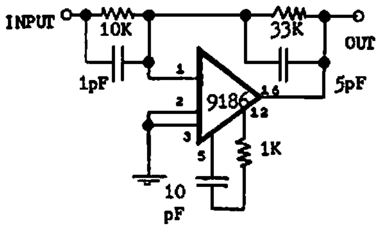
BROADBAND VIDEO AMPLIFIER—Uses CA3018 transistor IC array in two d-c coupled stages. Two feedback loops provide d-c stability. Frequency response is down 3 dB at 800 Hz and 32 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 309.


6 V
9
1
1000 OHMS VS 50-OHM SOURCE
6
CA3000
8
10
3
-6V
2
AGC VOLTAGE
1000 OHMS
0.47μF
100pf
0.47μF
8000 OHMS
8000 OHMS
6V
CA3000
-6V
V_{OUT}
R_f
4.7μF

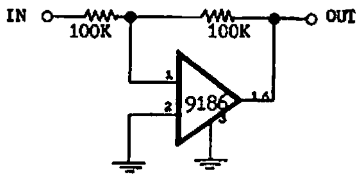
FOR $V_{AGC} = 0$

R_f	G_V
∞	63 db (OPEN LOOP)
100000 OHMS	40 db
9000 OHMS	20 db

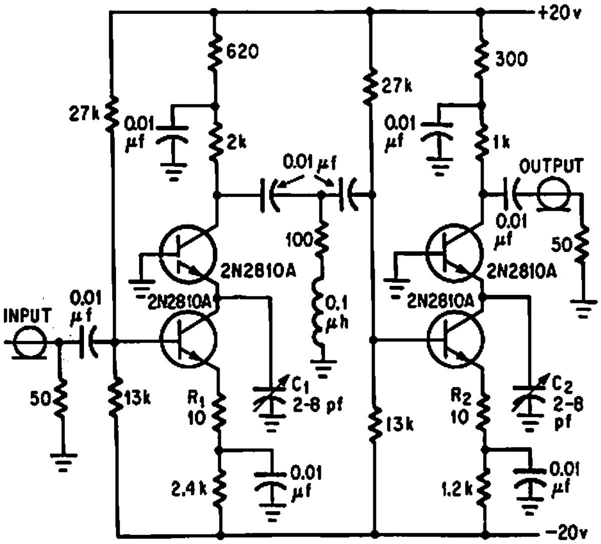
CASCADED IC WITH FEEDBACK—With R-C coupling of two IC d-c amplifiers, open-loop mid-band gain is 63 dB, and bandpass is 18 Hz to 135 kHz. Under closed-loop conditions, bandpass is 0.13 Hz to 6.6 MHz for 20 dB gain.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 126.


INPUT
10K
1pF
33K
OUT
5pF
9186
1K
10 pF

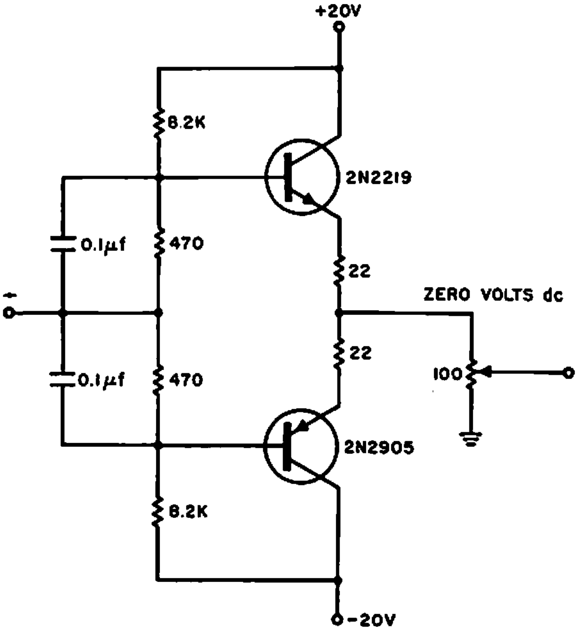
30-MHZ FAST-RISE AMPLIFIER—Provides gain of 3.3 and 7-ns rise time with OEI 9186 opamp.—Three Inverting Amplifiers Using the 9186, Optical Electronics, Tuscon, Ariz., No. 10124.


IN
100K
100K
OUT
9186

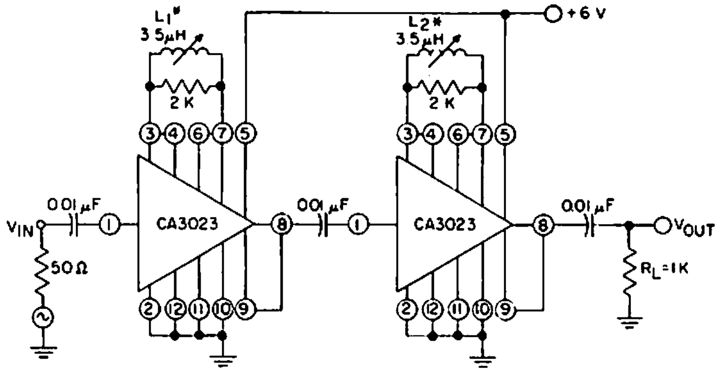
UNITY-GAIN BUFFER—Used as wide-band inverting amplifier having high input impedance, as required by vidicon, high-impedance transducer, and some detectors. With OEI 9186 opamp, provides unity gain up to 17 MHz.—Three Inverting Amplifiers Using the 9186, Optical Electronics, Tucson, Ariz., No. 10124.


+20v
620
27k
0.01 μf
2k
0.01μf
27k
300
0.01 μf
1k
OUTPUT
100
0.01 μf
50
2N2810A
2N2810A
0.1 μh
2N2810A
2N2810A
INPUT
0.01 μf
50
13k
R_1 10
C_1 2-8 pf
13k
R_2 10
C_2 2-8 pf
2.4k
0.01 μf
1.2k
0.01 μf
-20v

500-MHZ VIDEO—Variable capacitors C1 and C2 adjust bandwidth of two-stage cascode amplifier. Increased bandwidth is achieved by adding common-base transistor amplifier to single common-emitter stage having 50-ohm input; inductive component of common-base stage forms resonant rise in current to compensate for dropoff of other stage at high frequencies.—H. T. McAleer, Emitter Peaking Pushes Bandwidth to 500 MHz, *Electronics*, Sept. 4, 1967, p 96–97.

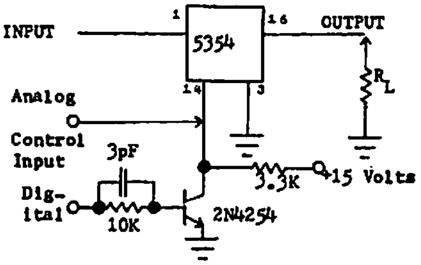

+20V
8.2K
2N2219
0.1μf
470
22
ZERO VOLTS dc
22
0.1μf
470
100
2N2905
8.2K
-20V

GAIN CONTROL—Push-pull emitter-follower provides high-level gain control of video signal while maintaining zero d-c voltage at output. Transistors must be balanced; common heat sink helps. Can be used to drive long cables, with signals up to 30 V p-p. —H. F. Stearns, Gain-Control Circuit Avoids D-C Shift, *Electronic Design*, Feb. 1, 1965, p 28.


L1*
3.5μH
2 K
L2*
3.5μH
2 K
+6 V
VIN
0.01μF
50Ω
CA3023
0.01μF
CA3023
0.01μF
VOUT
RL=1K
1
2
3
4
5
6
7
8
9
10
11
12

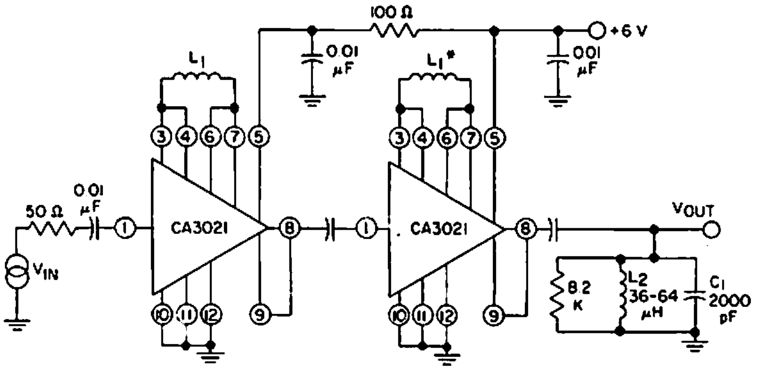
* SELF-RESONANT AT 28 MHz

28-MHZ LIMITER—Uses two IC video amplifiers to provide full limiting at input of 300 μV. Total gain is 61 dB, and bandwidth before limiting is 3.8 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 179.

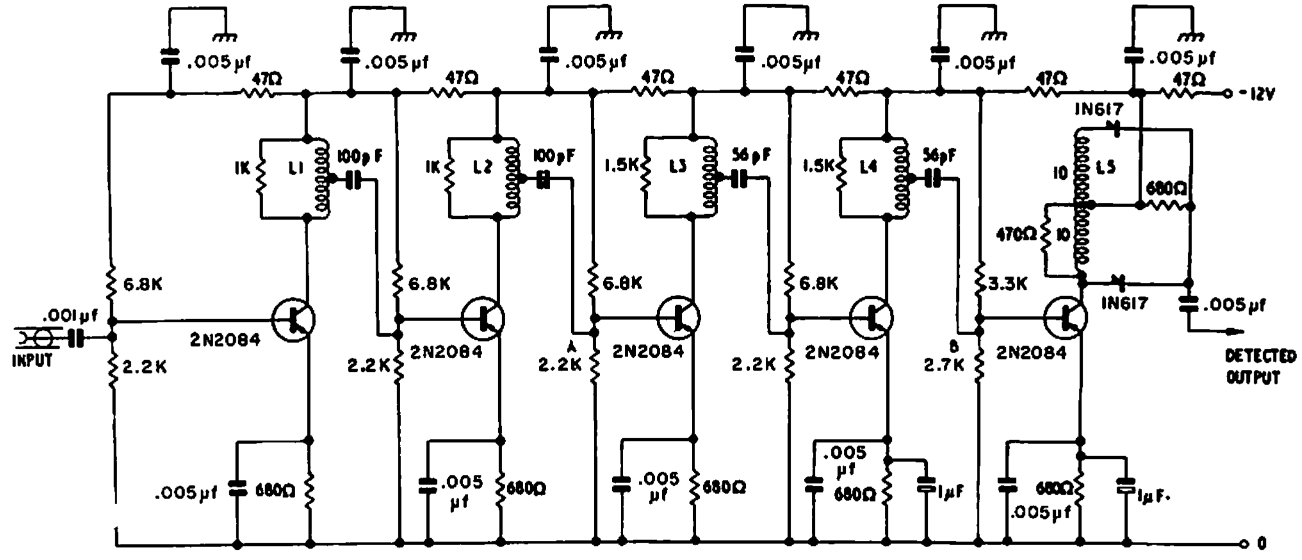

INPUT
1
16
OUTPUT
5354
14
3
RL
Analog
Control
Input
3pF
Dig-
ital
10K
3.3K
15 Volts
2N4254

FAST SWITCH—OEI 5354 analog switch is basically spst, either on or off. Provides very high isolation at video frequencies, with sufficiently fast switching time to allow video switching during vertical retrace interval. Switching voltage is at analog levels of 0 and +10 V. For spdt switching, two 5354 switches are needed.—A Fast Video Switcher Using Analog Switches, Optical Electronics, Tucson, Ariz., No. 10171.

500-KHZ LIMITER—Uses two IC video amplifiers to provide voltage gain of at least 100 dB, with limited signal becoming apparent above noise for 1-μV input signal. Limiting is good for input signals up to 3 V. —"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 180.

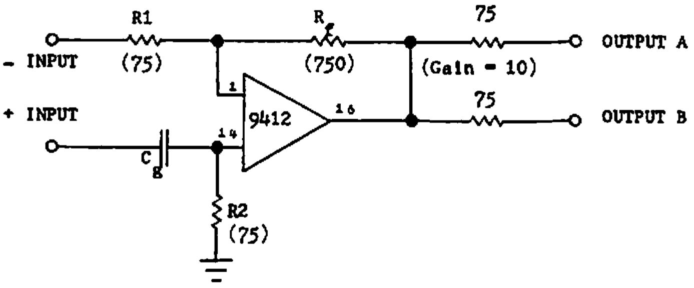

100Ω
+6 V
0.01
μF
0.01
μF
L1
L1*
0.01
μF
50Ω
VIN
CA3021
CA3021
VOUT
8.2
K
L2
36-64
μH
C1
2000
pF
1
3
4
5
6
7
8
9
10
11
12

* SELF-RESONANT AT 500 kHz

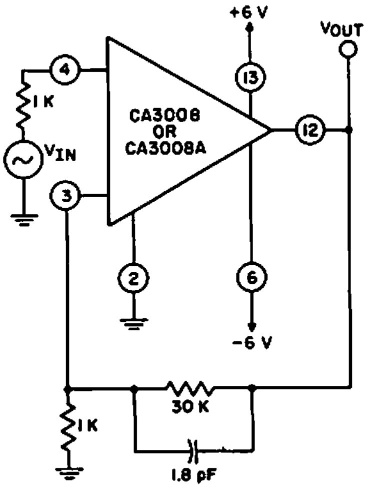

.005μf
47Ω
-12V
IN617
IK
L1
100pF
IK
L2
100pF
1.5K
L3
56pF
1.5K
L4
56pF
10
L5
680Ω
470Ω
10
IN617
.005μf
DETECTED
OUTPUT
6.8K
3.3K
.001μf
INPUT
2N2084
2.2K
A
B
2.7K
680Ω
.005
μf
1μF
0

L2, L1	12 TURNS	30 S.W.G. ENAMELLED COPPER WIRE ¼ DIAM.	CENTER TAPPED	5/8" FERRITE CORE
L3, L4	9 TURNS	"	"	
L5	20 TURNS	"	"	

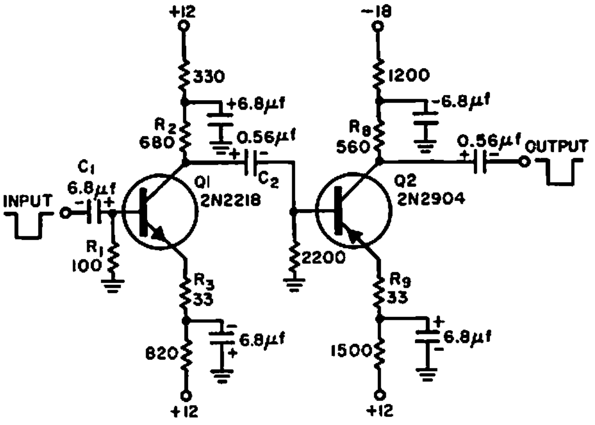
15-MHZ BANDWIDTH AT 30 MHZ—Stagger-tuned video amplifier with balanced detector has gain of 60 dB. Article gives detailed design procedure and instructions for alignment.—A 30 MC Wide Band Transistor Amplifier Using the 2N2084 Universal Transistor, Amperex Electronic Corp., Hicksville, L.I., N.Y., ALR-5621, 1964.


R1
(75)
- INPUT
+ INPUT
C
g
R2
(75)
R
f
(750)
9412
1
14
16
75
(Gain = 10)
75
OUTPUT A
OUTPUT B

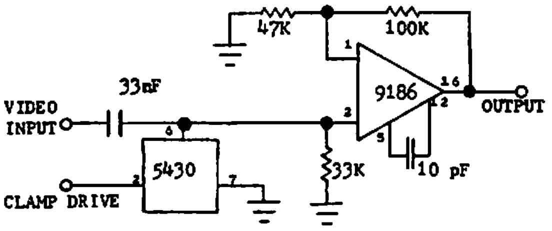
SINGLE-CHIP LINE DRIVER—Module contains high-level output stage and high-performance opamp in one package, for applications requiring low closed-loop gain (below 30). Will drive 50-ohm load at 10 V with either polarity, and may therefore be used to drive two cables with full output swing, or more if lower voltage is permissible. Use negative input if phase inversion is required. Either input may be d-c or a-c coupled.—A Video Amplifier/Line Driver, Optical Electronics, Tucson, Ariz., No. 10170.


+6 V
VOUT
4
1 K
VIN
3
CA3008
OR
CA3008A
13
12
2
6
-6 V
30 K
1 K
1.8 pF

30-DB NONINVERTING WITH PHASE COMPENSATION—Use of 1.8-pF capacitor in parallel with feedback resistor of IC opamp gives flat response to about 3 MHz, with feedback ratio rolling off at slope of one for higher frequencies.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 247.

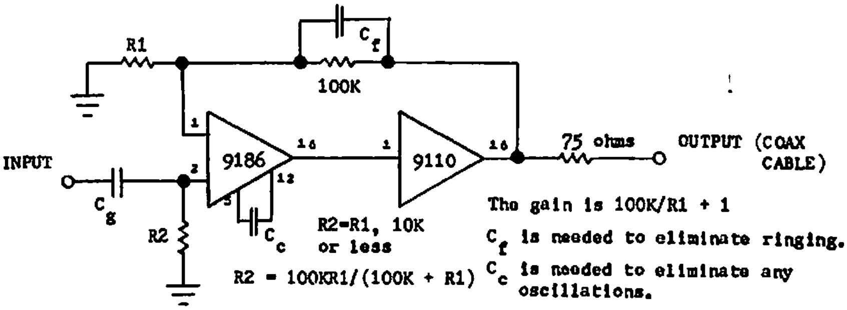

+12
330
+6.8μf
R2
680
0.56μf
C2
C1
6.8μf
INPUT
R1
100
Q1
2N2218
R3
33
6.8μf
820
+12
2200
-18
1200
-6.8μf
R8
560
0.56μf
OUTPUT
Q2
2N2904
R9
33
6.8μf
1500
+12

SELF-LIMITING—Use of complementary transistors in pulsed video amplifier provides compression without limiter diodes, for operation over wide dynamic range of input voltages, from 5 mV to 5 V. Can be used to drive Schmitt trigger for reshaping of pulses. —R. P. Fischi, Jr., Pulsed-Video Amplifier Limits Without Diodes, *Electronic Design*, April 13, 1964, p 68 and 70.


47K
100K
1
9186
16
2
12
5
10 pF
OUTPUT
33nF
VIDEO
INPUT
6
5430
2
7
CLAMP DRIVE
33K

CLAMP AMPLIFIER—Used in cable tv circuits when hum level is so high that shaded horizontal bars appear in picture. Video is clamped during horizontal blanking interval, at known sync level. Clamping also restores d-c information. Clamping reduces hum amplitude as much as 6 dB per octave. Uses OEI 5430 spst analog switch.—A Video Clamp Amplifier, Optical Electronics, Tucson, Ariz., No. 10164.

LINE DRIVER—Combination of 9186A opamp and 9110 current booster will drive 100-ohm load with up to 10 V of either polarity, at bandwidths up to 10 MHz. Slewing rate of opamp is 600 V per μs. Circuit is useful for gain levels up to 100 (40 dB).—A Video Amplifier/Line Driver, Optical Electronics, Tucson, Ariz., No. 10170.


R1
C
f
100K
1
9186
16
2
12
5
C
c
1
9110
16
INPUT
C
g
R2
75 ohms
OUTPUT (COAX
CABLE)

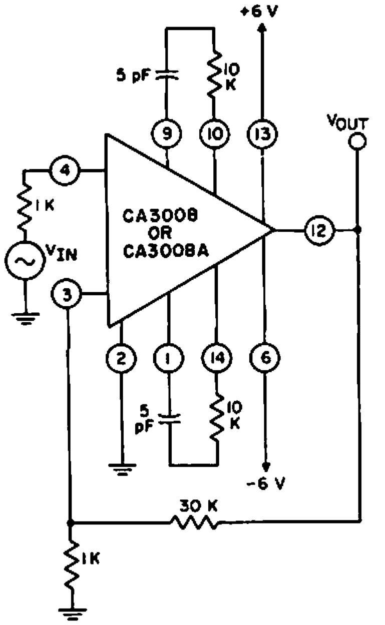
R2=R1, 10K or less

R2 = 100KR1/(100K + R1)

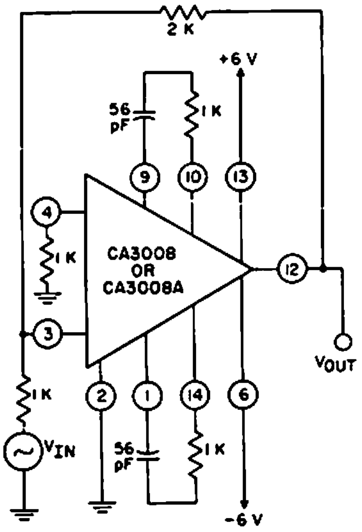
The gain is 100K/R1 + 1

C_f is needed to eliminate ringing.

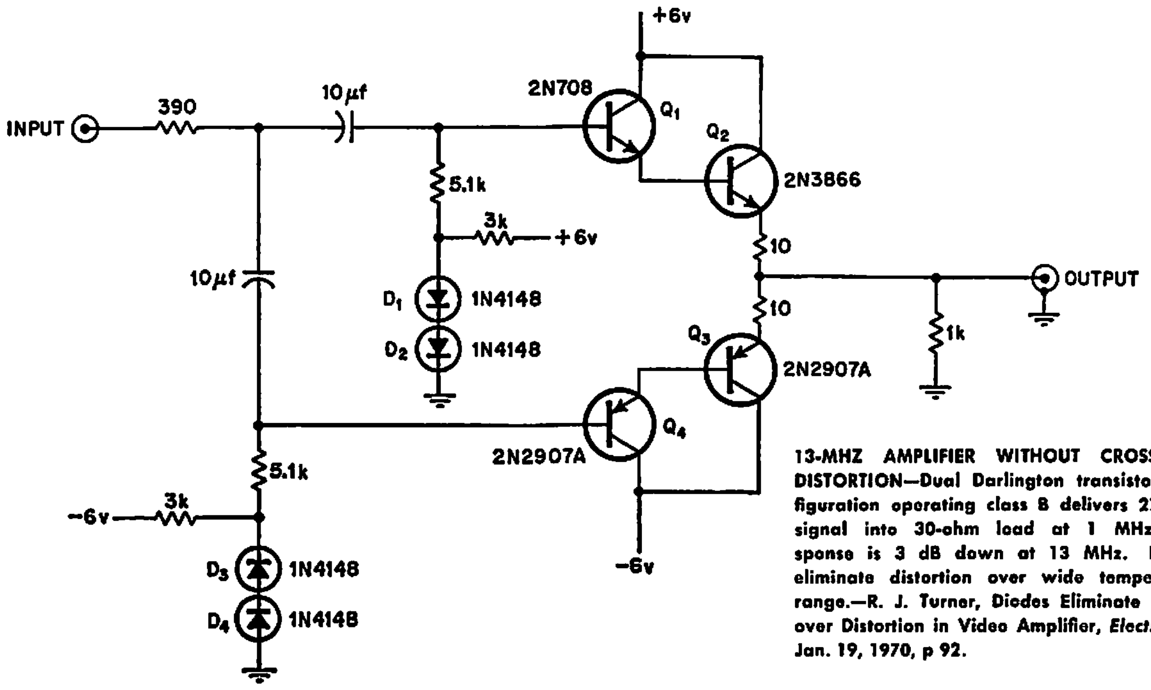
C_c is needed to eliminate any oscillations.


+6 V
5 pF
10 K
9
10
13
VOUT
4
1 K
VIN
3
CA3008
OR
CA3008A
12
2
1
14
6
5 pF
10 K
-6 V
30 K
1 K

30-DB NONINVERTING—Phase compensation of IC opamp is provided by 5-pF capacitor in series with 10K. Used as video amplifier having flat closed-loop response up to about 3 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 246.


2 K
+6 V
56 pF
1 K
9
10
13
4
1 K
CA3008
OR
CA3008A
12
3
VOUT
1 K
2
1
14
6
VIN
56 pF
1 K
-6 V

6-DB INVERTING IC OPAMP—Response of video amplifier with 56-pF phase-compensating capacitance is flat within 3 dB up to 5.6 MHz. Changing compensating capacitance to 33 pF increases 3-dB bandwidth to 11 MHz.—"Linear Integrated Circuits," RCA, Harrison, N.J., IC-41, p 248.

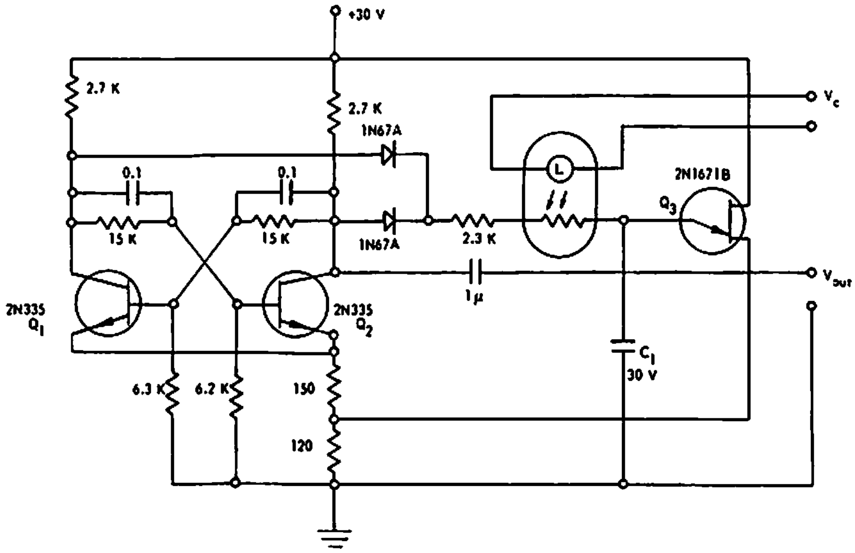

+6v
INPUT
390
10μf
2N708
Q1
Q2
2N3866
5.1k
3k
+6v
10
10μf
D1
1N4148
D2
1N4148
OUTPUT
10
Q3
1k
2N2907A
Q4
2N2907A
5.1k
-6v
3k
D3
1N4148
D4
1N4148
-6v

13-MHZ AMPLIFIER WITHOUT CROSSOVER DISTORTION—Dual Darlington transistor configuration operating class B delivers 270-mA signal into 30-ohm load at 1 MHz. Response is 3 dB down at 13 MHz. Diodes eliminate distortion over wide temperature range.—R. J. Turner, Diodes Eliminate Crossover Distortion in Video Amplifier, *Electronics*, Jan. 19, 1970, p 92.

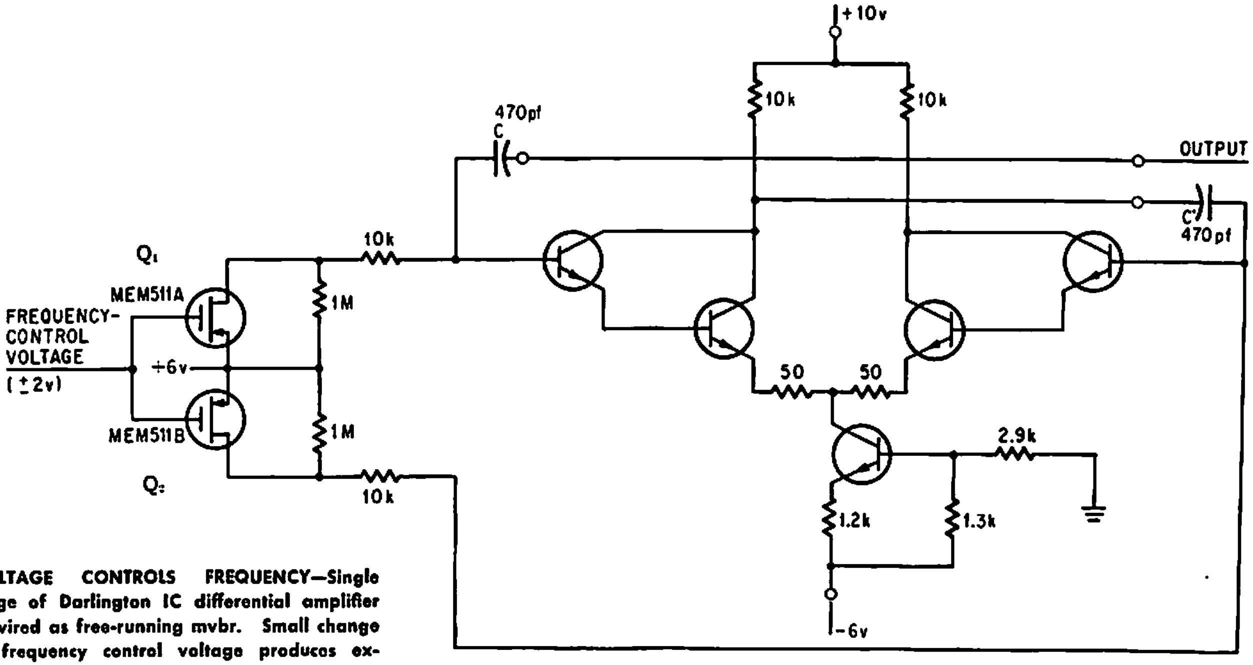
NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 96

Voltage-Controlled Oscillator Circuits

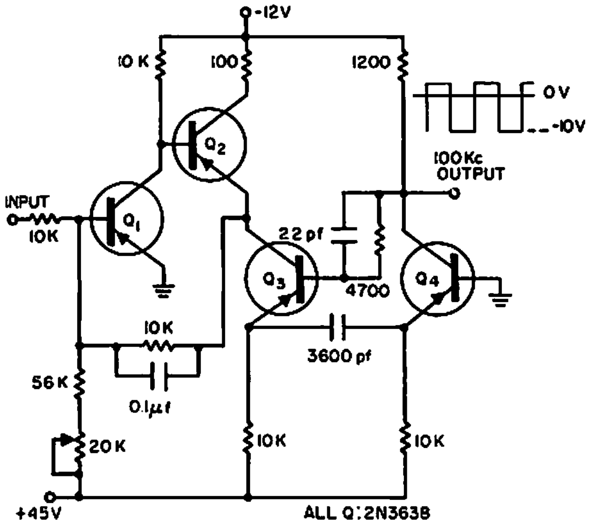

+30 V
2.7 K
2.7 K
1N67A
0.1
0.1
15 K
15 K
1N67A
2.3 K
L
2N1671B
Q_3
V_c
V_{out}
1μ
2N335
Q_1
2N335
Q_2
C_1
30 V
6.3 K
6.2 K
150
120

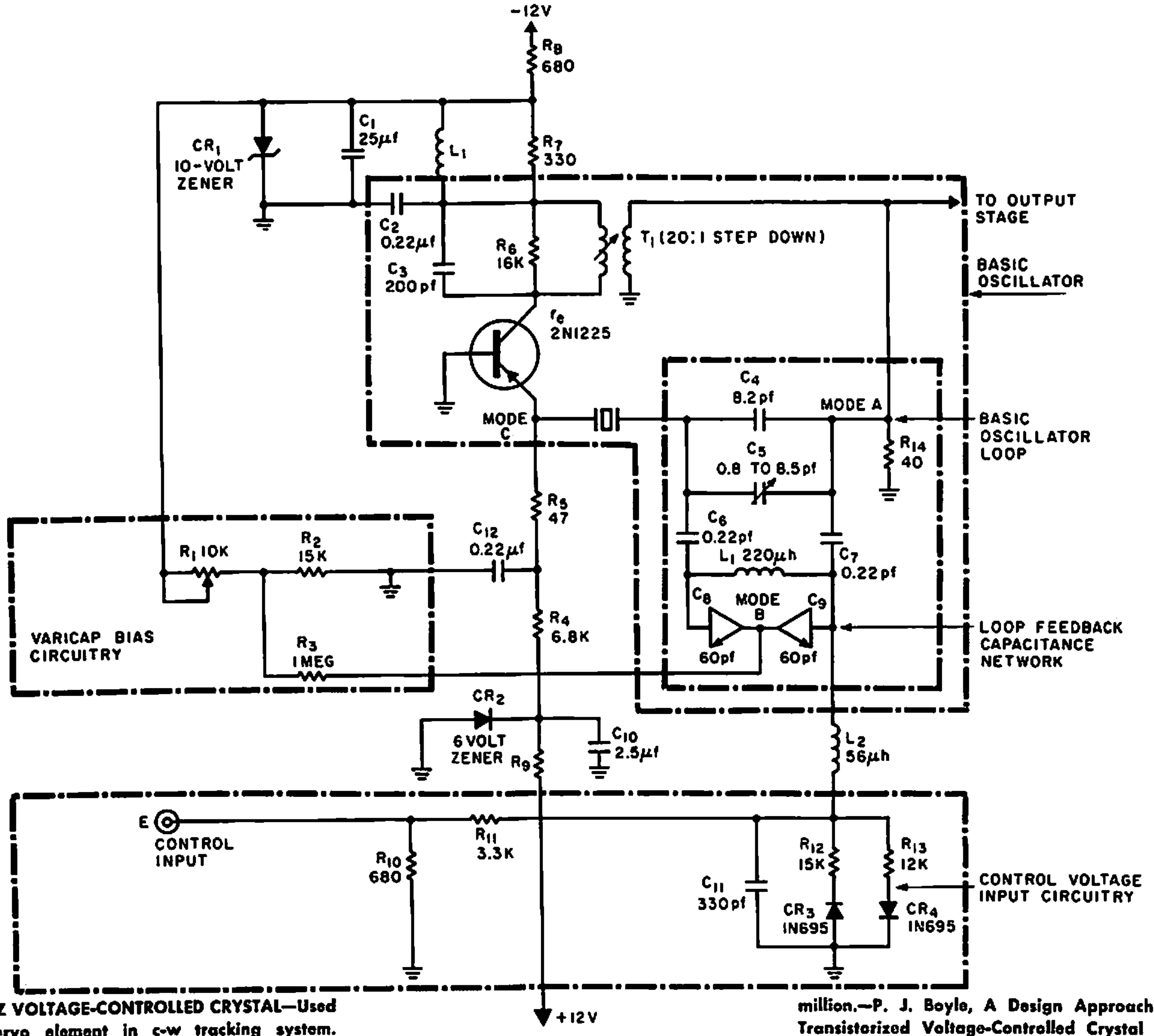
OPTOELECTRONIC VCO—Output frequency is proportional to d-c voltage applied to lamp terminals of Raysistor. Multivibrator is driven at half speed, to produce square wave at output terminals. Output frequency increases with lamp voltage. Oscillator is isolated from control voltage, permitting simple remote control of frequency.—Raysistor Optoelectronic Devices, Raytheon Components Division, Quincy, Mass., 1967, p 16.


+10v
10k
10k
470pf
C
OUTPUT
C'
470pf
Q_1
MEM511A
FREQUENCY-CONTROL VOLTAGE
(±2v)
+6v
MEM511B
Q_2
10k
1M
1M
10k
50
50
2.9k
1.2k
1.3k
-6v

VOLTAGE CONTROLS FREQUENCY—Single stage of Darlington IC differential amplifier is wired as free-running mvbr. Small change in frequency control voltage produces extremely large frequency shift because input fet's act as voltage-variable resistors. Sensitivity is 40 kHz per volt, essentially independent of temperature.—F. G. Christiansen, Multivibrator Sensitivity Improved by MOS FET's, *Electronics*, Dec. 11, 1967, p 96.

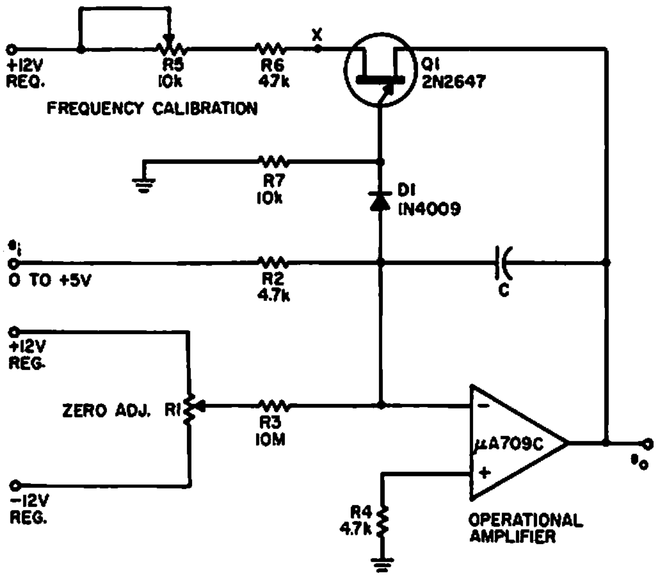
100-KHZ VOLTAGE-CONTROLLED—Addition of two feedback loops to saturating-type mvbr Q3-Q4 gives voltage-controlled square-wave oscillator whose frequency is determined by the 10K emitter current sources, 3,600-pF capacitor, and collector voltage of Q3 with respect to ground. Q1-Q2 form integrating opamp that changes collector voltage of Q3 to control frequency.—Modified Multi Forms Voltage-Controlled Oscillator, *Electronic Design*, Oct. 11, 1965, p 68.

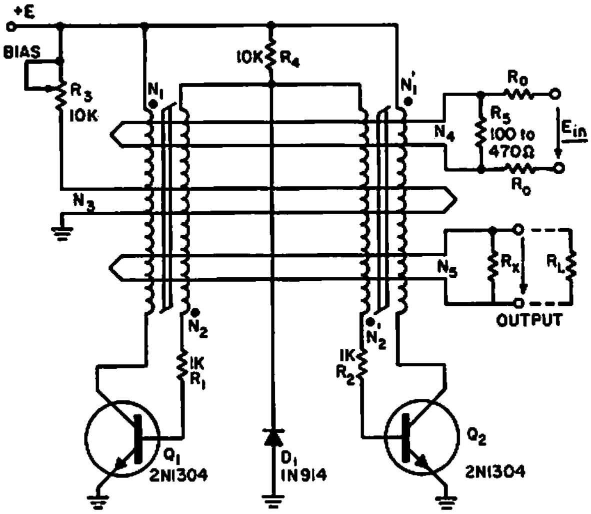

-12V
10 K
100
1200
0V
-10V
100Kc
OUTPUT
INPUT
10K
Q1
Q2
22pf
Q3
4700
Q4
10K
0.1μf
3600 pf
56K
20K
10K
10K
+45V
ALL Q: 2N3638


-12V
R8
680
CR1
10-VOLT
ZENER
C1
25μf
L1
R7
330
TO OUTPUT
STAGE
C2
0.22μf
C3
200pf
R6
16K
T1 (20:1 STEP DOWN)
BASIC
OSCILLATOR
fe
2N1225
C4
8.2pf
MODE A
MODE
C
C5
0.8 TO 8.5pf
R14
40
BASIC
OSCILLATOR
LOOP
R5
47
C6
0.22pf
L1 220μh
C7
0.22pf
R1 10K
R2
15K
C12
0.22μf
C8
MODE
B
C9
LOOP FEEDBACK
CAPACITANCE
NETWORK
VARICAP BIAS
CIRCUITRY
R3
1MEG
R4
6.8K
60pf
60pf
CR2
6 VOLT
ZENER
R9
C10
2.5μf
L2
56μh
E
CONTROL
INPUT
R11
3.3K
R10
680
C11
330pf
R12
15K
R13
12K
CR3
1N695
CR4
1N695
CONTROL VOLTAGE
INPUT CIRCUITRY
+12V

1-MHZ VOLTAGE-CONTROLLED CRYSTAL—Used as servo element in c-w tracking system. Article describes operation in detail and gives design procedure. Short-term stability can typically be 8 parts in one billion, and long-term drift as good as 2 parts in one million.—P. J. Boyle, A Design Approach to Transistorized Voltage-Controlled Crystal Oscillators, *Electronic Design*, March 2, 1964, p 22–24 and 26–27.

STEPPING MOTOR DRIVE—Produces sawtooth waveform over frequency range of 100,000:1 for d-c control voltage range of 0 to 5 V, as source of pulses for driving stepping motor in servo system. Upper frequency limit is about 250 Hz. Q1 discharges C at end of each timing period as set by R5.—W. F. Ball, Ultrawide-Range VCO Uses Op Amp and UJT, *Electronic Design*, Sept. 27, 1967, p 66 and 68.

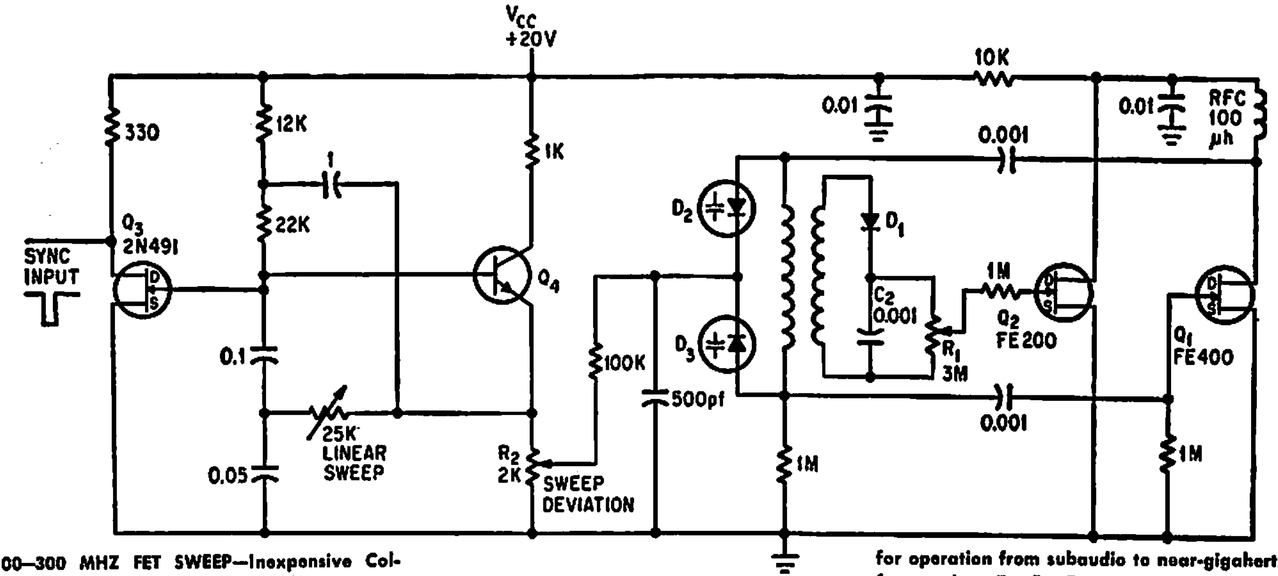

+12V REG.
R5 10k
R6 47k
X
Q1 2N2647
FREQUENCY CALIBRATION
R7 10k
D1 IN4009
e_i
0 TO +5V
R2 4.7k
C
+12V REG.
ZERO ADJ. R1
R3 10M
−
+
μA709C
e_o
−12V REG.
R4 4.7k
OPERATIONAL AMPLIFIER


+E
BIAS
R_3 10K
10K R_4
N_1
N_1'
R_0
R_5 100 to 470Ω
E_{in}
N_4
R_0
N_3
N_5
R_x
R_L
OUTPUT
N_2
N_2'
1K R_1
1K R_2
Q_1 2N1304
D_1 IN914
Q_2 2N1304

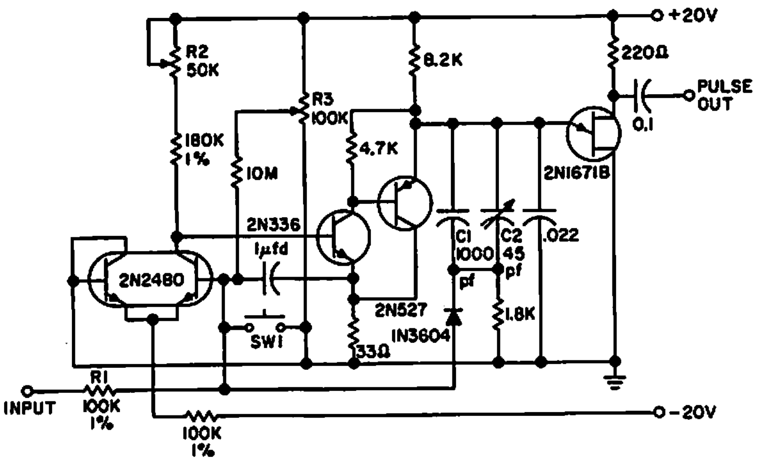
R_0—CHOSEN TO PROVIDE DESIRED SENSITIVITY

R_x—<R_L (THE DESIRED LOAD)

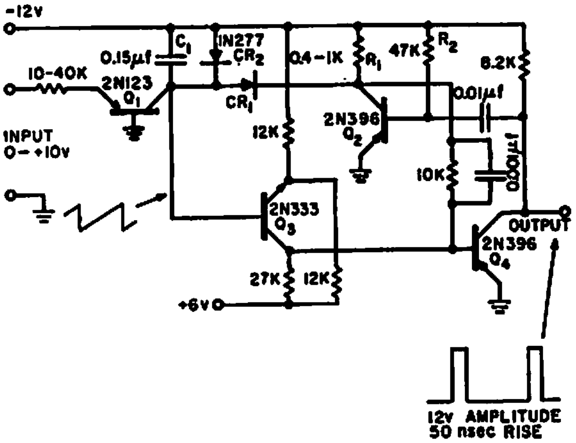
LINEAR VCO—Output frequency is proportional to input current or voltage within 1% for 15% deviation from given center frequency. Typical values for 10-V supply voltage and operation between 5 and 10 kHz, using Magnetics 50056-1D cores, are 350 to 500 turns for N4, 50 turns for N2 and N2′, and 150 turns for other windings. Can be operated with balanced floating input and output. Has good rejection for common-mode signals.—M. W. Barth, Voltage Controlled Oscillator Provides Good Linearity, *Electronic Design*, Nov. 23, 1964, p 65–67.


V_{CC} +20V
330
12K
1
22K
1K
10K
0.01
0.01
RFC 100 μh
0.001
SYNC INPUT
Q_3 2N491
D
S
Q_4
D_2
D_3
D_1
C_2 0.001
1M
R_1 3M
Q_2 FE200
Q_1 FE400
0.1
0.05
25K LINEAR SWEEP
R_2 2K
SWEEP DEVIATION
100K
500pf
1M
0.001
1M

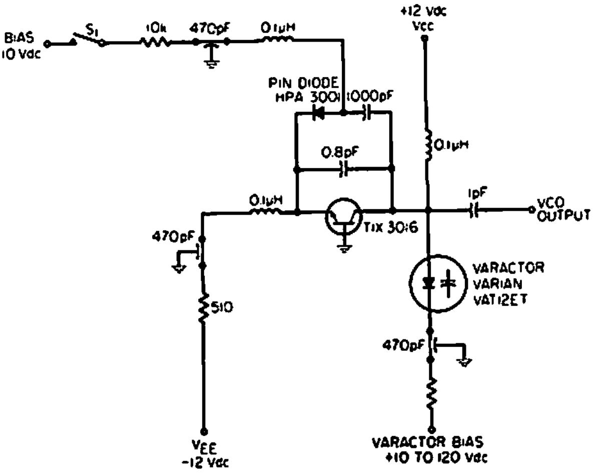
200–300 MHZ FET SWEEP—Inexpensive Colpitts oscillator uses voltage-variable capacitors D2 and D3 to change frequency of fet oscillator Q1-Q2. Sync input pulse initiates triangular output of Q3 for driving diodes through buffer Q4. Circuit can be designed for operation from subaudio to near-gigahertz frequencies.—T. F. Prosser, FET's Produce Stable Oscillators, *Electronics*, Oct. 3, 1966, p 102–103.


+20V
R2
50K
180K
1%
R3
100K
10M
8.2K
4.7K
220Ω
PULSE OUT
0.1
2N1671B
2N336
1μfd
2N2480
C1
1000
pf
C2
45
pf
.022
2N527
1N3604
1.8K
SW1
33Ω
R1
100K
1%
INPUT
100K
1%
-20V

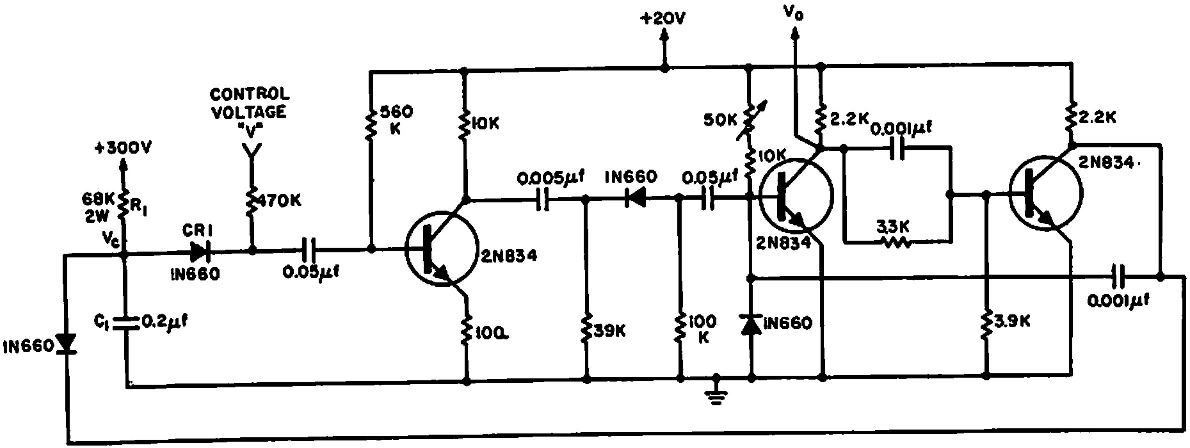
VOLTAGE-FREQUENCY—Output frequency is proportional to input voltage, with 1 V d-c input producing 1 kHz with better than 0.1% linearity. Input impedance is 100K. Article gives adjustment procedure. Supply voltages must be as stable as accuracy required. —Unijunction Circuit Hints, General Electric, Syracuse, N.Y., Fig. 11.


-12V
C1
0.15μf
1N277
CR2
0.4-1K
R1
47K
R2
8.2K
10-40K
2N123
Q1
CR1
0.01μf
INPUT
0-+10V
12K
2N396
Q2
10K
0.001μf
2N333
Q3
OUTPUT
2N396
Q4
27K
12K
+6V
12V AMPLITUDE
50 nsec RISE

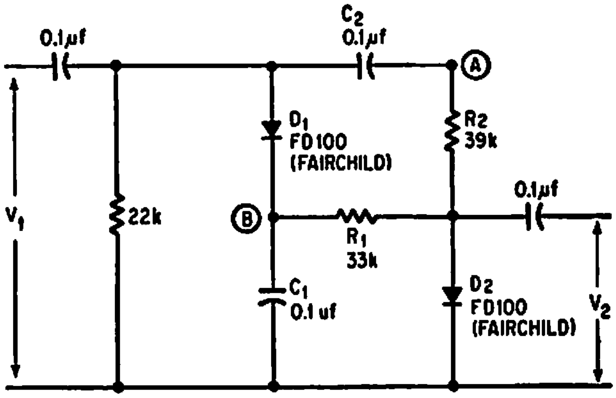
VOLTAGE-FREQUENCY CONVERTER—Produces pulse rate directly proportional to varying d-c input voltage, for driving digital motor of servo system. Frequency of output varies linearly from zero for no input to 300 Hz for 10 V input.—J. M. Howe, Transistorized Voltage-Frequency Converter Operates Linearly, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 77.


BIAS
+10 Vdc
S1
10k
470pF
0.1μH
+12 Vdc
Vcc
PIN DIODE
HPA 3001
1000pF
0.8pF
0.1μH
0.1μH
1pF
VCO
OUTPUT
470pF
TIX 3016
VARACTOR
VARIAN
VAT12ET
510
470pF
VEE
-12 Vdc
VARACTOR BIAS
+10 TO 120 Vdc

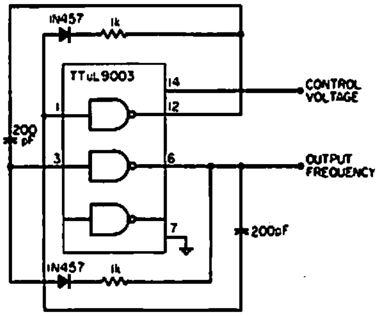
1,500-MHZ VCO—Tunable range is 500 MHz, and frequency drift less than 100 kHz after vco is turned off for 15 min. Useful when several vco's are used alternately to cover larger frequency range. Diode in feedback loop minimizes thermal effects.—A. Barone, PIN-Diode Turnoff for Microwave VCO, *EEE*, Sept. 1967, p 133–134.


+20V
Vo
CONTROL
VOLTAGE
"V"
+300V
68K
2W
R1
Vc
CR1
1N660
470K
0.05μf
560
K
10K
2N834
100
0.005μf
1N660
0.05μf
39K
100
K
50K
10K
2N834
2.2K
0.001μf
33K
1N660
2.2K
2N834
3.9K
0.001μf
C1
0.2μf
1N660

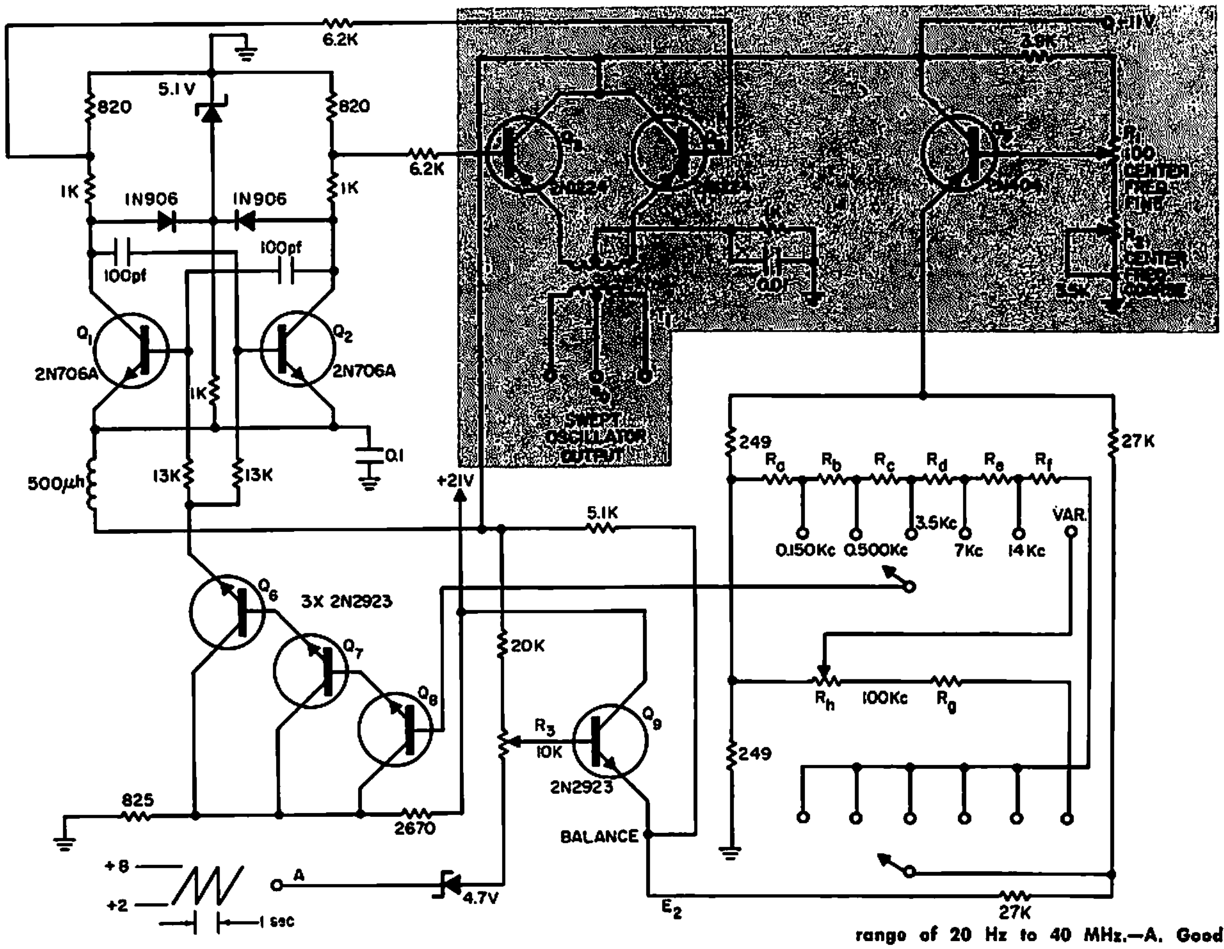
PULSE PERIOD CONTROL—Provides linear voltage control of pulse repetition period. Control range is about 4 to 45 V, with pulse period varying from about 0.2 to 2 ms. Comparator diode CR1 triggers mono mvbr through 2N834 amplifier.—B. Pearl, Comparator Circuit Controls Repetition Period Linearly, *Electronic Design*, June 22, 1964, p 66 and 68.


0.1µf
C2
0.1µf
A
D1
FD100
(FAIRCHILD)
R2
39k
V1
22k
B
R1
33k
0.1µf
C1
0.1 uf
D2
FD100
(FAIRCHILD)
V2

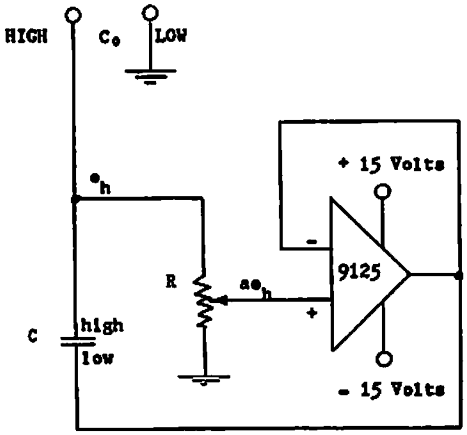
STABILIZING VCO—Output amplitude of voltage-controlled oscillator (V1) is stabilized over its frequency range by simple junction diode circuit that acts as nonlinear resistive divider whose output V2 varies inversely with input changes. Proper circuit operation is obtained when V2 is about 10 mV. Operation depends on the fact that dynamic resistance of junction diode varies inversely with input changes.—F. Giannazzi, Diode's Resistance Variation Stabilizes Signal Amplitudes, *Electronics*, June 26, 1967, p 107.


IN457
1k
TTµL9003
14
CONTROL VOLTAGE
1
12
200 pF
3
6
OUTPUT FREQUENCY
7
200pF
IN457
1k

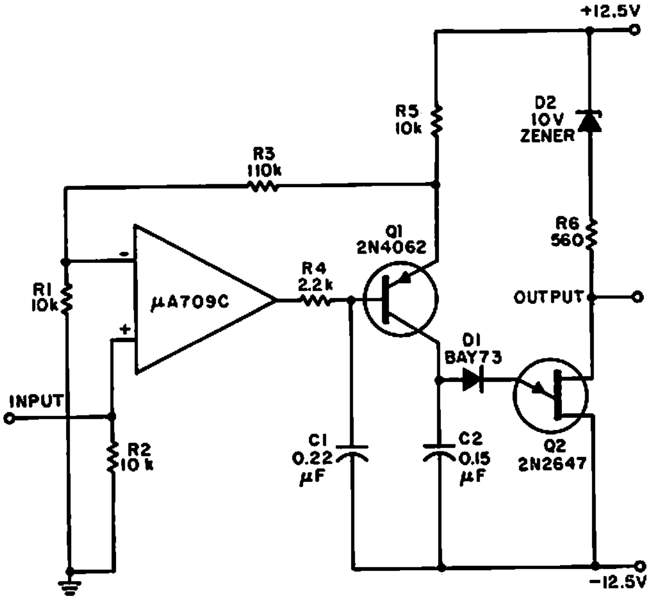
3–11 MHZ VCO WITH CROSS-COUPLED IC GATES—Linearity is better than 5% of full-scale frequency over entire control voltage range of 3.5 to 7 V d-c. Output waveform is square, with rise and fall times typically less than 5 ns. Output amplitude varies with control voltage, but this can be overcome by adding another gate or buffer.—I. Israely, Improved VCO Uses TTL IC, *EEE*, Sept. 1968, p 106–107.


6.2K
5.1V
820
820
6.2K
1K
IN906
IN906
1K
100pf
100pf
Q1
2N706A
Q2
2N706A
1K
0.1
500µh
13K
13K
+21V
-11V
3.9K
2N1224
2N404
R1
100
CENTER FREQ FINE
R2
CENTER FREQ COARSE
0.01
SWEPT OSCILLATOR OUTPUT
249
27K
Ra
Rb
Rc
Rd
Re
Rf
0.150Kc
0.500Kc
3.5Kc
7Kc
14Kc
VAR.
5.1K
Q6
3X 2N2923
Q7
Q8
20K
Rh
100Kc
Rg
R3
10K
Q9
2N2923
249
825
2670
BALANCE
+8
+2
A
4.7V
1 sec
E2
27K

PANORAMIC-RECEIVER VCO—Balanced-bridge summing network at lower right makes center frequency of vco Q1-Q2 independent of modulation on signal. Article gives design equations. Oscillator has linear voltage-frequency characteristic over required receiver range of 20 Hz to 40 MHz.—A. Goodman, Improve VCO Frequency Control Via Balanced-Bridge Mixer, *Electronic Design*, Nov. 22, 1965, p 48 and 50–53.

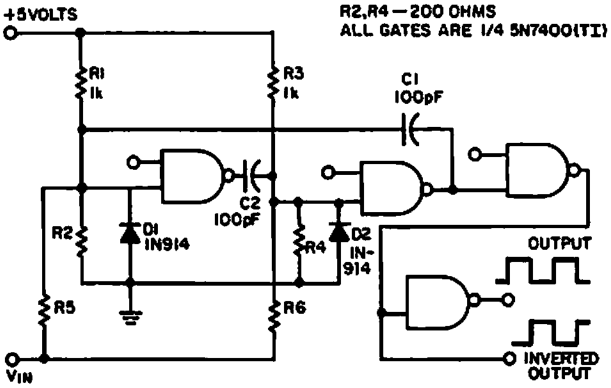

HIGH
C₀
LOW
e_h
+ 15 Volts
−
9125
R
ae_h
+
C
high
low
− 15 Volts

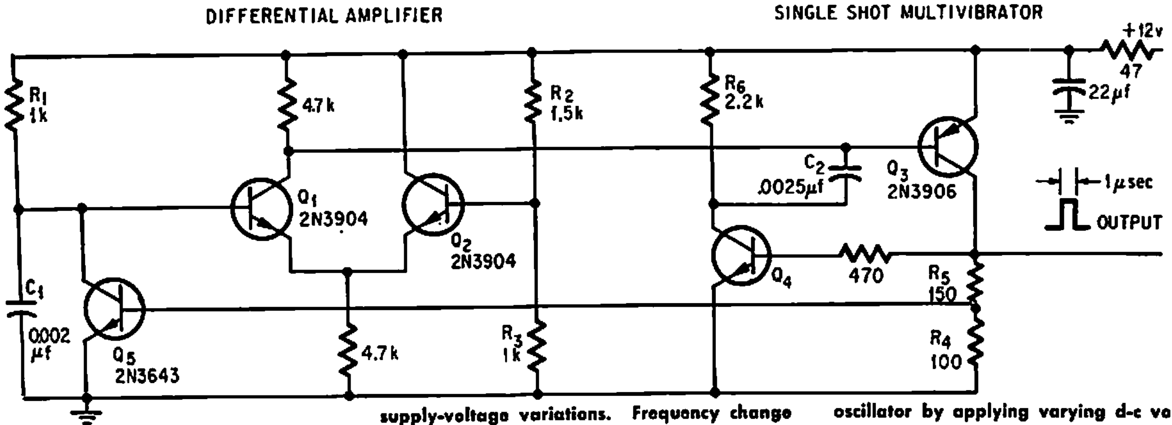
ELECTRONICALLY VARIABLE CAPACITOR—Gives output swing of over 100 kHz in voltage follower mode when using OEI opamp having unity-gain frequency of 60 MHz. Report gives detailed description of operation. Useful in voltage-controlled L-C and R-C oscillators and filters.—An Electronically Variable Capacitor, Optical Electronics, Tucson, Ariz., No. 10042.


+12.5V
R5
10k
D2
10V
ZENER
R3
110k
Q1
2N4062
R6
560
R1
10k
−
μA709C
R4
2.2k
OUTPUT
+
D1
BAY73
INPUT
R2
10k
C1
0.22
μF
C2
0.15
μF
Q2
2N2647
−12.5V

VOLTAGE-FREQUENCY CONVERTER—Linearity is better than 0.5% over frequency range of two decades produced by input signal range of 0 to 1 V d-c. Rate of charge of C2 in ujt oscillator Q2 varies linearly with input voltage.—S. G. Johnson, Voltage-To-Frequency Convertor Built With One UJT Oscillator, *Electronic Design*, Dec. 6, 1967, p 122.

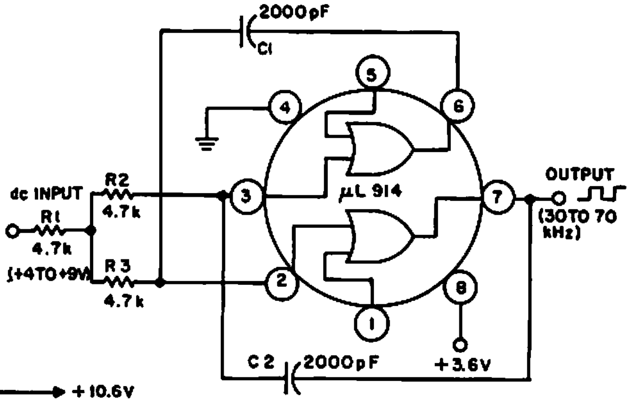
7-MHZ VCO USING TTL GATES—Low shunt capacitance of gates permits much higher upper frequency limit than is possible with cross-coupled transistors. Frequency can be increased or decreased 10% by varying input control voltage between +5 V and −5 V. Resistor values are chosen to bias gates at their turnover points, typically 1.4 to 2 V. Inverting gates are optional, but will improve wave shape and buffer output from external clock load.—A. C. Burley and A. V. Aellen, High-Frequency VCO Uses TTL Gates, *Electronic Design*, May 24, 1970, p 112 and 114.

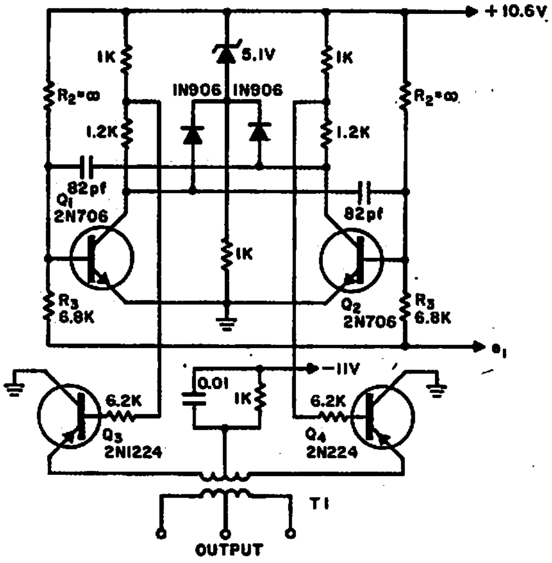

+5VOLTS
R2,R4—200 OHMS
ALL GATES ARE 1/4 SN7400(TI)
R1
1k
R3
1k
C1
100pF
C2
100pF
R2
D1
IN914
R4
D2
IN-914
OUTPUT
R5
R6
V_IN
INVERTED OUTPUT


DIFFERENTIAL AMPLIFIER
SINGLE SHOT MULTIVIBRATOR
+12v
47
22μf
R1
1k
4.7k
R2
1.5k
R6
2.2k
C2
.0025μf
Q3
2N3906
1μsec
OUTPUT
Q1
2N3904
Q2
2N3904
Q4
470
R5
150
C1
0.002
μf
Q5
2N3643
4.7k
R3
1k
R4
100

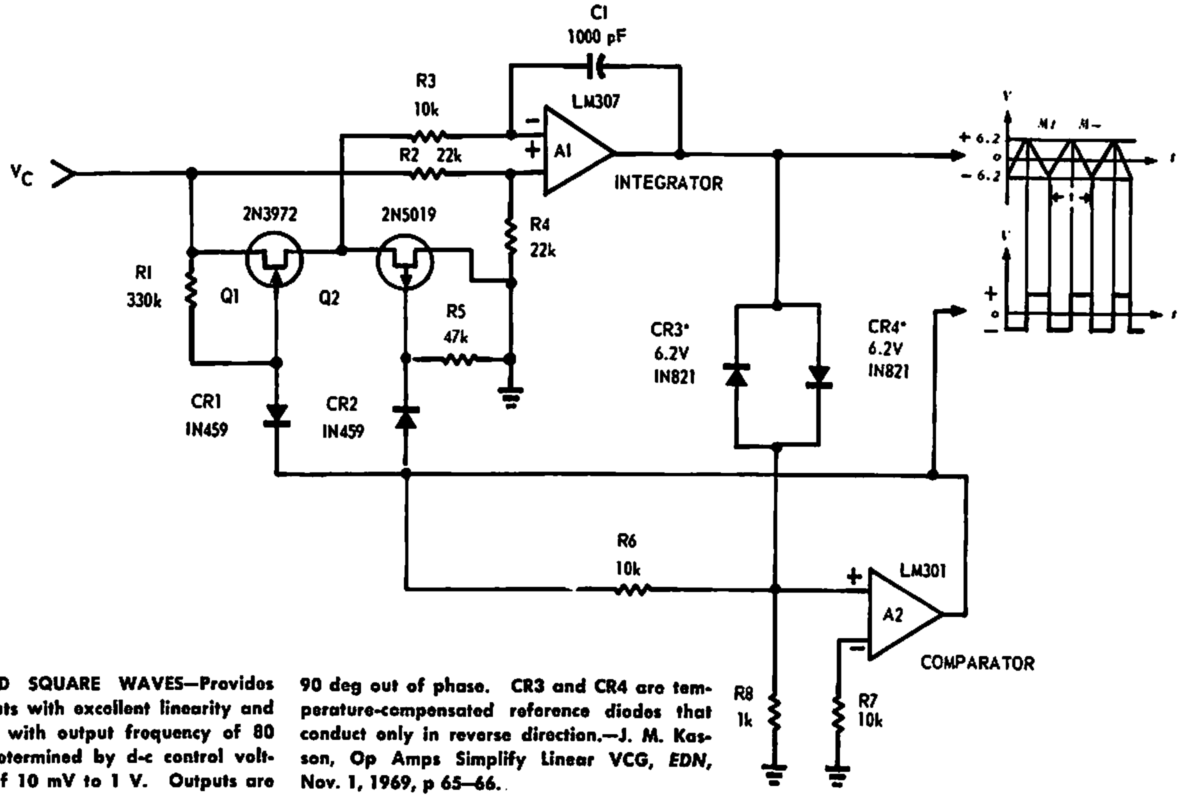
STABLE SQUARE-WAVE—Time constant R1C1 is essentially independent of temperature and supply-voltage variations. Frequency change is less than 1% for 30% supply-voltage change and temperature range of −25 to 100 C. Can be used as voltage-controlled oscillator by applying varying d-c voltage to base of Q2.—J. Kisslinger, Pulse Generator Is Supply And Temperature Independent, *Electronics*, May 27, 1968, p 106.

DUAL-GATE IC AS VCO—Total cost of parts is under $1. Gates are connected as free-running mvbr whose frequency is controlled over range of 30 to 70 kHz by d-c input control voltage of 4 to 9 V.—L. Toth, Voltage-Controlled Oscillator Uses Two Integrated Circuits, *Electronic Design*, Nov. 8, 1969, p 109.

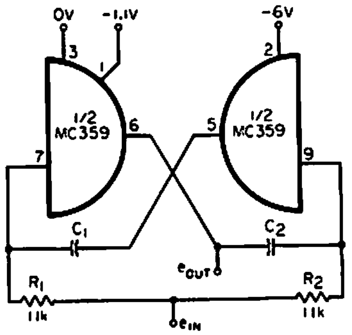

2000pF
C1
5
4
6
dc INPUT
R2
4.7k
R1
4.7k
(+4TO+9V)
R3
4.7k
3
μL 914
7
OUTPUT
(30TO 70 kHz)
2
1
8
+3.6V
C2
2000pF


+10.6V
1K
5.1V
1K
R2=∞
IN906
IN906
R2=∞
1.2K
1.2K
82pf
82pf
Q1
2N706
1K
R3
6.8K
Q2
2N706
R3
6.8K
e1
0.01
−11V
1K
6.2K
6.2K
Q3
2N1224
Q4
2N224
T1
OUTPUT

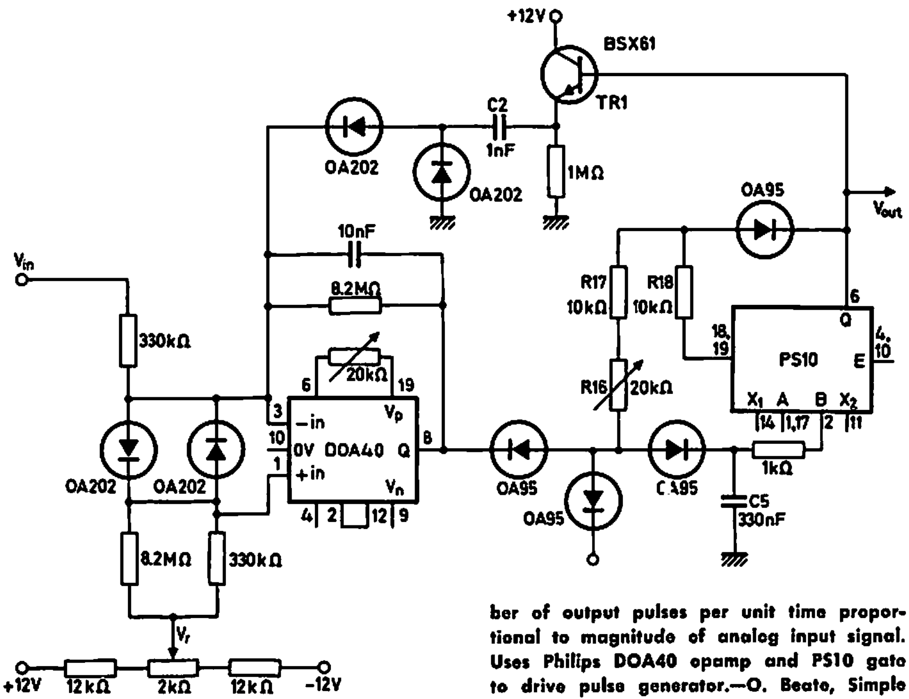
VOLTAGE-CONTROLLED 800 KHZ–1.7 MHZ—Serves as local sweep oscillator in superhet receiver used for signal analysis and/or signal identification. Provides greater linearity over wider bandwidth of modulation than conventional circuits. Uses mvbr operating from well-regulated power supply. Article gives design equations and performance graphs.—A. Goodman, Increasing the Band Range of a Voltage-Controlled Oscillator, *Electronic Design*, Sept. 28, 1964, p 28–35.


C1
1000 pF
R3
10k
LM307
R2 22k
A1
INTEGRATOR
VC
2N3972
2N5019
R4
22k
R1
330k
Q1
Q2
R5
47k
CR1
IN459
CR2
IN459
CR3*
6.2V
IN821
CR4*
6.2V
IN821
+6.2
0
−6.2
R6
10k
LM301
A2
COMPARATOR
R8
1k
R7
10k

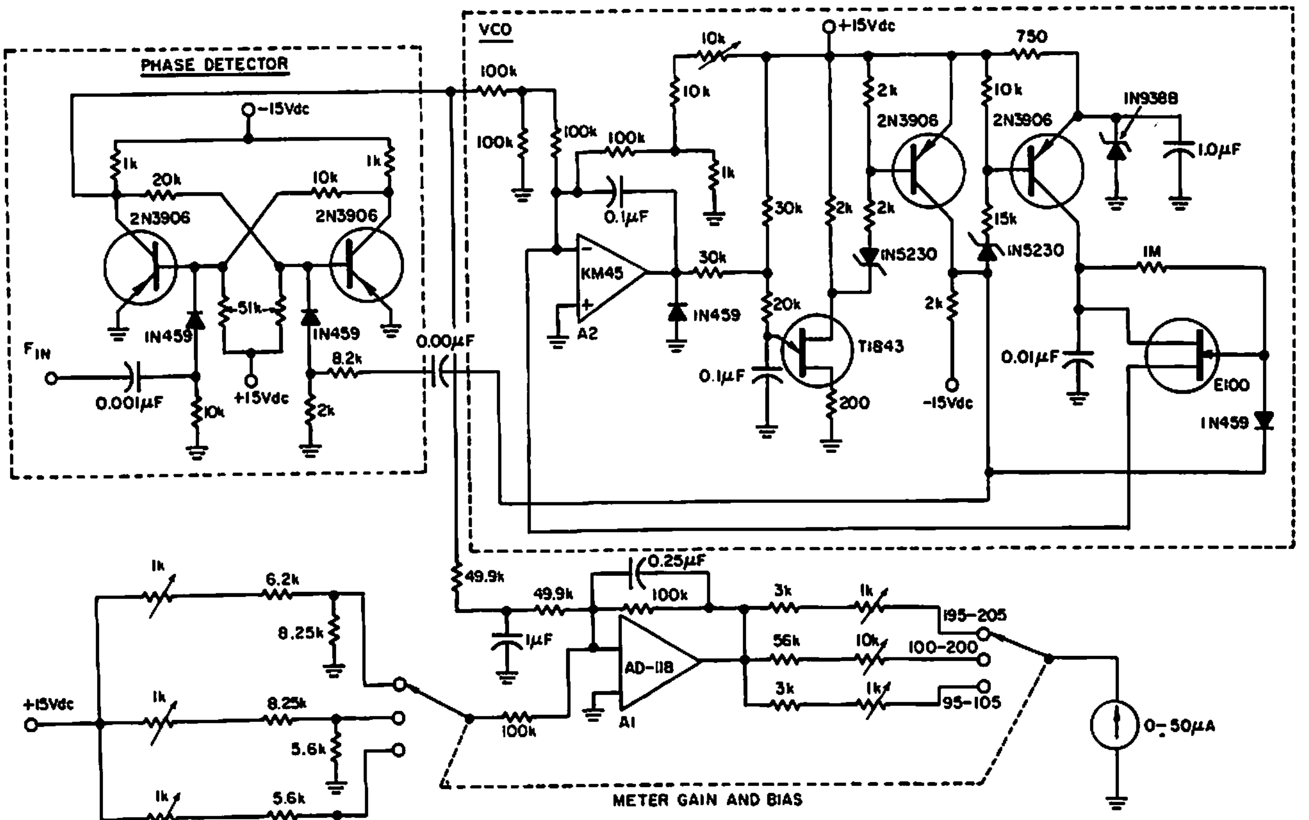
TRIANGLE AND SQUARE WAVES—Provides choice of outputs with excellent linearity and good stability, with output frequency of 80 to 8,000 Hz determined by d-c control voltage in range of 10 mV to 1 V. Outputs are 90 deg out of phase. CR3 and CR4 are temperature-compensated reference diodes that conduct only in reverse direction.—J. M. Kasson, Op Amps Simplify Linear VCG, *EDN*, Nov. 1, 1969, p 65–66.


0V
-1.1V
-6V
1/2 MC359
1/2 MC359
C_1
C_2
e_{OUT}
R_1
1 1k
R_2
1 1k
e_{IN}

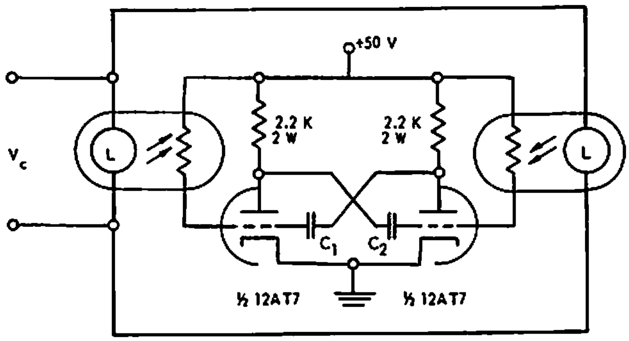
CROSS-COUPLED NOR GATES—Low-cost vco may be used as f-m generator, phase-lock loop reference, or analog-digital converter. IC gate connections form astable mvbr for which frequency is 0.5 Hz when C1 and C2 are 100 μF and control voltage is zero. With 10 μF for both capacitors, frequency is 6.3 Hz; 4,700 pF gives 20 kHz; 110 pF gives 757 kHz.—E. S. Donn, Wide Range VCO Uses IC, *EEE*, May 1967, p 182 and 184.


+12V
BSX61
TR1
C2
1nF
1MΩ
OA202
OA202
OA95
V_{out}
10nF
8.2MΩ
V_{in}
R17 10kΩ
R18 10kΩ
330kΩ
20kΩ
-in
0V DOA40 Q
+in
V_p
V_n
PS10
Q
E
X_1 A B X_2
R16 20kΩ
OA202
OA202
OA95
OA95
OA95
1kΩ
C5 330nF
8.2MΩ
330kΩ
V_r
+12V 12kΩ 2kΩ 12kΩ -12V

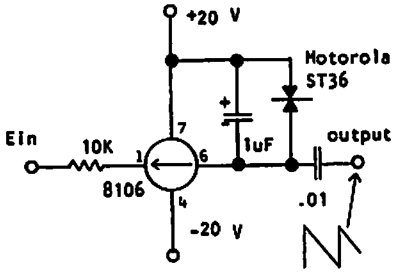
A/D CONVERTER DRIVES STEPPING MOTOR—Magnitude of analog input voltage determines period between output pulses, making number of output pulses per unit time proportional to magnitude of analog input signal. Uses Philips DOA40 opamp and PS10 gate to drive pulse generator.—O. Beato, Simple Analogue-to-Digital Converter, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 68.


PHASE DETECTOR
VCO
-15Vdc
+15Vdc
2N3906
2N3906
IN459
F_{IN}
0.001μF
0.00μF
KM45
A2
T1843
E100
IN9388
IN5230
1.0μF
0.01μF
AD-118
A1
195–205
100–200
95–105
0–50μA
+15Vdc
METER GAIN AND BIAS

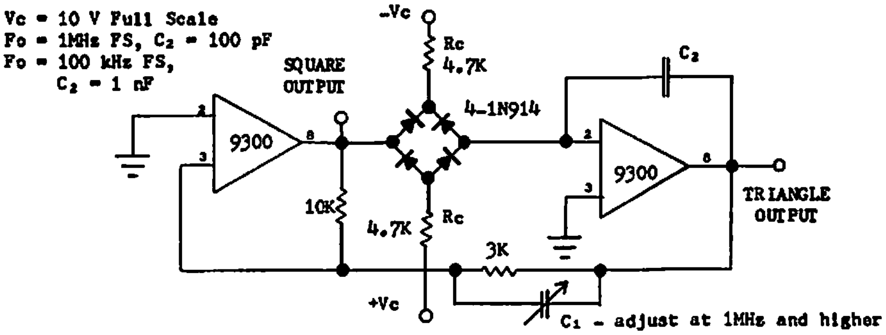
VCO AS DISCRIMINATOR—Vco is phase-locked to incoming prr in range of 95 to 205 Hz. Average value of phase-detector output varies linearly with phase angle over full 360-deg range. System is similar to that long used in f-m/f-m telemetry. Frequency coverage is achieved in three ranges by switch at bottom.—P. B. Uhlenhopp and L. G. Smeins, Try Using VCOs as Discriminators, *Electronic Design*, June 7, 1970, p 86–87.


+50 V
Vc
L
2.2 K 2 W
2.2 K 2 W
C1
C2
L
½ 12AT7
½ 12AT7

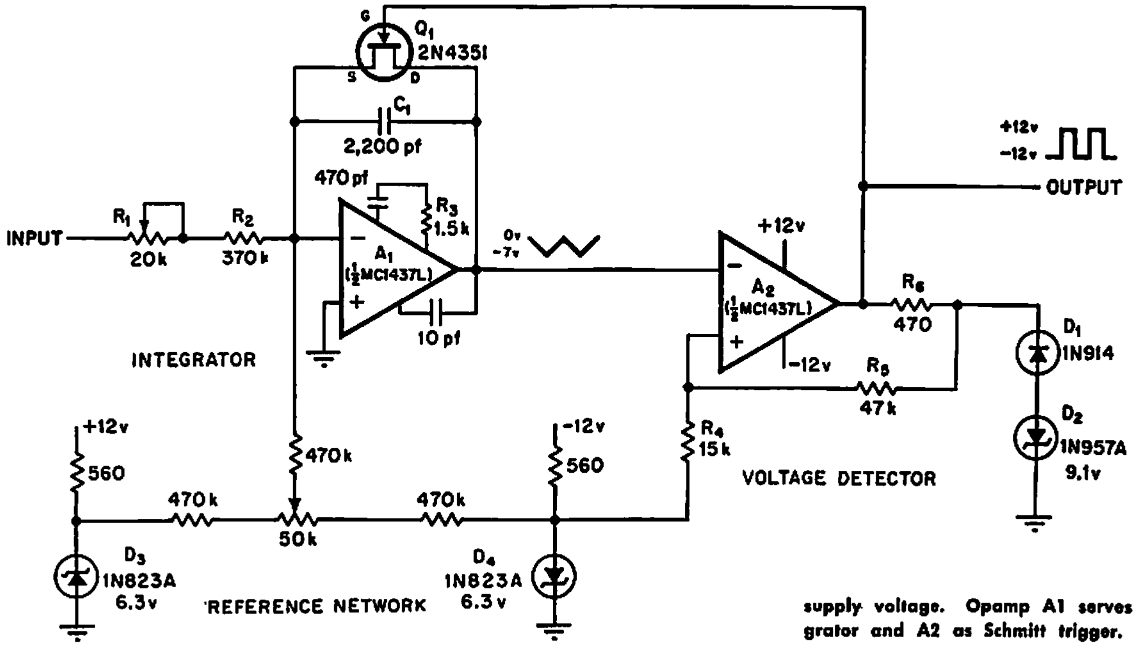
OPTOELECTRONIC VCO—Two Raysistors in grid circuits of anode-coupled mvbr, with lamps in parallel, provide frequency range of 5 to 5,000 Hz for d-c input control voltage range of 0.4 V. Raysistors can be Raytheon CK1102.—Raysistor Optoelectronic Devices, Raytheon Components Division, Quincy, Mass., 1967, p 18.


+20 V
Motorola ST36
Ein
10K
1
7
6
+
1uF
output
8106
4
-20 V
.01

CURRENT SOURCE AS VCO—Current source charges capacitor linearly at rate determined by input voltage. Capacitor discharges when its voltage exceeds breakdown voltage of four-layer diode. Can be used as sweep circuit, with or without synchronization by external pulse. Linearity is better than 1% of full scale as voltage-frequency transducer below 1 kHz.—Applying the Model 8106 Monolithic Precision Current Source, Optical Electronics, Tucson, Ariz., No. 10168.

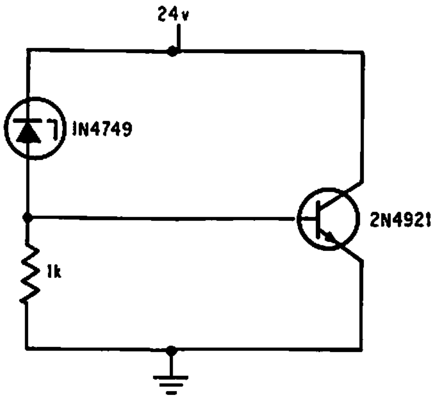

Vc = 10 V Full Scale
Fo = 1MHz FS, C2 = 100 pF
Fo = 100 kHz FS,
C2 = 1 nF
-Vc
Rc 4.7K
SQUARE OUTPUT
4-1N914
C2
2
9300
8
3
10K
4.7K
Rc
2
9300
8
3
TRIANGLE OUTPUT
3K
+Vc
C1 - adjust at 1MHz and higher

LINEAR VCO—Generates both square and sawtooth waveforms at frequency dependent on differential control voltage Vc having equal positive and negative levels. Control voltage is readily generated by signal itself and inverted signal of opamp such as OEI 9302.—Applying the Model 9300 Monolithic Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10134.


G
Q1
2N4351
S
D
C1
2,200 pf
470 pf
R3 1.5k
+12v
-12v
OUTPUT
INPUT
R1 20k
R2 370k
A1 (½MC1437L)
0v
-7v
+12v
A2 (½MC1437L)
-12v
R6 470
R5 47k
D1 1N914
D2 1N957A 9.1v
10 pf
INTEGRATOR
R4 15k
VOLTAGE DETECTOR
+12v
560
470k
-12v
560
470k
50k
470k
D3 1N823A 6.3v
D4 1N823A 6.3v
REFERENCE NETWORK

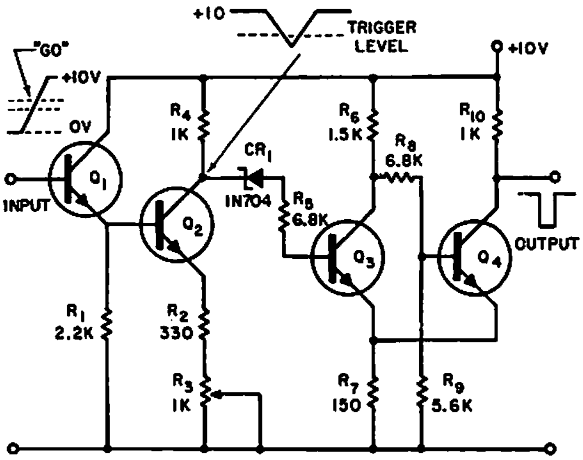
0–1 KHZ VCO—Increasing d-c input voltage from 0 to 5 V makes output frequency of voltage-controlled oscillator increase linearly from 0 to 1 kHz. Output frequency is stable within 0.1% for variations up to 15% in supply voltage. Opamp A1 serves as integrator and A2 as Schmitt trigger. Used in analog-digital converters.—D. J. Knowlton, Two OP Amps Simplify Design of Oscillator, *Electronics*, April 27, 1970, p 92.

CHAPTER 97
Voltage-Level Detector Circuits



24v
1N4749
2N4921
1k

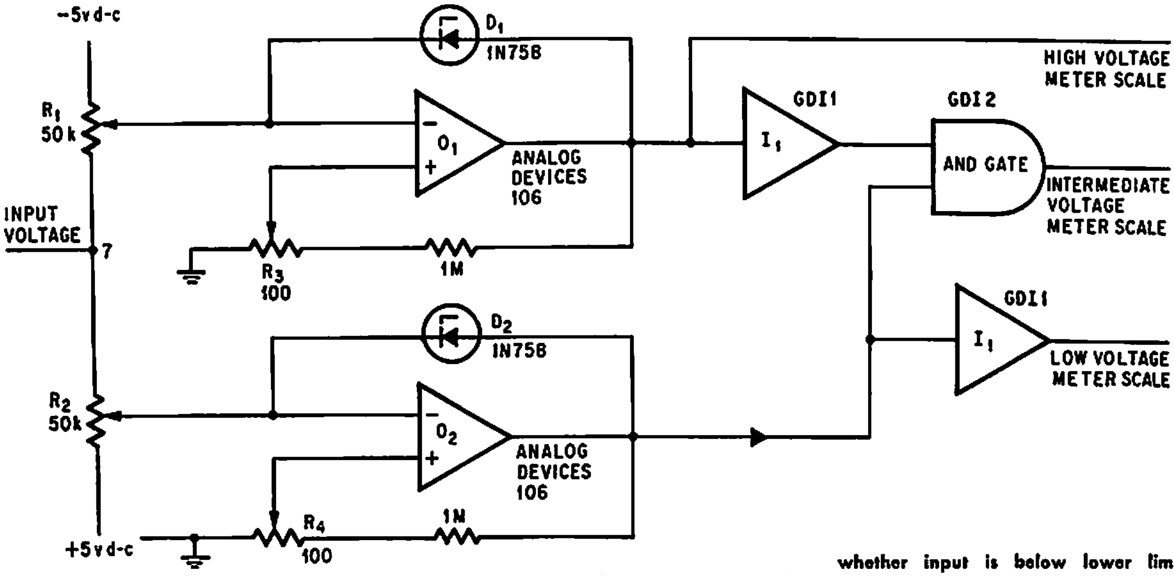
POWER ZENER—Zener conducts when supply voltage reaches 24 V, developing voltage across 1K resistor that turns on transistor. Resulting increased power is obtained at fraction of cost of power zener otherwise required.—J. O. Schroeder, Transistor Increases Zener's Power Capability, *Electronics*, Sept. 16, 1968, p 99–100.



+10
TRIGGER LEVEL
"GO"
+10V
0V
INPUT
Q1
Q2
Q3
Q4
R4 1K
CR1
1N704
R6 1.5K
R8 6.8K
R5 6.8K
R10 1K
+10V
OUTPUT
R1 2.2K
R2 330
R3 1K
R7 150
R9 5.6K

ALL TRANSISTORS 2N696

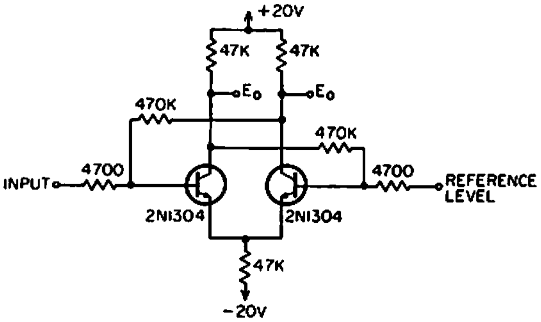
5.6–5.8 V GO-NO-GO—Provides voltage discrimination within 0.2-V passband for automatic testing. Only voltages within passband cause switching of Schmitt trigger. R3 controls width of passband. For other GO bands, input voltages should be applied to Q1 through suitable voltage dividers or zener diodes.—R. Vokoun, Voltage Level Discriminator Provides Go-No-Go Indication, *Electronic Design*, Nov. 23, 1964, p 67–69.

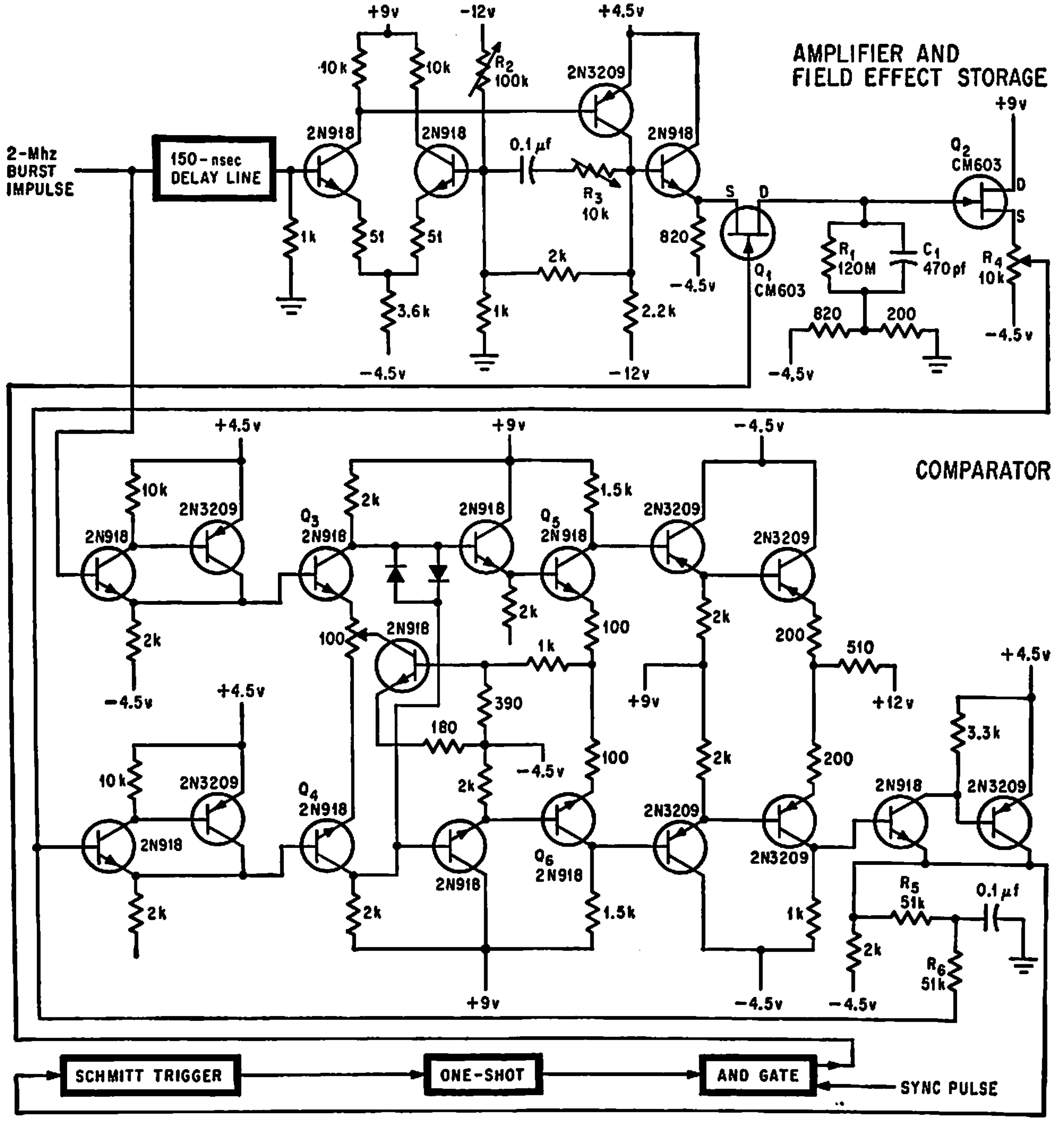


-5v d-c
R1 50k
INPUT VOLTAGE
7
R2 50k
+5v d-c
D1 1N758
D2 1N758
O1
O2
ANALOG DEVICES 106
ANALOG DEVICES 106
R3 100
1M
R4 100
1M
GDI1
I1
GDI 2
AND GATE
GDI1
I1
HIGH VOLTAGE METER SCALE
INTERMEDIATE VOLTAGE METER SCALE
LOW VOLTAGE METER SCALE

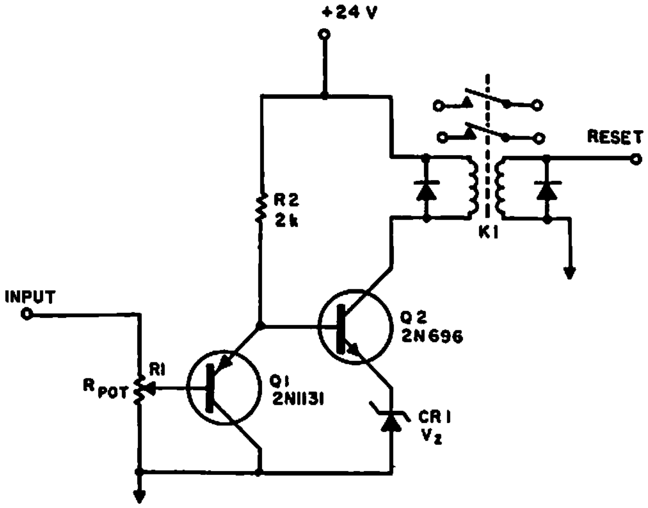
AUTOMATIC VOLTMETER—IC opamps and other standard logic circuits connected as shown give automatic three-range switching for voltage comparator. Voltage limits are independently adjustable. One output will indicate whether input is above upper limit, another will indicate whether input is between limits, and third output will indicate whether input is below lower limit. Any limit may be either positive or negative.—W. Ellermeyer, Voltage Comparator Is Made With Op Amps and Logic Gates, *Electronics*, July 8, 1968, p 91–92.

VOLTAGE-LEVEL DETECTOR—Differential amplifier has two stable states as in flip-flop, and changes state whenever d-c input level goes above preset reference level. With components shown, differential of only 100 mV with respect to reference will change state. —G. Richwall, Adjustable Level-Detector, *EEE*, Oct. 1966, p 139.

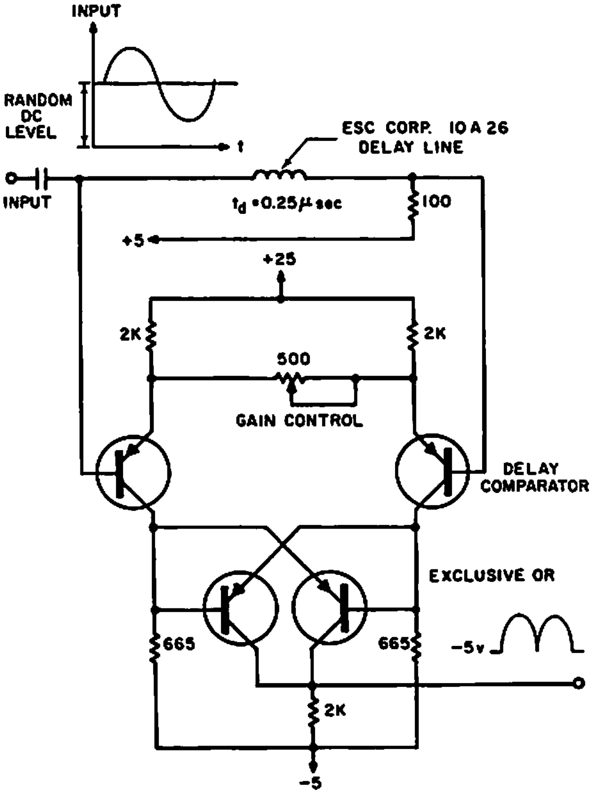

+20V
47K
47K
E₀
E₀
470K
470K
INPUT
4700
4700
REFERENCE LEVEL
2N1304
2N1304
47K
-20V


AMPLIFIER AND FIELD EFFECT STORAGE
2-Mhz BURST IMPULSE
150-nsec DELAY LINE
+9v
-12v
+4.5v
10k
10k
R₂ 100k
2N3209
2N918
2N918
2N918
0.1 µf
R₃ 10k
1k
51
51
3.6k
1k
2k
2.2k
820
-4.5v
-4.5v
-12v
S
D
Q₁ CM603
Q₂ CM603
R₁ 120M
C₁ 470pf
R₄ 10k
820
200
-4.5v
+9v
-4.5v
COMPARATOR
+4.5v
+9v
-4.5v
10k
2N3209
2N918
Q₃ 2N918
2k
2N918
Q₅ 2N918
1.5k
2N3209
2N3209
2k
2k
100
2N918
1k
100
2k
200
510
+12v
+9v
-4.5v
+4.5v
390
180
-4.5v
100
2k
200
+4.5v
3.3k
10k
2N3209
2N918
Q₄ 2N918
2k
2N918
Q₆ 2N918
2N3209
2N3209
2N918
2N3209
2k
2k
1.5k
1k
R₅ 51k
0.1µf
2k
R₆ 51k
+9v
-4.5v
-4.5v
SCHMITT TRIGGER
ONE-SHOT
AND GATE
SYNC PULSE

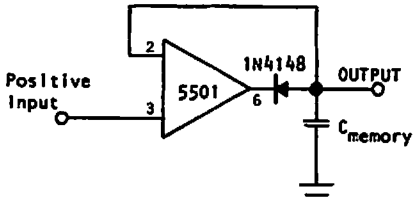
VIDEO BURST PEAK DETECTOR—Useful where position of peak in video signal is required, as for sampling time delay signals and for video, radar, and sonar equipment. Comparator circuit can sense highest peak of 2-MHz a-m burst to within 5 mV for peaks up to 1 V.—D. S. Greenstein, Detector Stores Peaks of Video Bursts, *Electronics*, Oct. 3, 1966, p 104–106.


+24 V
RESET
R2
2k
K1
INPUT
Q2
2N696
R1
R_{POT}
Q1
2N1131
CR1
V_Z

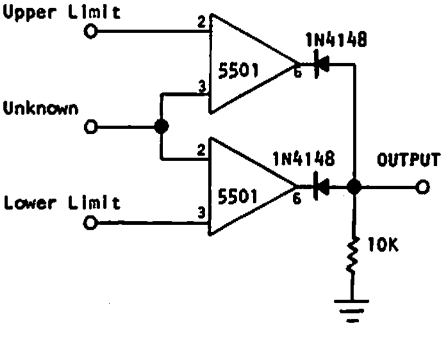
FAIL-SAFE VOLTAGE MONITOR—Operates latching relay when input voltage exceeds threshold level set by R1. For fail-safe application, relay contacts are connected to remove power from system or perform other required function. Transistors provide temperature compensation to improve accuracy. —M. Furukawa, Voltage-Sensing Circuit Is Temperature-Compensated, *Electronic Design*, May 10, 1967, p 90–91.


INPUT
RANDOM DC LEVEL
t
ESC CORP. 10A26 DELAY LINE
INPUT
t_d =0.25μsec
100
+5
+25
2K
2K
500
GAIN CONTROL
DELAY COMPARATOR
EXCLUSIVE OR
665
665
-5v
2K
-5

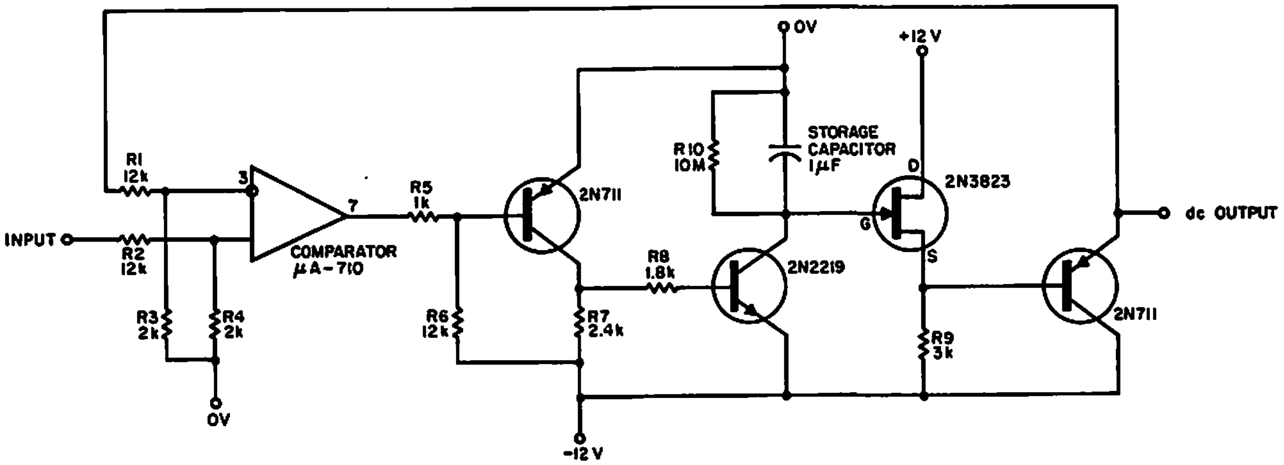
CORE PULSE-HEIGHT DETECTOR—Self-tracking detector is virtually independent of duty cycle, recovers core-memory outputs having random d-c component, and can detect signals in presence of noise frequencies that are one order of magnitude lower than signal. Will detect 200-ns pulse with rise time of 100 ns. Uses comparator method, by making comparison between each half-cycle preceding and following d-c level crossing. All transistors are 2N711.—R. T. Shevlin, Pulse-Height Detector Operates Independently of D-c Input Level, *Electronic Design*, March 29, 1965, p 32–33.


Positive Input
2
3
5501
6
1N4148
OUTPUT
C_{memory}

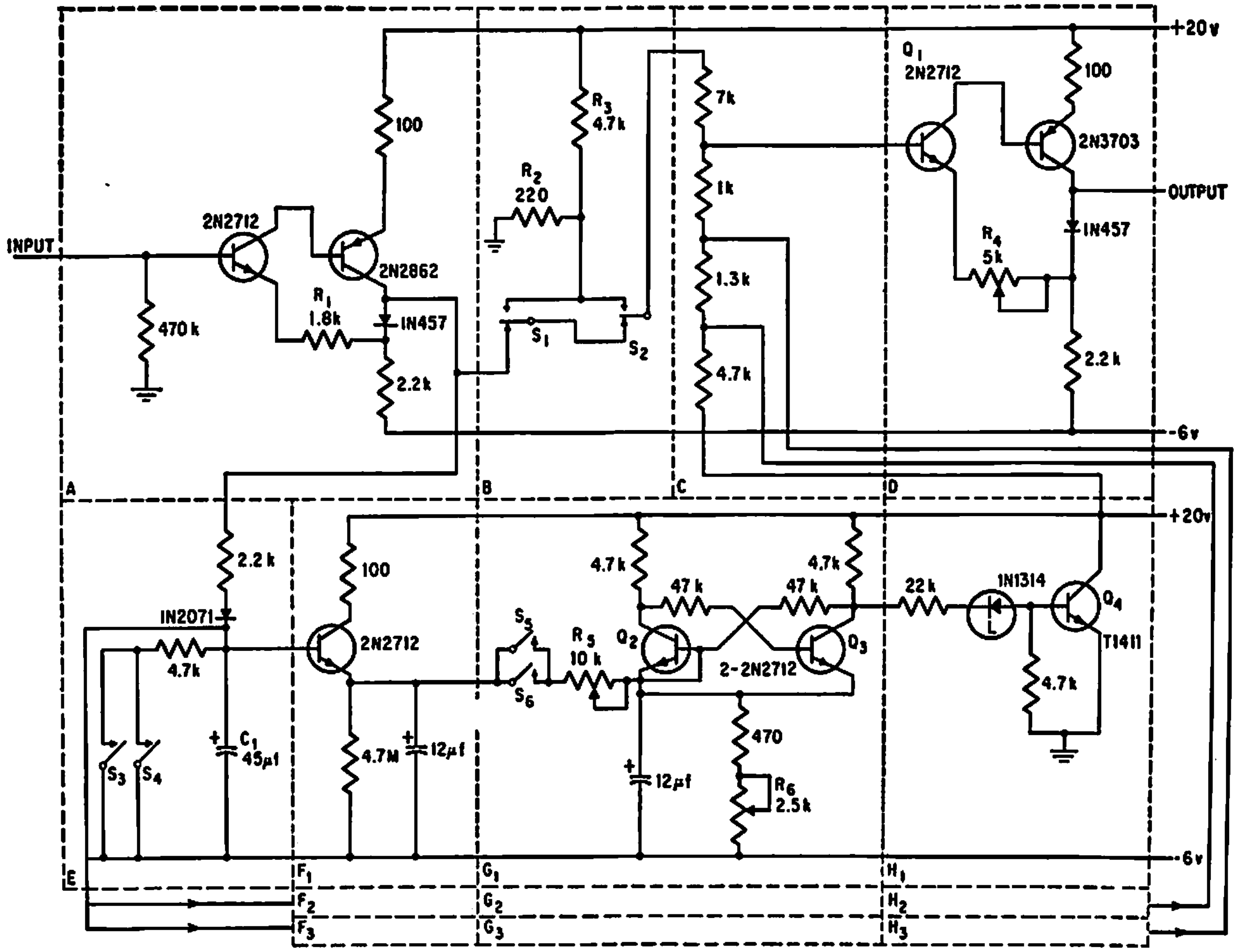
PEAK SENSE AND HOLD—IC analog comparator serves for comparing input voltage with that across memory capacitor. If input is greater than that of capacitor, output moves in positive direction to charge capacitor until it equals input voltage. 5501 then changes state and reverse-biases diode, isolating capacitor to hold value of input voltage.—Applying the Model 5501 Monolithic Analog Comparator, Optical Electronics, Tucson, Ariz., No. 10147.


Upper Limit
2
3
5501
6
1N4148
Unknown
2
3
5501
6
1N4148
OUTPUT
Lower Limit
10K

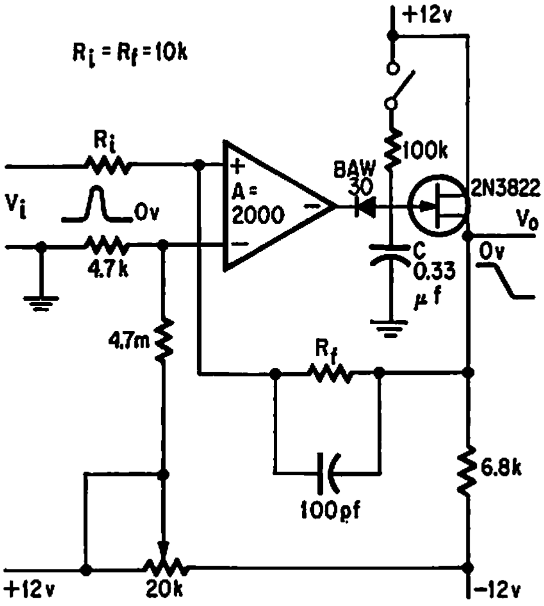
WINDOW DETECTOR—Uses two analog comparators to give zero output when unknown input voltage is within predetermined acceptable range or "window." Output is positive when unknown is beyond limits that are independently set.—Applying the Model 5501 Monolithic Analog Comparator, Optical Electronics, Tucson, Ariz., No. 10147.


0V
+12 V
R1
12k
3
INPUT
R2
12k
R3
2k
R4
2k
0V
7
COMPARATOR
µA-710
R5
1k
R6
12k
2N711
R7
2.4k
-12 V
R8
1.8k
2N2219
R10
10M
STORAGE
CAPACITOR
1µF
D
G
S
2N3823
R9
3k
2N711
dc OUTPUT

NARROW-PULSE PEAK SENSOR—Provides exact proportionality of d-c output to input signal peaks. Has low threshold, for response to very slight increases in peak amplitudes. Will handle pulses as narrow as 0.2 µs and duty cycle below 1% for repetitive signals. IC differential comparator samples peak and compares it with existing d-c output voltage, then drives level shifter controlling transistor switch that supplies current to storage capacitor that governs d-c output voltage.—W. C. Dillon, An Operational Peak Detector Captures Very Narrow Pulses, *Electronic Design*, Oct. 25, 1967, p 138 and 140.

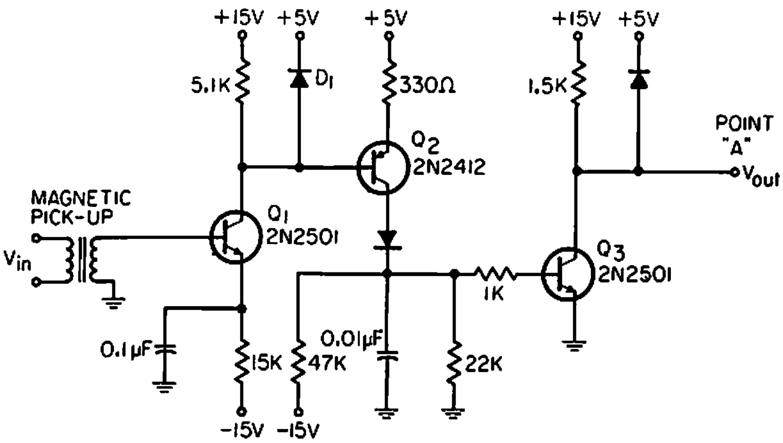

+20v
Q1
2N2712
100
2N3703
OUTPUT
1N457
R4
5k
2.2k
-6v
7k
1k
1.3k
4.7k
R3
4.7k
R2
220
S1
S2
100
2N2712
2N2862
INPUT
470 k
R1
1.8k
1N457
2.2k
A
B
C
D
+20v
2.2 k
1N2071
4.7k
C1
45µf
S3
S4
100
2N2712
4.7M
12µf
S5
S6
R5
10 k
Q2
4.7k
47 k
47 k
4.7k
2-2N2712
Q3
12µf
470
R6
2.5k
22k
1N1314
Q4
T1411
4.7k
-6v
E
F1
F2
F3
G1
G2
G3
H1
H2
H3

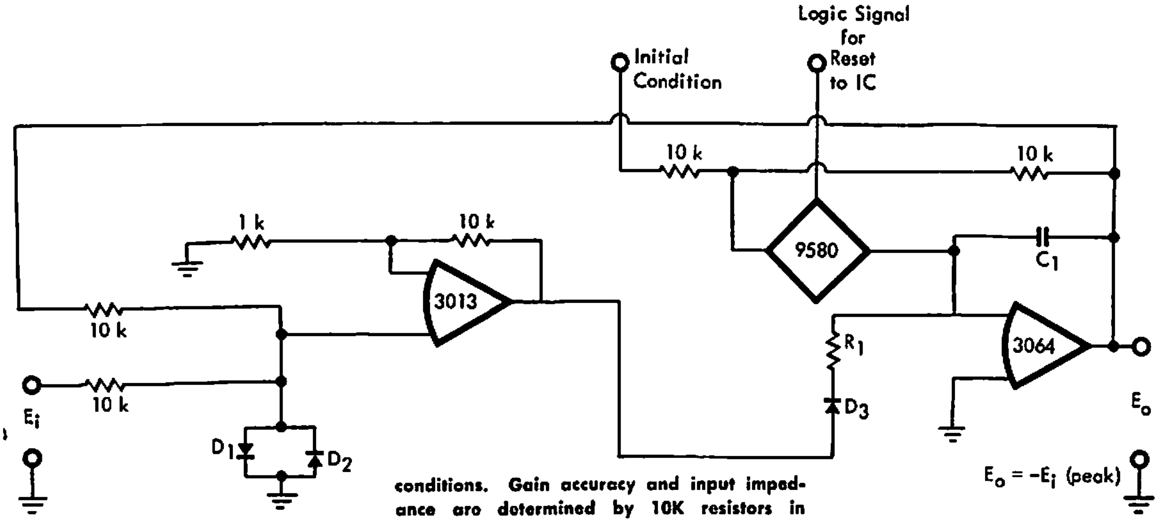
PEN RECORDER SCALE CHANGER—Although developed to operate with spectrometer that repetitively scans frequency band of light emissions in upper atmosphere, this low-cost scale changer can be used with other meters and recorders as well. Three ranges are provided, with automatic changing at end of scan when input during scan rises to 1 V, 2 V, and 4 V. Article gives operating details. Peak-level detector stage E drives three identical chains of F, G, and H stages, one for each scale factor. F stages provide impedance matching. G stages are flip-flops adjusted to switch at different input voltage levels. H stages operate as ground switches. —B. E. Bourne and R. L. Gattinger, Automatic Scale Changer Shifts Recorder Range, *Electronics*, May 15, 1967, p 95–97.


$R_i = R_f = 10k$
+12v
R_i
V_i
0v
4.7k
A = 2000
BAW 30
100k
2N3822
V_o
C 0.33 μf
0v
4.7m
R_f
100pf
6.8k
+12v
20k
-12v

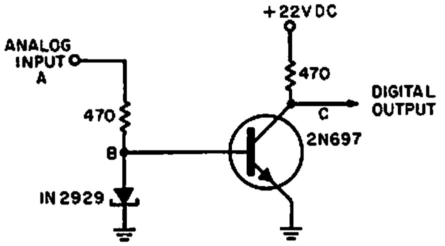
PEAK DETECTOR—Basic diode-capacitor peak detector accuracy is improved 1,000 times by adding fet and IC opamp. With nulling switch open and positive pulse at input, circuit acts as inverting amplifier. When downward transition of pulse begins, output is held constant at peak value because detector and source follower cannot follow change in polarity. To adjust output for zero offset with zero input voltage, close nulling switch and adjust 20K pot.—A. E. Vinatzer, High Accuracy Obtained from Peak Detector Using Op Amp, *Electronics*, March 17, 1969, p 94.

DETECTOR AND COUNTER—Circuit shown will detect envelope of bursts of high-frequency pulses in range of 1 kHz to 1 MHz if suitable component values are used. For those shown, upper limit for input prf is 1 kHz. If D1 is connected to point A instead of to +5 V, circuit becomes pulse counter that delivers output pulse after arrival of specified number of input pulses. After each circuit lock-up, 0.01-μF capacitor must be discharged manually or given time to discharge before input is reapplied.—K. Sheth, Pulse-Train Detector and Counter, *EEE*, Nov. 1966, p 156.

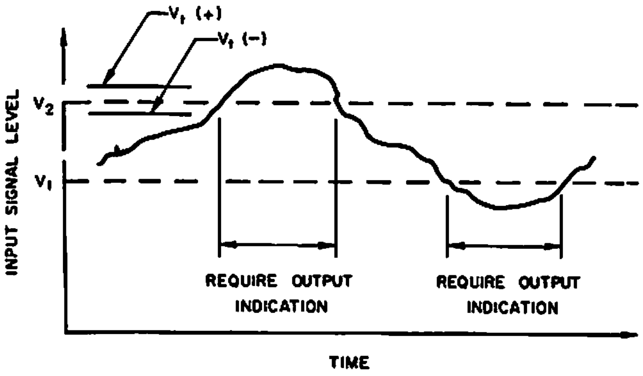

+15V
+5V
+5V
+15V
+5V
5.1K
D_1
330Ω
Q_2
2N2412
1.5K
POINT "A"
V_{out}
MAGNETIC PICK-UP
Q_1
2N2501
V_{in}
Q_3
2N2501
1K
0.1μF
15K
47K
0.01μF
22K
-15V
-15V

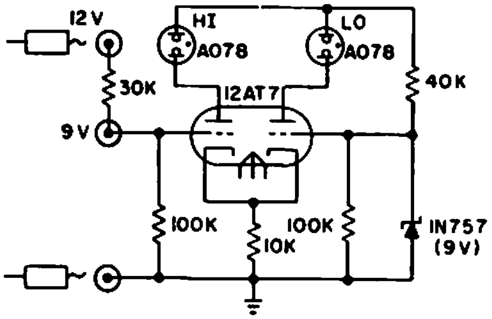

Initial Condition
Logic Signal for Reset to IC
10 k
10 k
1 k
10 k
9580
C_1
3013
10 k
3064
R_1
D_3
E_o
10 k
E_i
D_1
D_2
$E_o = -E_i$ (peak)

INVERTING PEAK DETECTOR—Uses Burr-Brown 9580 electronic switch and two opamps to provide high-speed reset to initial conditions. Gain accuracy and input impedance are determined by 10K resistors in summing network. Can reset to either negative or positive initial conditions, permitting use as peak detector even if some maxima are negative and some positive.—Operational Amplifiers, Burr-Brown Research, Tucson, Ariz., LI-327, 1969, p 43.

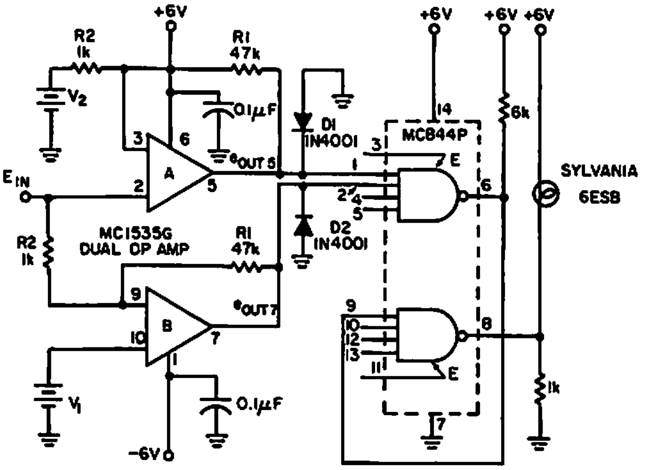

+22VDC
ANALOG INPUT A
470
470
C
DIGITAL OUTPUT
B
2N697
IN 2929

ANALOG VOLTAGE SENSOR—Action of positive-going analog input voltage on tunnel diode makes transistor saturate, at predetermined input point, so as to switch transistor on for positive halves of input signal cycles.—Tunnel Diode-Transistor Level Sensor (Circuit Digest), *Electronic Design*, March 2, 1964, p 58.



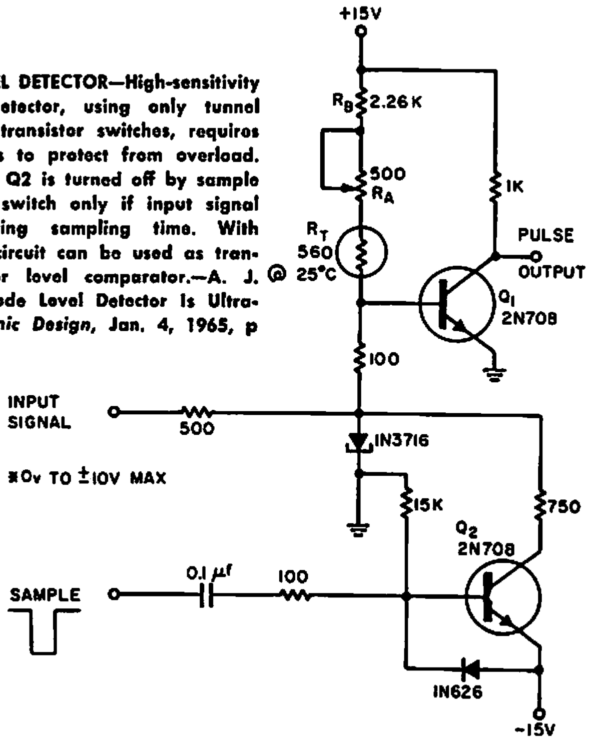

12V
HI
LO
A078
A078
30K
12AT7
40K
9V
100K
100K
10K
IN757 (9V)

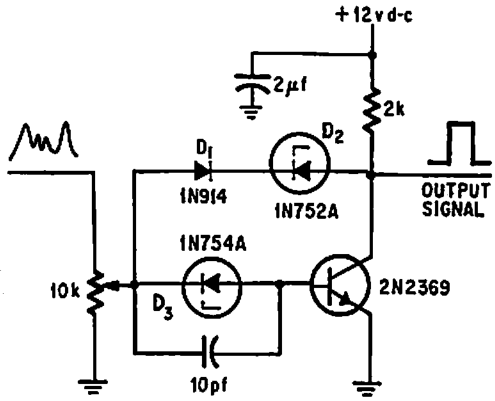
EQUAL VOLTAGE TEST—For balancing two voltage-divider points in production testing. Only 200-mV difference in either direction causes variation in illumination level of lamps. Any reference from zero to dissipation level of tube can be used instead of 9 V shown.—E. Bauman, "Applications of Neon Lamps and Gas Discharge Tubes," Signalite, Neptune, N.J., p 145.


+6V
R2 1k
R1 47k
V₂
0.1μF
OUT 5
D1 IN4001
14
MC844P
6k
+6V
+6V +6V
SYLVANIA 6ESB
E_IN
A
MC1535G DUAL OP AMP
R2 1k
R1 47k
D2 IN4001
OUT 7
B
V₁
0.1μF
−6V
1k
E
E

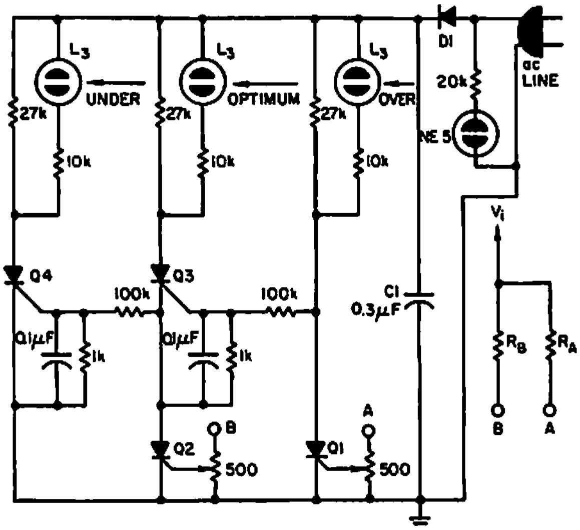
ENVELOPE DETECTOR—Pilot lamp is turned on when input signal voltage is above upper limit V2 or below lower limit V1. Amount of hysteresis about each limit is function of R1 and R2, and is 69 mV for limits of 2.5 V and 3.5 V.—K. Wolf, Signal-Level Envelope Detector Uses Dual Operational Amplifier, *Electronic Design*, Feb. 1, 1969, p 78 and 80.

5 MV—10 V LEVEL DETECTOR—High-sensitivity voltage level detector, using only tunnel diode and two transistor switches, requires no diode limiters to protect from overload. To sample input, Q2 is turned off by sample pulse. Q1 will switch only if input signal is positive during sampling time. With minor changes, circuit can be used as transient detector or level comparator.—A. J. Welty, Tunnel-Diode Level Detector Is Ultra-Sensitive, *Electronic Design*, Jan. 4, 1965, p 73–74.

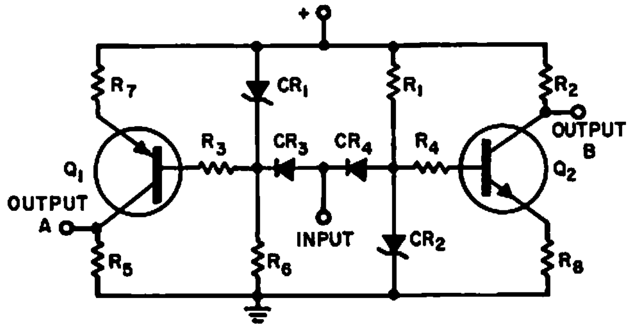

+15V
R_B 2.26K
500 R_A
1K
R_T 560 @ 25°C
PULSE OUTPUT
Q₁ 2N708
100
INPUT SIGNAL
500
IN3716
*0v TO ±10V MAX
15K
750
Q₂ 2N708
SAMPLE
0.1 μf
100
IN626
−15V


+12vd-c
2μf
2k
D₁
D₂
1N914
1N752A
OUTPUT SIGNAL
1N754A
10k
D₃
2N2369
10pf

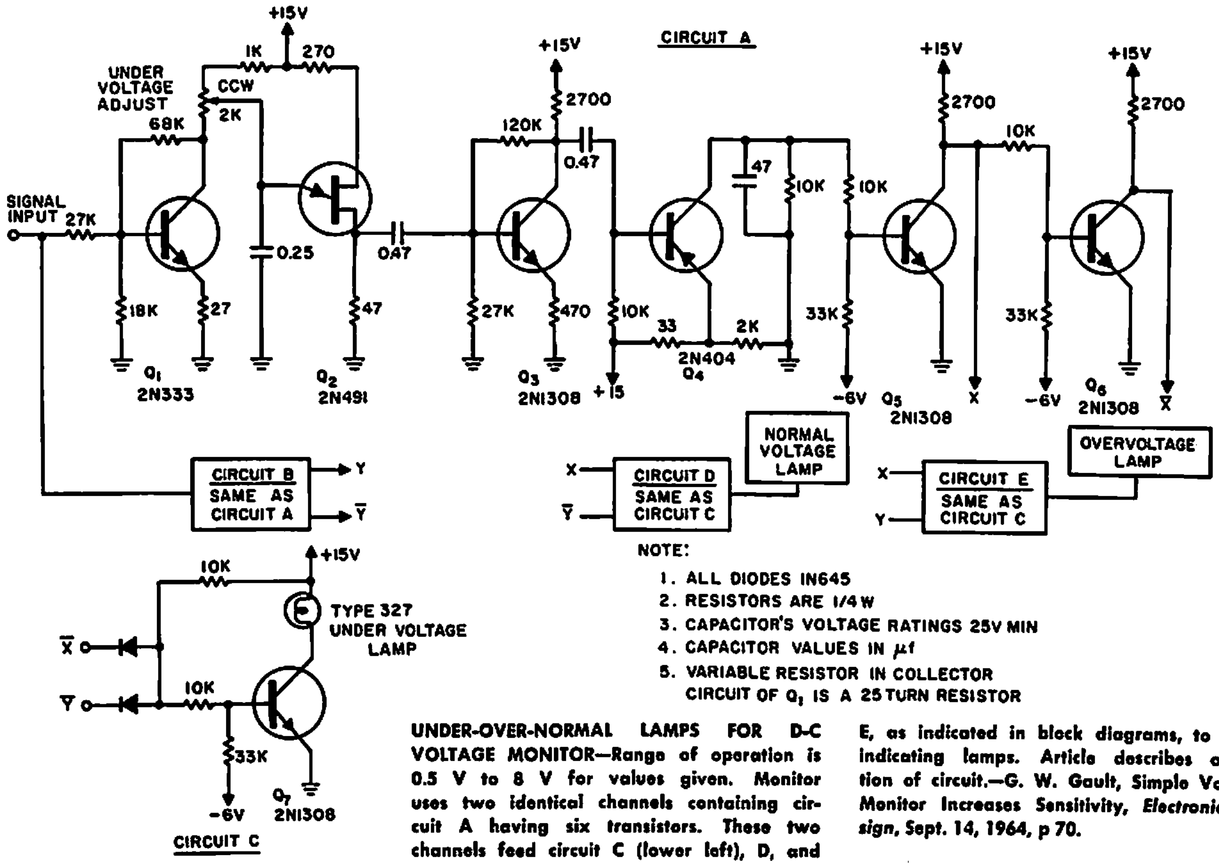
THRESHOLD DETECTOR—Zener diodes clamp collector of transistor at 0.5 V, just outside saturation region, to eliminate turnoff delay and thereby give faster rise and fall times, of order of 30 ns. Threshold value is independent of temperature if temperature coefficient of D1 is matched to D2 and that of D3 is matched to base-emitter junction of Q1. Potentiometer sets threshold level.—B. Fugit, Collector Clamping Improves Threshold Detector, *Electronics*, Sept. 30, 1968, p 81.


L3
UNDER
L3
OPTIMUM
L3
OVER
27k
10k
27k
10k
27k
10k
D1
ac LINE
20k
NE 5
Vi
Q4
Q3
100k
100k
.01μF
1k
.01μF
1k
C1 0.3μF
RB
RA
B
A
B
A
Q2
500
Q1
500

AMBIGUITY—Three-level voltage monitor automatically turns off lower-level indicator lamps when lamp at higher level is triggered, to eliminate ambiguity in display. Uses C106B1 scr's and any suitable neon lamps. If circuit is to monitor 100 V d-c to tolerance of 2 V, RA and RB are chosen to make Q1 and Q2 fire when Vi is 102 V and 98 V. Technique can be extended to more levels by adding more sections like middle one (Q2-Q3-L3).—A. Prokop, SCR Threshold Detector Eliminates Ambiguities, *Electronic Design*, Sept. 1, 1969, p 104 and 106.


+
R7
CR1
R1
R2
OUTPUT B
Q1
R3
CR3
CR4
R4
Q2
OUTPUT A
INPUT
CR2
R5
R6
R8

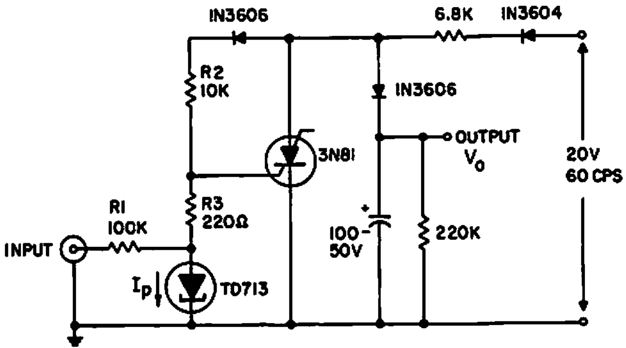
PULSE AMPLITUDE-POLARITY SORTER—Q1 detects positive input pulses and amplifies them sufficiently to drive several output circuits, while Q2 similarly detects and amplifies negative input pulses. Transistor types are not critical, as long as Q1 is pnp and Q2 is npn. Zenérs CR1 and CR2 are chosen to maintain associated transistors back-biased until incoming pulse makes transistors conduct. Other two diodes simply provide isolation. Signal-level adjustments are best made by using variable resistors for R1 and R6. Pulses of different levels can be sorted by using several circuits in parallel and adjusting each for different level. Other resistor values are not critical.—F. W. Kear, Pulse-Sorter Network Detects, Amplifies Bi-Polar Signals, *Electronic Design*, Aug. 30, 1965, p 48–49.


CIRCUIT A
+15V
1K
270
UNDER VOLTAGE ADJUST
CCW
2K
68K
SIGNAL INPUT
27K
0.25
18K
27
Q1 2N333
47
Q2 2N491
0.47
+15V
2700
120K
0.47
27K
470
Q3 2N1308
+15
10K
33
2K
2N404 Q4
47
10K
10K
33K
-6V
Q5 2N1308
+15V
2700
10K
X
33K
-6V
+15V
2700
Q6 2N1308
X̄
CIRCUIT B SAME AS CIRCUIT A
Y
Ȳ
X
Ȳ
CIRCUIT D SAME AS CIRCUIT C
NORMAL VOLTAGE LAMP
X
Y
CIRCUIT E SAME AS CIRCUIT C
OVERVOLTAGE LAMP
+15V
10K
TYPE 327 UNDER VOLTAGE LAMP
X̄
Y
10K
33K
-6V
Q7 2N1308
CIRCUIT C

NOTE:

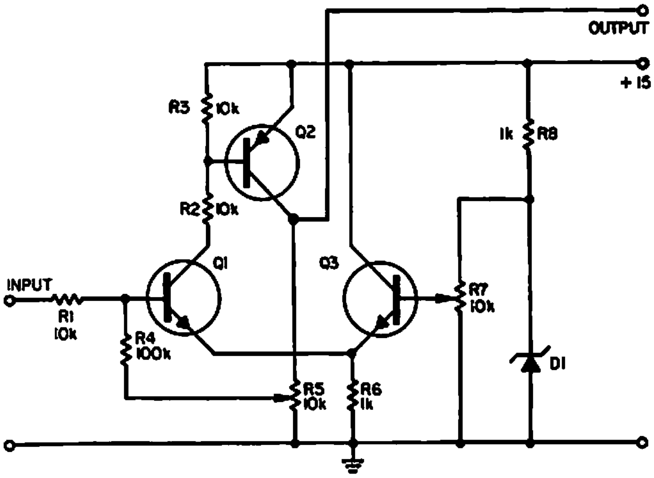
1. ALL DIODES IN645
2. RESISTORS ARE 1/4 W
3. CAPACITOR'S VOLTAGE RATINGS 25V MIN
4. CAPACITOR VALUES IN μf
5. VARIABLE RESISTOR IN COLLECTOR CIRCUIT OF Q_1 IS A 25 TURN RESISTOR

UNDER-OVER-NORMAL LAMPS FOR D-C VOLTAGE MONITOR—Range of operation is 0.5 V to 8 V for values given. Monitor uses two identical channels containing circuit A having six transistors. These two channels feed circuit C (lower left), D, and E, as indicated in block diagrams, to drive indicating lamps. Article describes operation of circuit.—G. W. Gault, Simple Voltage Monitor Increases Sensitivity, *Electronic Design*, Sept. 14, 1964, p 70.

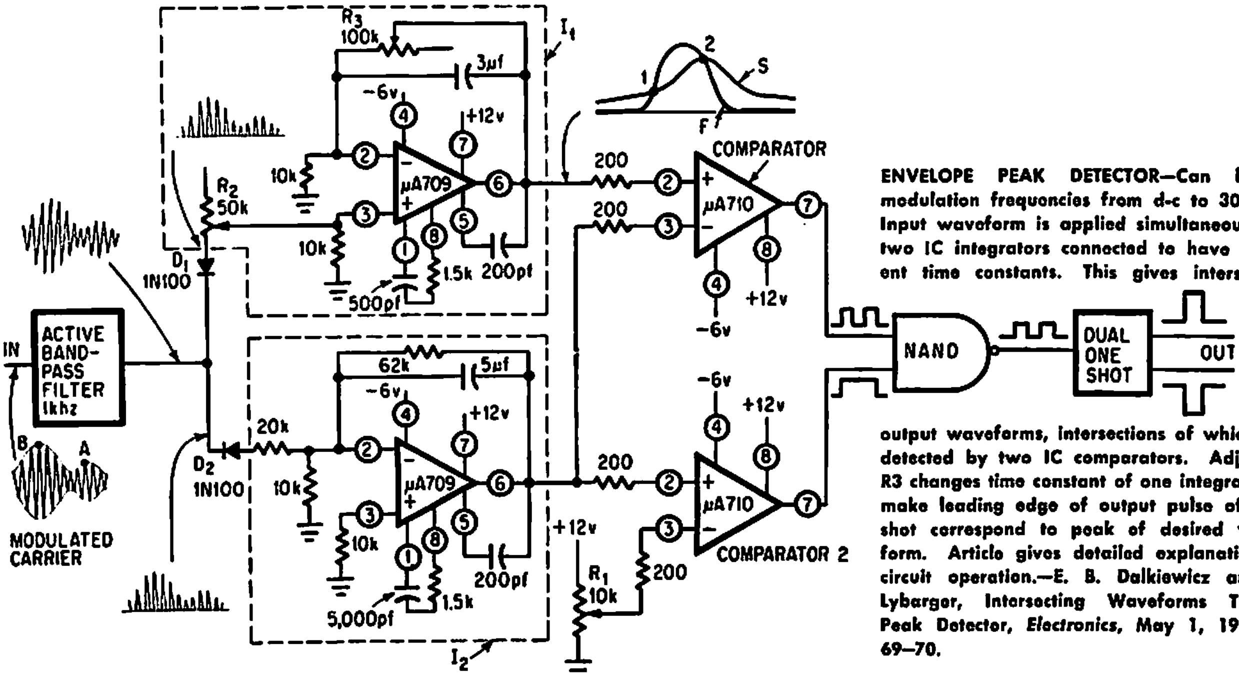

IN3606
6.8K
IN3604
R2
10K
IN3606
OUTPUT
V_o
3N81
20V
60 CPS
R1
100K
R3
220Ω
INPUT
100-
50V
220K
I_p
TD713

$$V_o = \left[I_p - \frac{V_{inpk}}{R1} \right] (R2+R3)$$

PEAK SENSING WITH TUNNEL DIODE—Used to measure peak voltage of waveform that repeats well above 60 times per second. 100-μF capacitor is charged by half-wave rectified 60-Hz voltage that also is applied to anode of scs 3N81. When input waveform brings tunnel diode to its peak point current, diode switches and turns on scs, terminating charging of capacitor. In negative half-cycle, capacitor discharges slightly but is recharged on next positive half-cycle. Output voltage is thus proportional to peak of input waveform.—W. R. Spofford, Jr., Applications For The New Low Cost TD700 Series Tunnel Diodes, General Electric, Syracuse, N.Y., No. 90.66, 3/67, p 10.

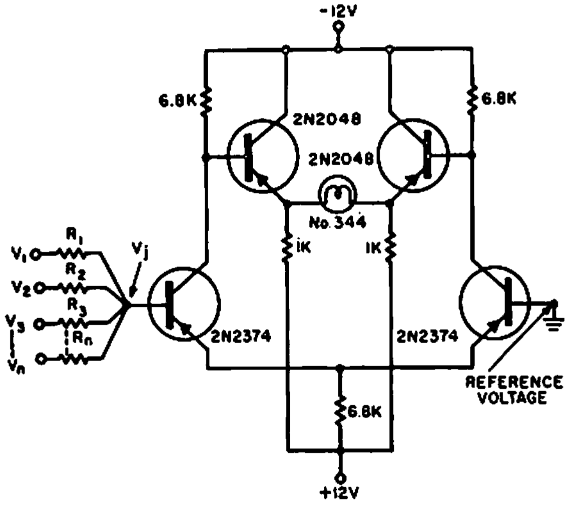

OUTPUT
+15
R3
10k
Q2
R2
10k
Q1
Q3
1k
R8
INPUT
R1
10k
R4
100k
R7
10k
D1
R5
10k
R6
1k

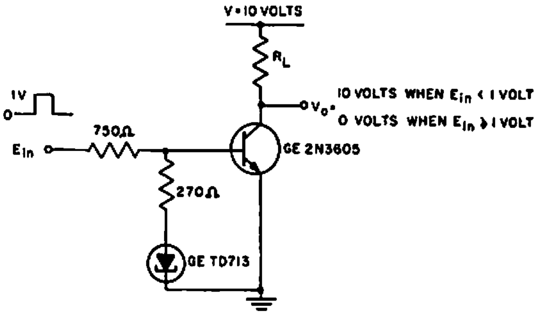
ADJUSTABLE HYSTERESIS—Differential comparator and zener provide independently adjustable voltage trip point and hysteresis. Q1 and Q3 can be 2N3904 or equivalent, Q2 2N3096 or equivalent, and D1 1N708. R7 varies reference level, for changing trip point from 0.7 V to 5 V, while R5 changes hysteresis.—R. Billon, Level Detector Has Independently Adjustable Hysteresis and Trip Point, *Electronic Design*, Oct. 11, 1967, p 98.


R_3
100k
3µf
I_1
-6v
+12v
10k
R_2
50k
µA709
10k
D_1
1N100
1.5k
200pf
500pf
1
2
S
F
COMPARATOR
200
200
µA710
+12v
-6v
IN
ACTIVE BAND-PASS FILTER 1khz
NAND
DUAL ONE SHOT
OUT
62k
5µf
20k
D_2
1N100
10k
10k
µA709
200pf
1.5k
5,000pf
I_2
B
A
MODULATED CARRIER
+12v
R_1
10k
200
COMPARATOR 2

ENVELOPE PEAK DETECTOR—Can handle modulation frequencies from d-c to 30 MHz. Input waveform is applied simultaneously to two IC integrators connected to have different time constants. This gives intersecting output waveforms, intersections of which are detected by two IC comparators. Adjusting R3 changes time constant of one integrator to make leading edge of output pulse of one-shot correspond to peak of desired waveform. Article gives detailed explanation of circuit operation.—E. B. Dalkiewicz and E. Lybarger, Intersecting Waveforms Trigger Peak Detector, *Electronics*, May 1, 1967, p 69–70.

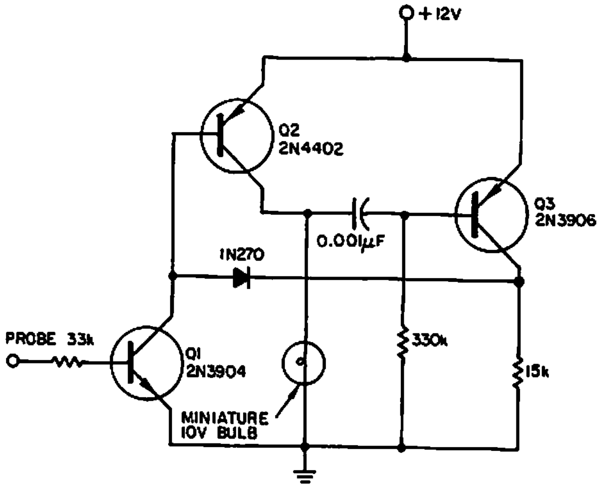
MULTIPLE-VOLTAGE MONITOR—Simple comparison amplifier and summing junction are used to compare junction voltage with reference voltage that is actually system ground or zero. Used for monitoring system having many power supplies with voltage levels of both polarities. Any change in one of monitored voltage levels will unbalance comparison amplifier and make warning lamp glow. Voltage measurements must then be made to identify defective supply. Sensing accuracy is 5%.—R. C. Gerdes, Voltage Sensor Monitors Multiple Power Supply Outputs, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 216.


-12V
6.8K
6.8K
2N2048
2N2048
No. 344
IK
IK
R1
R2
R3
Rn
V1
V2
V3
Vn
Vj
2N2374
2N2374
REFERENCE VOLTAGE
6.8K
+12V

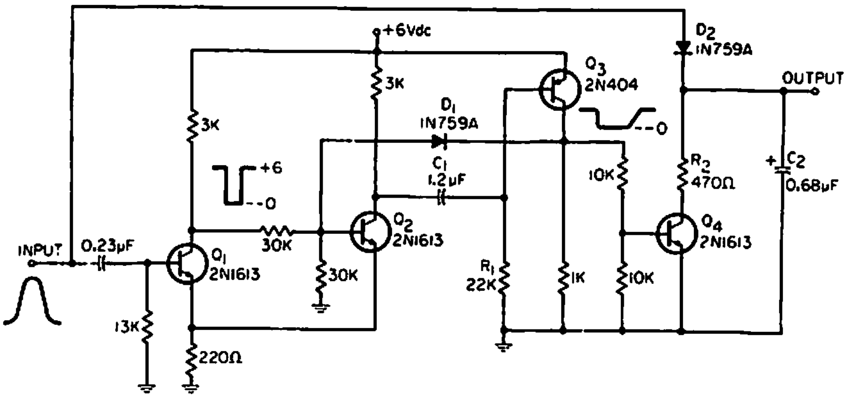

V=10 VOLTS
RL
Vo
10 VOLTS WHEN Ein < 1 VOLT
0 VOLTS WHEN Ein > 1 VOLT
1V
0
750Ω
Ein
GE 2N3605
270Ω
GE TD713

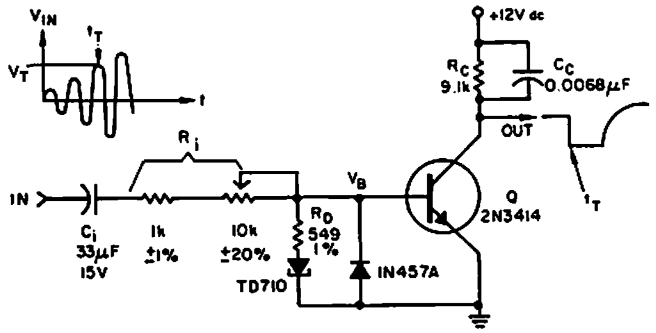
TUNNEL-DIODE LEVEL DETECTOR—Adjusting value of input resistor will make tunnel diode switch at any desired threshold voltage, and turn back off when input voltage is dropped to zero.—W. R. Spofford, Jr., Applications For The New Low Cost TD 700 Series Tunnel Diodes, General Electric, Syracuse, N.Y., No. 90.66, 1967, p 8.

LOGIC-LEVEL LAMP—Lamp lights when probe is touched to terminal having pulse amplitude or d-c level above 0.7 V. Speeds troubleshooting of digital circuits by eliminating need to look at cro or meter. Lamp is mounted directly on probe. Light-emitting diodes such as HP5082-4400 in series with 470-ohm resistor may be used in place of lamp for faster response. Level detector Q1 triggers 1-ms mono mvbr Q2-Q3.—J. M. Firth, Go/No Go Circuit Gives Visual Indication of RTL Logic Level, *Electronic Design*, Feb. 15, 1970, p 88.


+12V
Q2
2N4402
Q3
2N3906
0.001μF
1N270
PROBE 33k
Q1
2N3904
MINIATURE 10V BULB
330k
15k

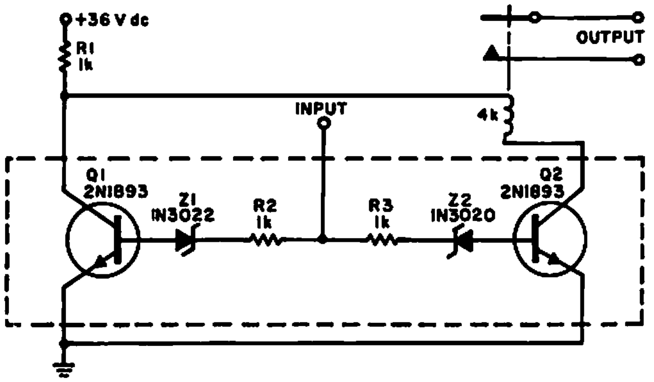
HOLDING PEAK VOLTAGE—Will hold peak voltage of short-duration analog signal for any required period up to several hundred ms. Permits use of pen recorders having slow response. Value of C1 determines holding period. First three transistors form combined Schmitt trigger and one-shot.—P. P. Tong, Peak-Hold Circuit, *EEE*, March 1967, p 164 and 166.


+6Vdc
D2
1N759A
OUTPUT
3K
Q3
2N404
3K
D1
1N759A
+6
--0
--0
C1
1.2μF
10K
R2
470Ω
C2
0.68μF
INPUT
0.23μF
Q1
2N1613
30K
Q2
2N1613
30K
R1
22K
IK
10K
Q4
2N1613
13K
220Ω



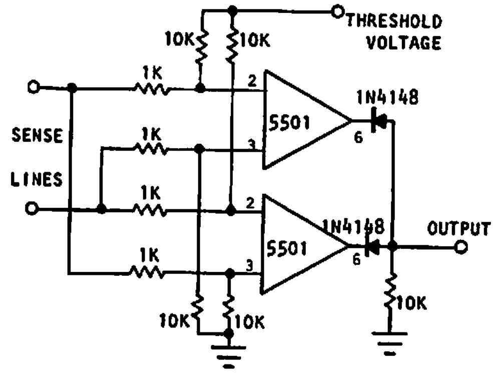
VIN
tT
VT
t
+12V dc
RC 9.1k
CC 0.0068μF
OUT
tT
Ri
IN
Ci 33μF 15V
1k ±1%
10k ±20%
VB
RD 549 1%
TD710
1N457A
Q 2N3414

10-KHZ SINE-WAVE PEAK DETECTOR—Simple tunnel-diode threshold detector senses peak values exceeding preset level. Output voltage is near supply voltage while input is low, and drops to about zero when input exceeds threshold value controlled by setting of Ri.—D. B. Heckman, Sense Signal Levels with a Tunnel Diode, *Electronic Design*, Feb. 1, 1969, p 48–51.



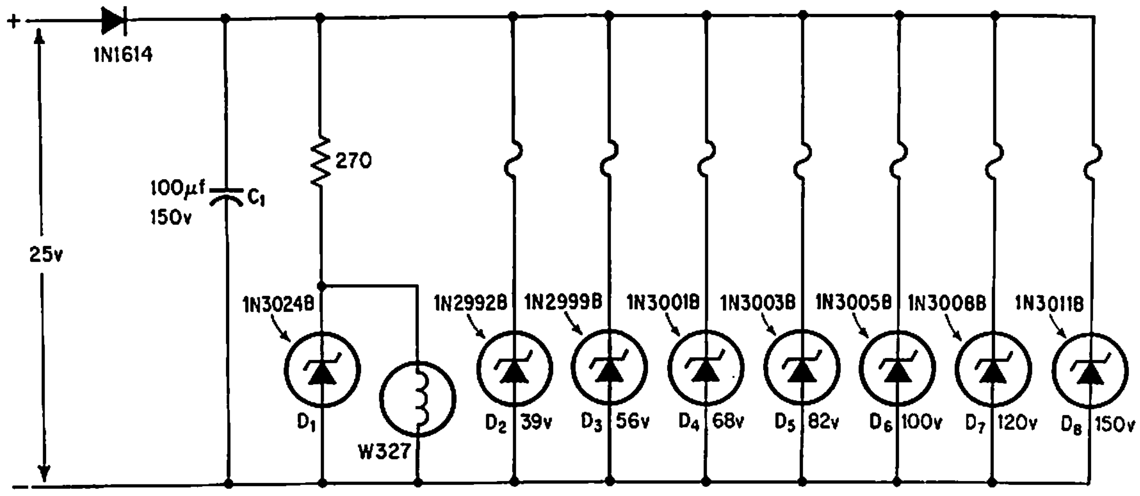
+36 V dc
R1 1k
OUTPUT
INPUT
4k
Q1 2N1893
Z1 1N3022
R2 1k
R3 1k
Z2 1N3020
Q2 2N1893

VOLTAGE LIMIT MONITOR—Relay contacts are closed as long as d-c input voltage is within specified limits. If voltage rises above limit, Q1 conducts and shorts out relay coil. If voltage drops below limit, both transistors cut off and relay drops out. Zeners determine voltage limits.—O. Tedenstig, Monitor DC Levels with a Simple Circuit, *Electronic Design*, June 6, 1968, p 110 and 112.



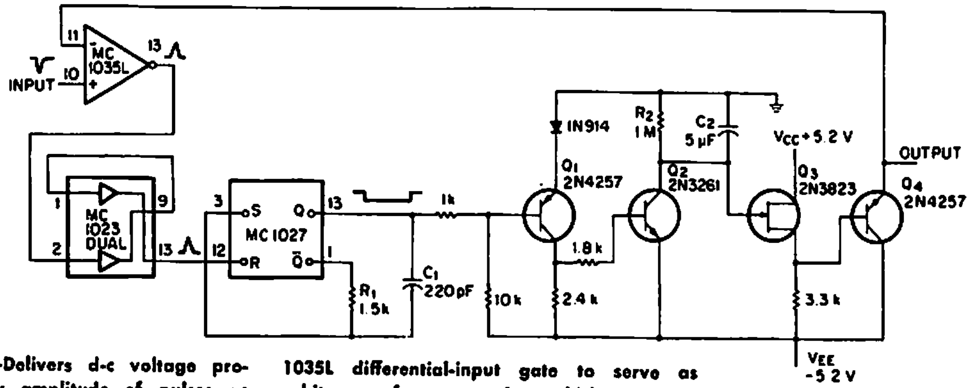
THRESHOLD VOLTAGE
10K
10K
1K
2
5501
1N4148
6
3
SENSE
LINES
1K
1K
2
5501
1N4148
6
3
OUTPUT
1K
10K
10K
10K

DUAL SENSE AMPLIFIER—Uses two 5501 analog comparators to indicate when any unbalance or voltage difference exists on two input lines. Output is positive regardless of which input line is more positive. Noise on lines does not cause false output indication.—Applying the Model 5501 Monolithic Analog Comparator, Optical Electronics, Tucson, Ariz., No. 10147.

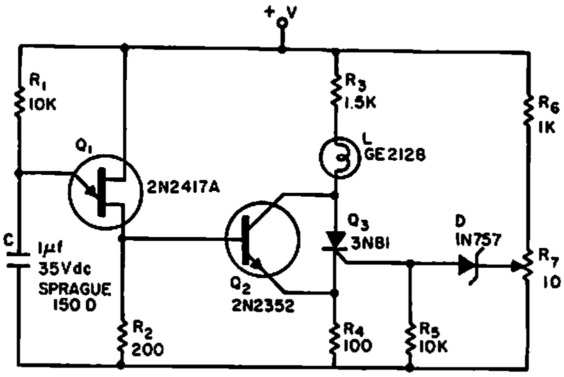


+
1N1614
25v
100μf 150v
C1
270
1N3024B
D1
W327
1N2992B
D2 39v
1N2999B
D3 56v
1N3001B
D4 68v
1N3003B
D5 82v
1N3005B
D6 100v
1N3008B
D7 120v
1N3011B
D8 150v

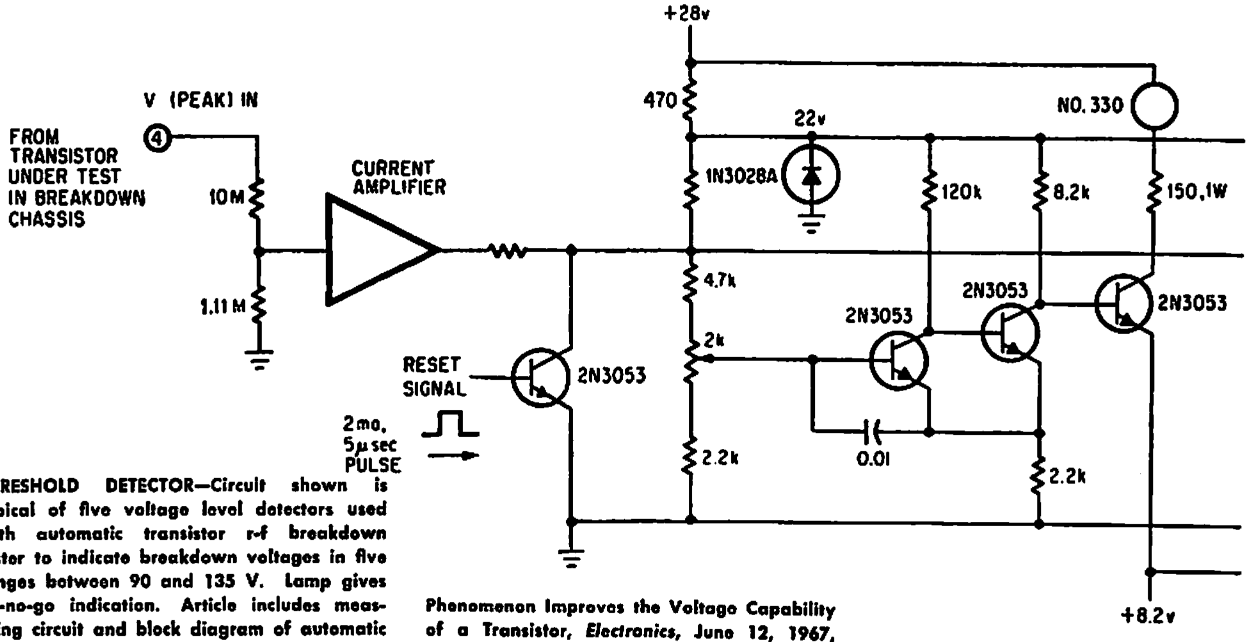
MONITORING POWER-LINE TRANSIENTS—Provides continuous surveillance of 28-V d-c supply line, storing approximate voltage magnitude of largest transient spike. Each zener is in series with sensitive 10-ohm 0.066-A instrument fuse, and each zener-fuse combination corresponds to detected voltage level about 5 V above zener breakdown voltage. Detection levels for zeners shown are 44, 61, 73, 87, 105, 125, and 155 V. 37-V spike on 28-V line means total peak of 65 V, which blows fuses for D2 and D3 because they avalanche into conduction. Operator then knows that spike was greater than 61 V but less than 73 V required to blow fuse for D4.—O. Pitzalis, Jr., Zener Circuit Detects Transients in Power Lines, *Electronics*, May 12, 1969, p 111.


INPUT
10
11
MC 1035L
13
MC 1023 DUAL
1
2
9
13
3
12
S
R
Q
Q̄
MC 1027
13
1
R1 1.5k
C1 220pF
1k
10k
1N914
Q1 2N4257
1.8k
2.4k
R2 1M
C2 5μF
Q2 2N3261
Vcc +5.2 V
Q3 2N3823
3.3k
Q4 2N4257
OUTPUT
VEE -5.2 V

PEAK DETECTOR—Delivers d-c voltage proportional to peak amplitude of pulses as narrow as 10 ns. Negative output voltage, proportional to voltage across C2, is fed back to inverting input of Motorola MC-1035L differential-input gate to serve as arbitrary reference against which negative-going input pulse is compared. Reference rises with each input pulse until equilibrium is reached and C2 stops charging. Output is independent of pulse width.—M. J. Prickett, Peak Detector for Very Narrow Pulses, *EEE*, June 1970, p 92 and 94.

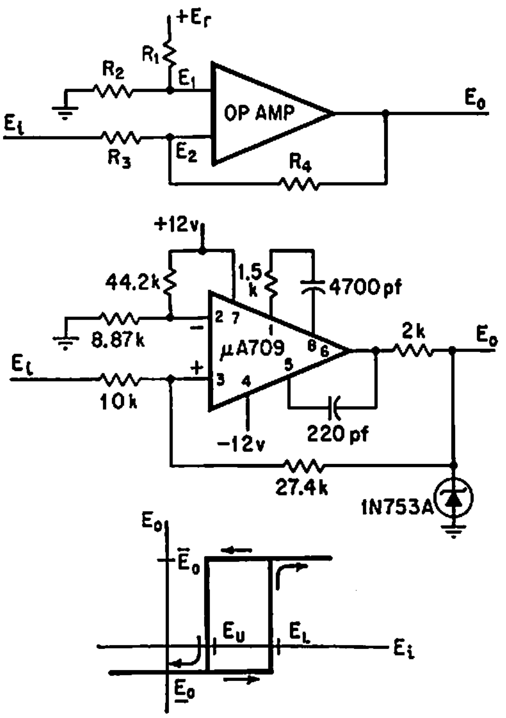

+V
R1 10K
Q1
2N2417A
C 1μf 35Vdc SPRAGUE 150 D
R2 200
Q2 2N2352
R3 1.5K
L GE2128
Q3 3N81
R4 100
R5 10K
D 1N757
R6 1K
R7 10K

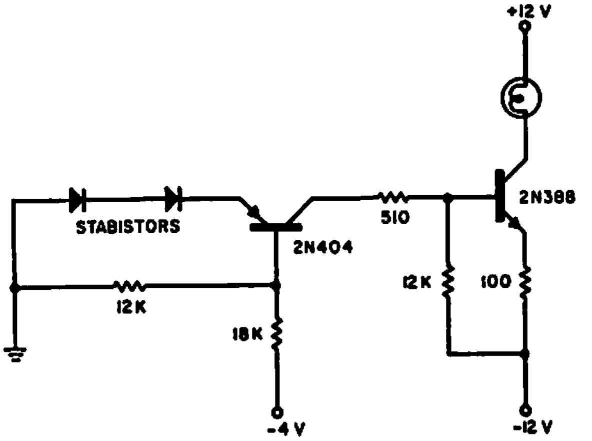
CURE FOR VOLTAGE-DROPPING HYSTERESIS—Use of ujt oscillator Q1 in voltage indicator overcomes hysteresis effect. Circuit will trigger off within 2% of desired level for triggering on, over wide temperature range. Supply voltage is 28 V. Lamp glows when voltage reaches desired level. If two circuits are used, with relays in place of lamps, they can be used to remove power whenever voltage goes above or below 2% of desired trigger level determined by R7.—J. V. Crowling, Solid-State Voltage Indicator Overcomes Hysteresis Problem, *Electronic Design*, Dec. 21, 1964, p 51–52.


V (PEAK) IN
FROM TRANSISTOR UNDER TEST IN BREAKDOWN CHASSIS
4
10M
1.11M
CURRENT AMPLIFIER
RESET SIGNAL
2ms, 5μsec PULSE
2N3053
+28v
470
1N3028A
22v
4.7k
2k
2.2k
0.01
120k
2N3053
8.2k
2N3053
2.2k
NO. 330
150,1W
2N3053
+8.2v

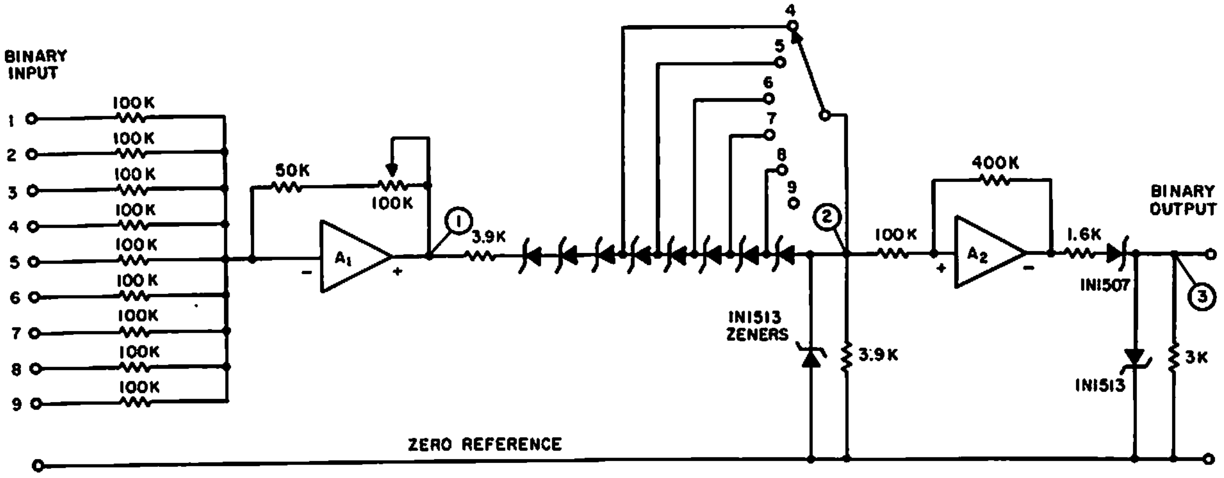
THRESHOLD DETECTOR—Circuit shown is typical of five voltage level detectors used with automatic transistor r-f breakdown tester to indicate breakdown voltages in five ranges between 90 and 135 V. Lamp gives go-no-go indication. Article includes measuring circuit and block diagram of automatic production tester.—P. Schiff, R-F Breakdown Phenomenon Improves the Voltage Capability of a Transistor, *Electronics*, June 12, 1967, p 97–101.

HYSTERESIS CIRCUIT DESIGN—Article gives mathematical procedure requiring calculation of only four resistor values to obtain desired upper and lower threshold points on hysteresis curve. Design approach assumes opamp input impedance is much larger than source impedance, and output impedance much smaller than load impedance, with amplifier switching state when differential input voltage is 0 V. Values shown are for 6.2 V upper threshold and −0.7 V lower threshold, with 3 V input required for switching amplifier from low to high state and 0.5 V for high to low state.—W. A. Cooke, A Simplified Design Approach for Hysteresis Circuits, *Electronics*, Nov. 10, 1969, p 106.

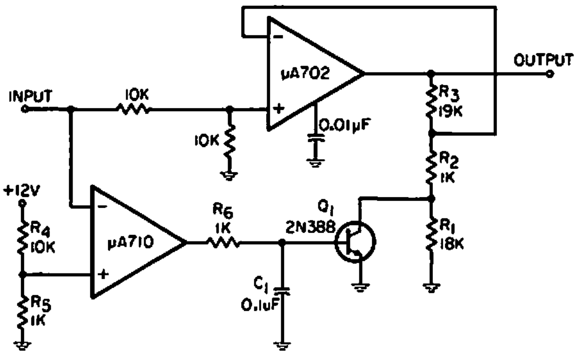

+Er
R1
R2
E1
OP AMP
E0
Ei
R3
E2
R4
+12v
44.2k
1.5k
4700pf
8.87k
−
2 7
1
µA709
8 6
5
+
3 4
2k
E0
Ei
10k
220pf
−12v
27.4k
1N753A
E0
+E0
EU
EL
Ei
−E0


+12 V
STABISTORS
2N404
510
2N388
12K
12K
100
18K
-4 V
-12 V

THREE-VOLTAGE MONITOR—Lamp glows only when all three supply voltages are present in typical pnp digital system having negative collector and clamp supplies, and positive bias supply. For npn system, use complementary version of circuit. Absence of any one voltage extinguishes lamp, giving true AND function. Stabistors provide tight control over error level of clamp voltage.—D. Chin, DC Presence Indicator Checks Three Voltages, "400 Ideas for Design Selected from Electronic Design," Hayden Book Co., N.Y., 1964, p 155.

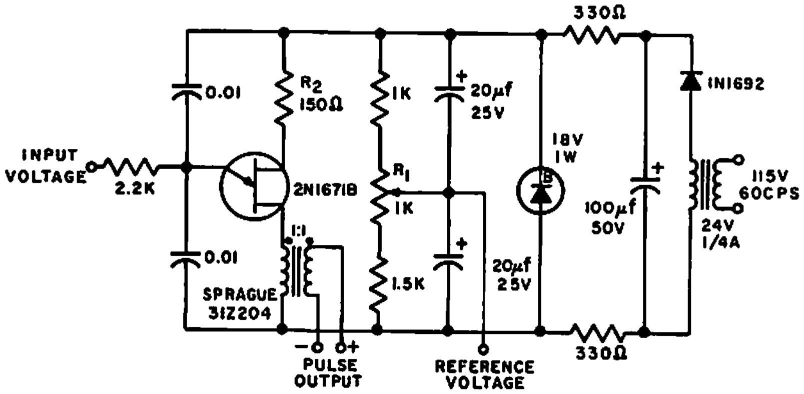

BINARY INPUT
1
2
3
4
5
6
7
8
9
100K
100K
100K
100K
100K
100 K
100K
100K
100K
50K
100K
A1
−
+
①
3.9K
4
5
6
7
8
9
②
IN1513 ZENERS
3.9K
100K
400K
A2
+
−
1.6K
IN1507
IN1513
3K
③
BINARY OUTPUT
ZERO REFERENCE

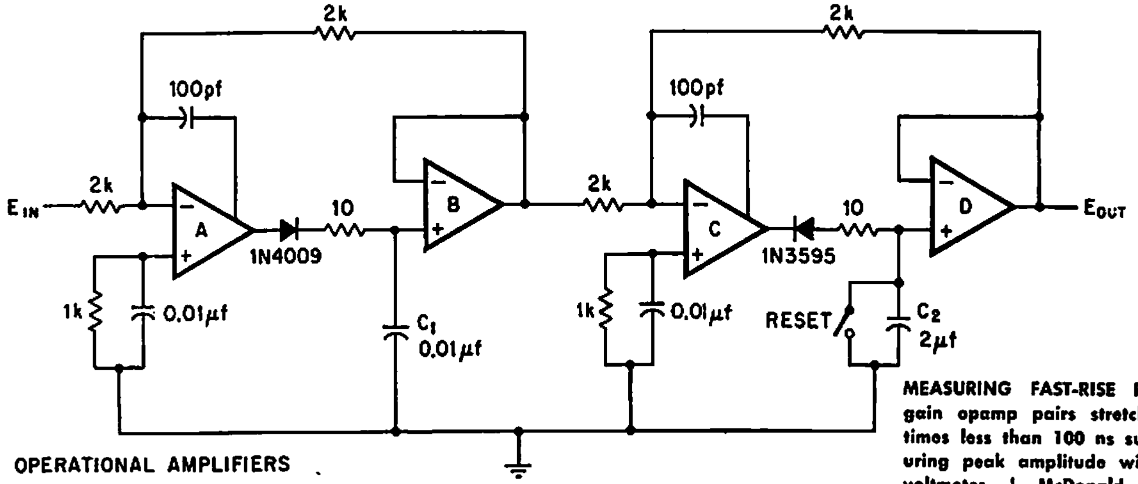
NINE-INPUT LEVEL DETECTOR—Simple opamp circuit with diode limiting serves in place of expensive binary logic. Binary output depends on whether each binary input is off (0 V for logical zero) or on (−11 V d-c for logical one). Output is binary one only when more than preselected number of inputs is one. Developed in connection with design of radio telescope.—W. Leroy Gahm, Binary Level Detector for Input Step-Voltages, *Electronic Design*, Oct. 26, 1964, p 50.


μA702
OUTPUT
INPUT
10K
10K
0.01μF
R3
19K
R2
1K
+12V
R4
10K
R5
1K
μA710
R6
1K
Q1
2N388
C1
0.1uF
R1
18K

AUTOMATIC RANGE SELECTOR—Electronic range-changing switch for voltmeter uses two opamps to compare input voltage with fixed reference derived from divider R4-R5. With values shown, ranges provided are 0–1 V and 0–10 V full-scale. When input voltage exceeds first range, output of opamp μA710 goes negative and shuts off Q1, decreasing gain by factor of 10 for upper range. Isolation diode can be added to Q1 for driving scale indicator showing which range is in use.—C. Becklein, Automatic Scaling Circuit Uses ICs, *EEE*, Dec. 1966, p 118.

VOLTAGE SENSING—When input voltage to be sensed exceeds reference voltage applied by external source, ujt fires and produces output pulse that can be used to fire scr or other pulse-sensitive device. R1 adjusts trigger level. Trigger current required is less than 5 μA. Long-term voltage stability is 10 mV, and short-term is 1 mV.—T. P. Sylvan, The Unijunction Transistor Characteristics and Applications, General Electric, Syracuse, N.Y., No. 90.10, 1965, p 79.


330Ω
0.01
R2
150Ω
1K
20μf
25V
1N1692
18V
1W
INPUT VOLTAGE
2.2K
2N1671B
R1
1K
100μf
50V
115V
60CPS
24V
1/4A
1:1
0.01
SPRAGUE
31Z204
1.5K
20μf
25V
− +
PULSE OUTPUT
REFERENCE VOLTAGE
330Ω


2k
2k
100pf
100pf
E_IN
2k
A
1N4009
10
B
2k
C
1N3595
10
D
E_OUT
1k
0.01μf
C1
0.01μf
1k
0.01μf
RESET
C2
2μf

OPERATIONAL AMPLIFIERS

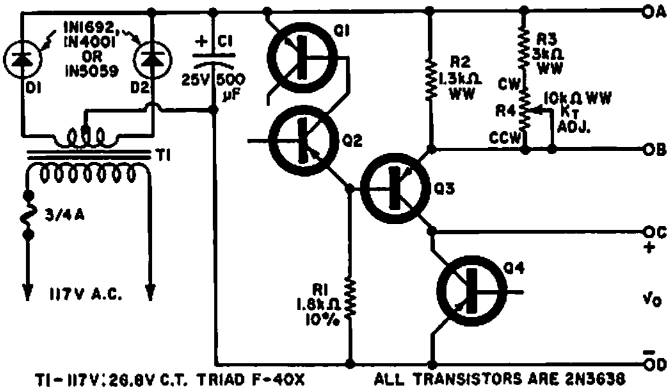
A,C	NIM MA-30 (NUCLEAR EQUIPMENT)
B	148-C (ANALOG DEVICES)
D	KM 47-C (K and M ELECTRONICS)

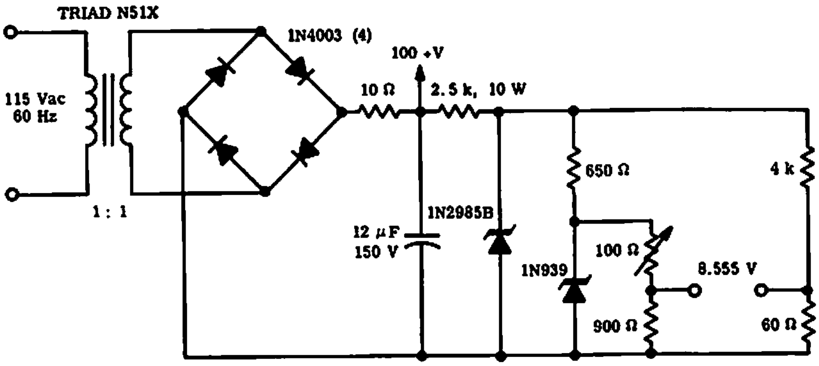
MEASURING FAST-RISE PULSES—Two unity-gain opamp pairs stretch pulses with rise times less than 100 ns sufficiently for measuring peak amplitude with ordinary digital voltmeter.—J. McDonald and A. Pinkerton, 2-Stage Peak-Holding Circuit Stores Submicrosecond Pulses, *Electronics*, Nov. 10, 1969, p 105.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 98
Voltage Reference Circuits

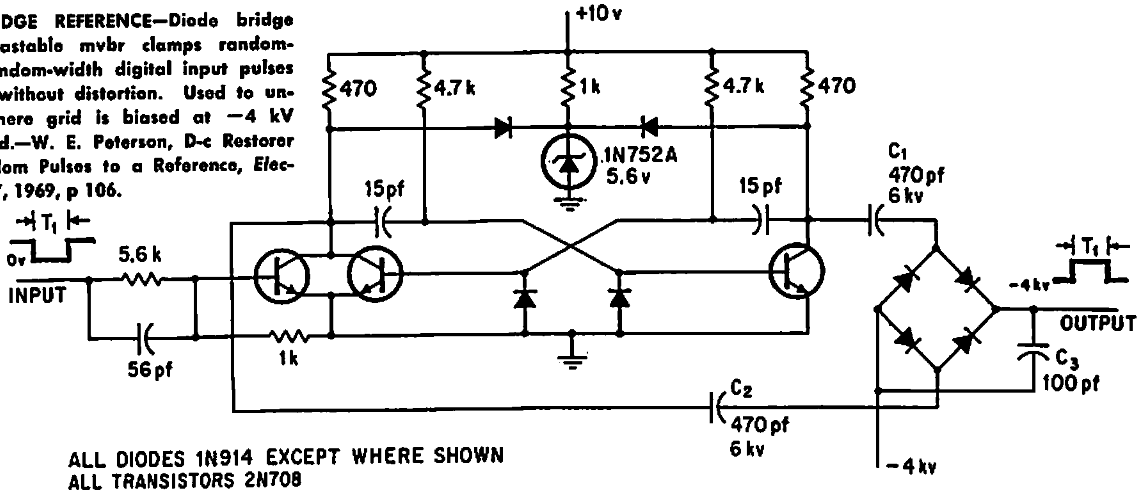
5-V REFERENCE SUPPLY—Circuit actually gives highly stable 6.7 V, but this can be adjusted to exactly 5 V by R5 in precision-type output control circuit. Transistor Q4 serves as temperature-compensating voltage-regulator diode. Article gives construction and adjustment details.—C. D. Todd, Stable, Low-Cost Reference Power Supplies, *Electronics World*, Dec. 1967, p 39–41 and 79.


1N1692, 1N4001 OR 1N5059
D1
D2
+ C1
25V 500 µF
T1
3/4A
117V A.C.
Q1
Q2
Q3
Q4
R1 1.8kΩ 10%
R2 1.3kΩ WW
R3 3kΩ WW
R4 10kΩ WW
CW
CCW
K_T ADJ.
A
B
C
+
V_o
−
D
T1–117V:26.8V C.T. TRIAD F-40X
ALL TRANSISTORS ARE 2N3638


TRIAD N51X
115 Vac 60 Hz
1 : 1
1N4003 (4)
100 +V
10 Ω
2.5 k, 10 W
12 µF 150 V
1N2985B
1N939
650 Ω
100 Ω
900 Ω
8.555 V
4 k
60 Ω

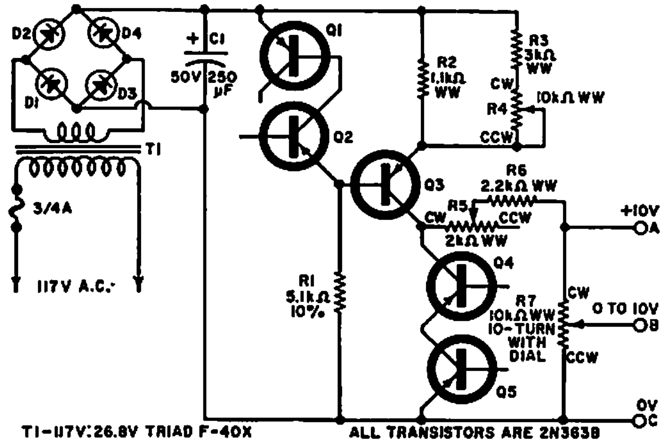
CASCADED ZENER REFERENCE—Provides reference voltage supply of 8.555 V, which changes only 0.0001% for 10% input voltage change. 1N2985B 22-V diode absorbs large changes in input, permitting operation of second diode over linear range.—"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 6–19.

−4 KV BRIDGE REFERENCE—Diode bridge coupled to astable mvbr clamps random-frequency random-width digital input pulses to d-c level without distortion. Used to unblank crt where grid is biased at −4 kV below ground.—W. E. Peterson, D-c Restorer Clamps Random Pulses to a Reference, *Electronics*, July 7, 1969, p 106.


+10 v
470
4.7 k
1 k
4.7 k
470
1N752A 5.6 v
15 pf
15 pf
C_1 470 pf 6 kv
T_1
0v
INPUT
5.6 k
56 pf
1 k
C_2 470 pf 6 kv
−4 kv
T_1
−4 kv
OUTPUT
C_3 100 pf

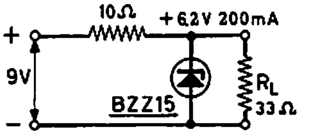
ALL DIODES 1N914 EXCEPT WHERE SHOWN
ALL TRANSISTORS 2N708

10-V REFERENCE SUPPLY—Provides constant voltage, independent of temperature, for calibrating lab or shop instruments and for monitoring very small voltage changes. Stability is achieved by using low-cost transistors as temperature-compensated voltage regulator diodes. Article gives construction and adjustment details, and chopper circuits for making a-c measurements.—C. D. Todd, Stable, Low-Cost Reference Power Supplies, *Electronics World*, Dec. 1967, p 39–41 and 79.

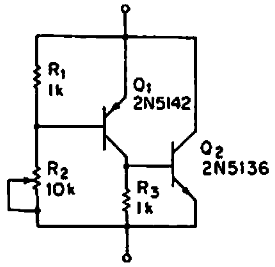

D2
D4
D1
D3
T1
3/4A
117V A.C.
+ C1
50V 250 μF
Q1
Q2
Q3
Q4
Q5
R2 1.1kΩ WW
R3 3kΩ WW
CW
R4
10kΩ WW
CCW
R6 2.2kΩ WW
R5
CW
CCW
2kΩ WW
+10V
A
R1 5.1kΩ 10%
R7 10kΩ WW 10-TURN WITH DIAL
CW
CCW
0 TO 10V
B
0V
C

T1–117V:26.8V TRIAD F-40X
D1–D4–1N1692, 1N4001 OR 1N5059

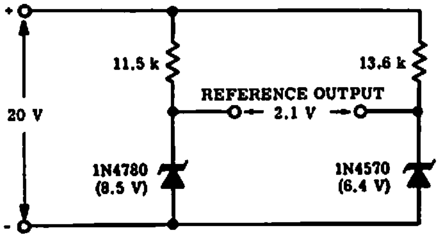
ALL TRANSISTORS ARE 2N3638


10Ω
+6.2V 200mA
+
9V
−
BZZ15
R_L
33Ω

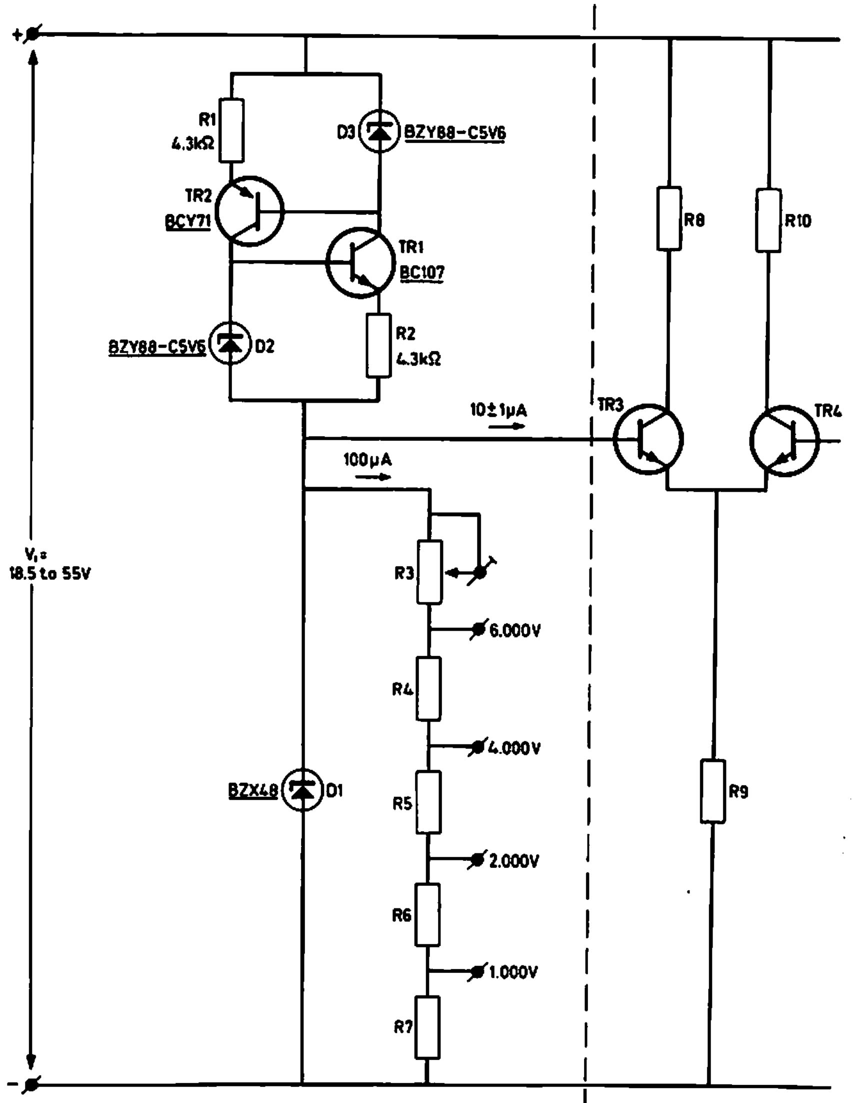
6.2 V D-C WITH POWER ZENER—Converts nonstabilized 9-V d-c supply to 6.2 V with stabilization factor of 50:1. Diode must be mounted on heat sink. Hum and ripple from source are attenuated in same ratio.—"Zener Diodes and Their Applications," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 17, 1966.


R1
1k
Q1
2N5142
Q2
2N5136
R2
10k
R3
1k

ADJUSTABLE ZENER—Performs functions of zener diode, with R2 determining operating voltage at any value above about 0.8 V. Impedance is maximum of 3 ohms below 5 V, where conventional zeners have considerably higher impedance and are not always readily available.—K. Karash, Adjustable, Low-Impedance Zener, *EEE*, March 1970, p 130.


+
11.5 k
13.6 k
REFERENCE OUTPUT
2.1 V
20 V
1N4780
(8.5 V)
1N4570
(6.4 V)
−

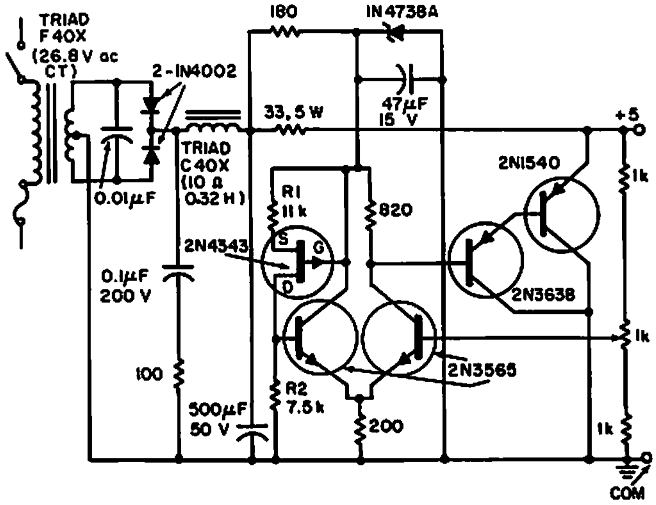
DIFFERENTIAL ZENER REFERENCE—Provides 2.1-V reference by utilizing difference between 8.5-V and 6.4-V zener references. Technique is particularly useful for temperature-compensated reference voltage sources. —"Zener Diode Handbook," Motorola, Phoenix, Ariz., 1967, p 6–19.


+
R1
4.3kΩ
D3
BZY88-C5V6
TR2
BCY71
TR1
BC107
BZY88-C5V6
D2
R2
4.3kΩ
10±1μA
100μA
TR3
TR4
R8
R10
V_s=
18.5 to 55V
R3
6.000V
R4
4.000V
BZX48
D1
R5
2.000V
R6
1.000V
R7
R9
−

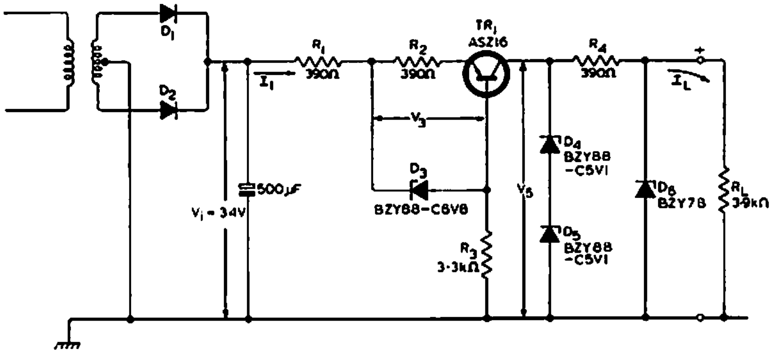
standard calibrator and reference source

long-tailed pair of power supply

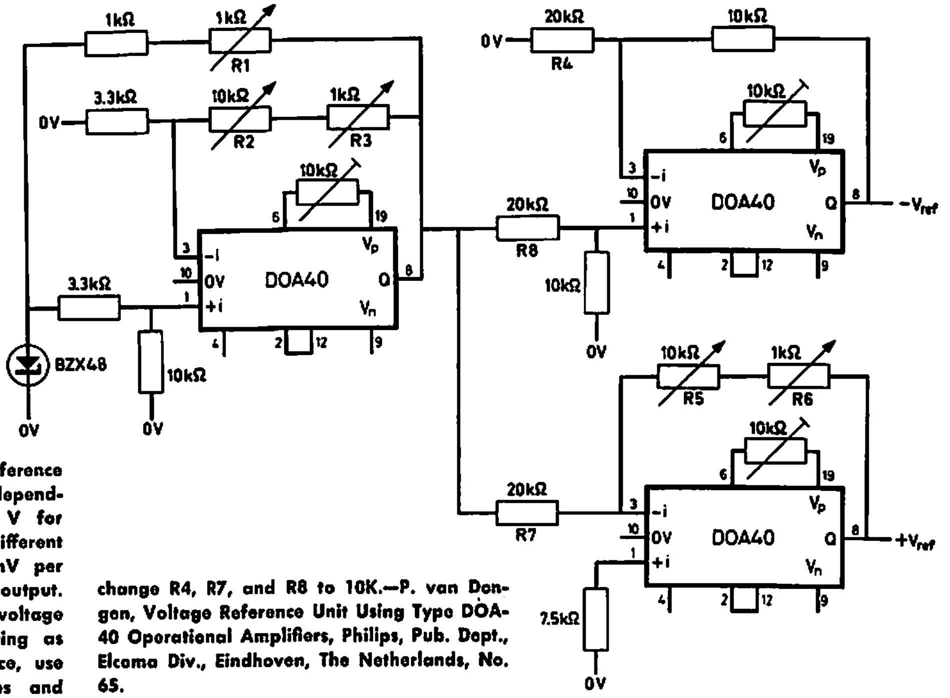
MULTIPLE-VOLTAGE REFERENCE SOURCE—Stabilizing circuit at left of dashed line, using zener D1 in series with two-transistor constant-current source, can be incorporated between differential amplifier and any supply between 18.5 and 55 V d-c, for excellent voltage and temperature stability. When D1 is changed, R3 can be adjusted to give same reference voltages and 6.5 V d-c across entire resistor string R3-R7.—High Stability Reference Diodes BZX47 Family, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 331, 1968.


TRIAD
F40X
(26.8 V ac
CT)
2-IN4002
0.01µF
TRIAD
C40X
(10 Ω
0.32 H)
180
IN4738A
47µF
15 V
33, 5 W
+5
R1
11 k
820
2N4343
S
G
D
0.1µF
200 V
100
500µF
50 V
R2
7.5 k
200
2N1540
2N3638
2N3565
1k
1k
1k
COM

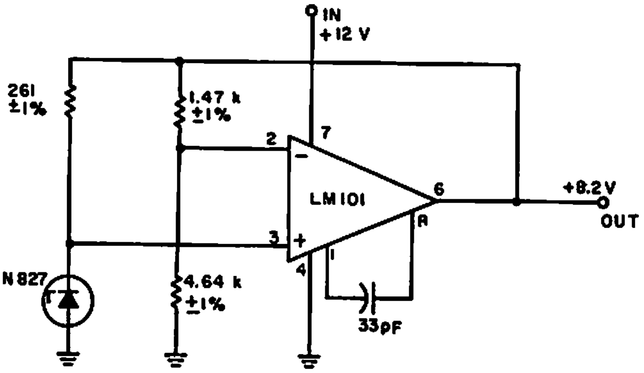
5-V FET REFERENCE—Use of p-channel 2N-4343 fet as constant-current source in combination with resistor gives much better temperature stability than convenional zener reference. Ouput impedance is below 0.1 ohm up to full load of 180 mA.—H. Olson, Stabilize Voltage Regulator by Replacing Zener with a FET, *Electronic Design*, Sept. 27, 1967, p 72 and 74.


D1
D2
R1
390Ω
I1
R2
390Ω
TR1
ASZ16
R4
390Ω
+
IL
V3
D3
BZY88-C6V8
R3
3·3kΩ
D4
BZY88
-C5V1
D5
BZY88
-C5V1
V5
D6
BZY78
RL
3·9kΩ
500µF
V1 = 34V

DIFFERENTIAL-AMPLIFIER SUPPLY—Provides highly stabilized output of about 5.3 V at 1.5 mA, as required by many differential amplifiers. Change of 20% in input voltage changes output less than 0.011%.—"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Application Book, p 46.

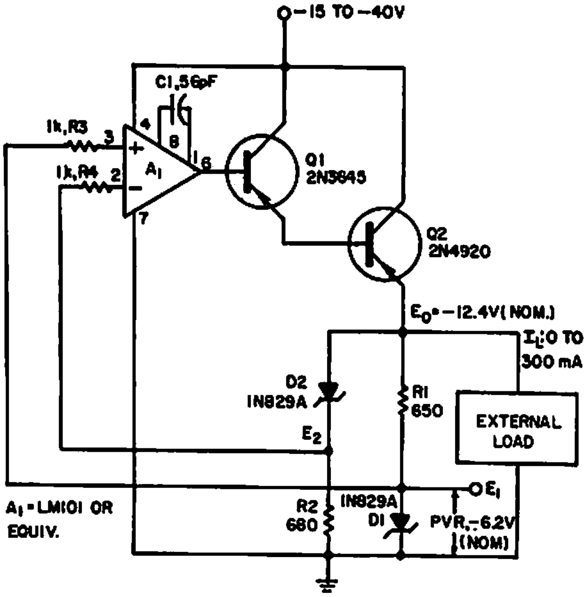

1kΩ
1kΩ
R1
3.3kΩ
0V
10kΩ
R2
1kΩ
R3
10kΩ
6
19
3
-i
10
0V
1
+i
DOA40
Vp
Q
Vn
8
4
2
12
9
3.3kΩ
BZX48
10kΩ
0V
0V
0V
20kΩ
R4
10kΩ
10kΩ
6
19
3
-i
10
0V
1
+i
DOA40
Vp
Q
Vn
8
-Vref
4
2
12
9
20kΩ
R8
10kΩ
0V
10kΩ
R5
1kΩ
R6
10kΩ
6
19
20kΩ
R7
3
-i
10
0V
1
+i
DOA40
Vp
Q
Vn
8
+Vref
4
2
12
9
7.5kΩ
0V

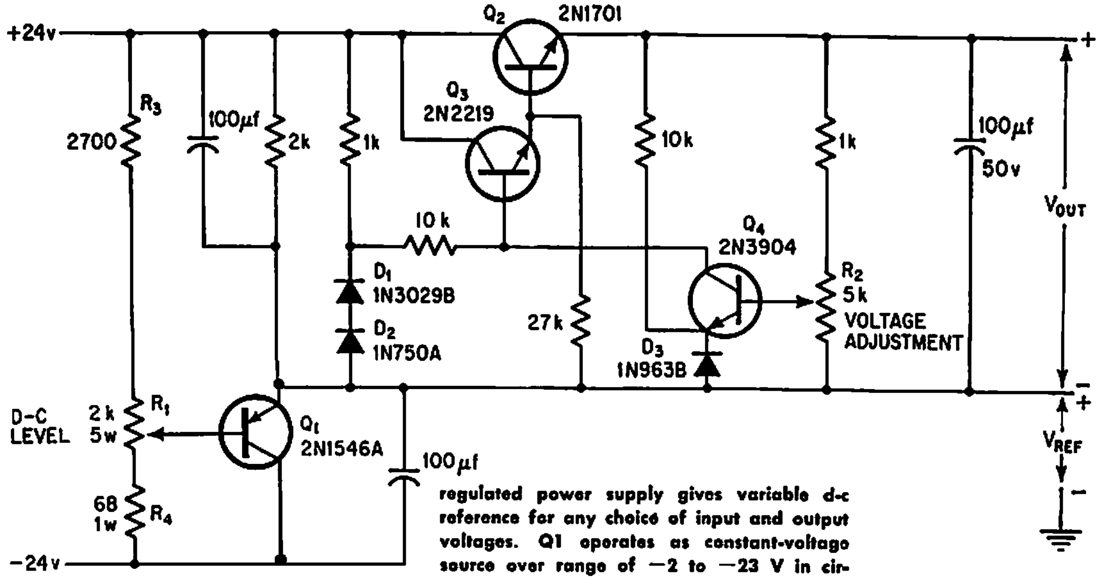
POSITIVE AND NEGATIVE 5 V—Reference voltages of opposite polarity are independently adjustable to same value, 5 V for resistor values shown, or 10 V with different values. Voltage drift is only 0.2 mV per deg C. Can deliver up to 5 mA per output. Uses three Philips DOA40 opamps as voltage comparators, with BZX48 zener serving as reference voltage. For 10 V reference, use 15-V positive and negative supplies and change R4, R7, and R8 to 10K.—P. van Dongen, Voltage Reference Unit Using Type DOA-40 Operational Amplifiers, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 65.


IN
+12 V
261
±1%
1.47 k
±1%
2
7
LM101
6
+8.2V
OUT
8
3
1
4
IN 827
4.64 k
±1%
33pF

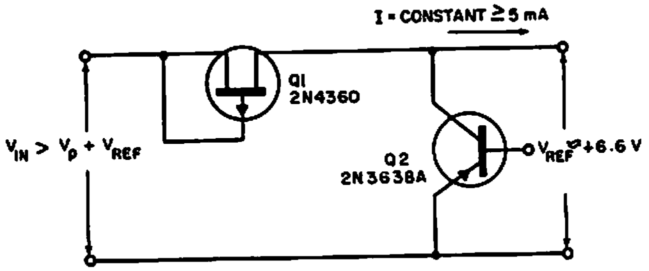
8.2 V D-C REFERENCE—Opamp and five components provide 0.01 mV per V d-c regulation for low-current applications (10 mA) such as for vco's in feedback loops and for precision digital-analog converters. Other output voltages are obtained by changing zener and resistor divider values.—F. R. Shirley and L. Vanderlosk, A Stable Voltage Reference Uses Only Six Components, *Electronic Design*, Jan. 18, 1968, p 128.

CONSTANT CURRENT FOR ZENER—Precision voltage obtained by sending constant current through temperature-compensated reference diode D1 is compared with voltage drop across R2 by differential amplifier A1. Amplifier adjusts its output to produce constant voltage drop across R2 for driving constant current through D2. Output voltage varies less than 2 mV for load currents of 0 to 300 mA and supply voltages of 15 to 40 V.—S. Miller, Precision Voltage Reference Combined with Voltage Regulator, *Electronic Design*, Sept. 1, 1969, p 102 and 104.


−15 TO −40V
C1,56pF
1k,R3
3
4
8
+
1
6
1k,R4
2
A1
−
7
Q1
2N3645
Q2
2N4920
E0 = −12.4V (NOM.)
IL:0 TO 300 mA
D2
1N829A
R1
650
EXTERNAL LOAD
E2
E1
A1 = LM101 OR EQUIV.
R2
680
1N829A
D1
PVR, −6.2V (NOM)

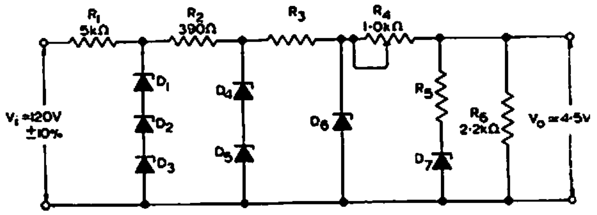

+24v
Q2
2N1701
+
R3
2700
100µf
2k
1k
Q3
2N2219
10k
1k
100µf
50v
VOUT
10 k
Q4
2N3904
D1
1N3029B
R2
5k
VOLTAGE ADJUSTMENT
D2
1N750A
27k
D3
1N963B
−
+
D-C LEVEL
2 k
5w
R1
Q1
2N1546A
VREF
100µf
−
68
1w
R4
−24v

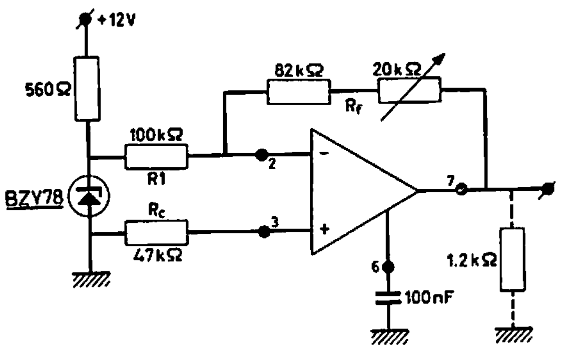
VARIABLE D-C REFERENCE—Addition of transistor Q1 to standard regulator circuit of regulated power supply gives variable d-c reference for any choice of input and output voltages. Q1 operates as constant-voltage source over range of −2 to −23 V in circuit shown, in which output voltage range is 15 to 24 V.—A. Steinman, Modified Regulator Yields Variable d-c Reference, *Electronics*, April 28, 1969, p 78.


I = CONSTANT ≥ 5 mA
Q1
2N4360
Q2
2N3638A
$V_{IN} > V_P + V_{REF}$
$V_{REF} \cong +6.6$ V

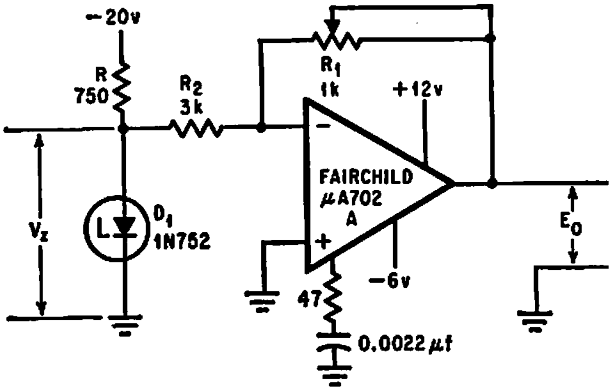
6 V AT 5 MA—Utilizes collector-emitter breakdown characteristic of bipolar transistor and constant-current property of junction fet to give low-cost reference source having output variation of only 3%.—E. J. Kennedy, Inexpensive 6-V Reference Is Also Temperature-Stable, *Electronic Design*, Nov. 8, 1967, p 112 and 114.

STANDARD-CELL REPLACEMENT — Provides constant output of about 4.5 V over temperature range of 30 to 60 C, is undamaged by intermittent short-circuits, and much more shock-resistant than Weston standard cell. D1-D6 are BZY88-C6V2 zeners and D7 is BZY88-C4V3. Values of R3 and R5 are determined by experiment as described in book. —"Voltage Regulator (Zener) Diodes," Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Application Book, p 26.

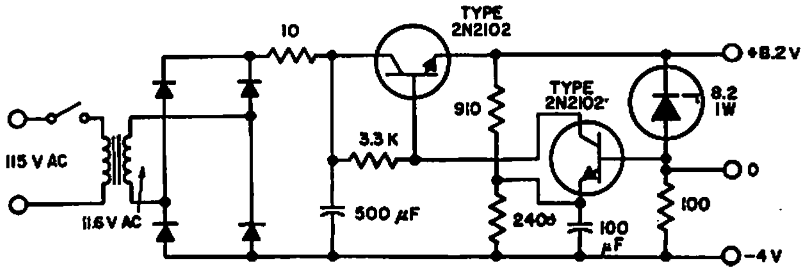

R_1 5kΩ
R_2 390Ω
R_3
R_4 1·0kΩ
D_1
D_2
D_3
D_4
D_5
D_6
D_7
R_5
R_6 2·2kΩ
$V_i \approx 120$V ±10%
$V_o \approx 4{\cdot}5$V


+12V
560Ω
100kΩ
R1
BZY78
Rc
47kΩ
82kΩ
20kΩ
Rf
2
3
7
6
1.2kΩ
100nF

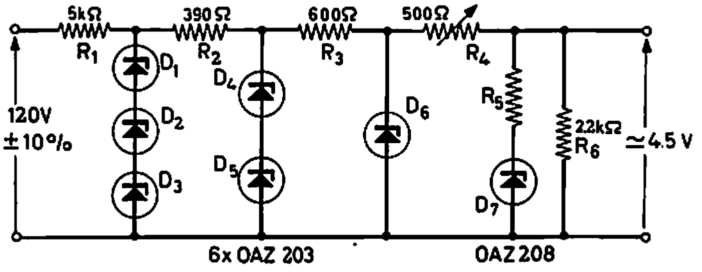
ADJUSTABLE REFERENCE—Uses Philips TAA-241 difference amplifier in circuit with 5.3 V zener. Can be adjusted to steady value close to −5 V with Rf. Rc provides compensation for bias current drift. Temperature drift of circuit is 0.5 mV per degree C. —J. Cohen and J. Oosterling, Applications of a Practical D. C. Difference Amplifier, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, No. 321, 1968.


−20v
R 750
R2 3k
R1 1k
+12v
FAIRCHILD μA702 A
−6v
47
0.0022μf
D1 1N752
Vz
E0

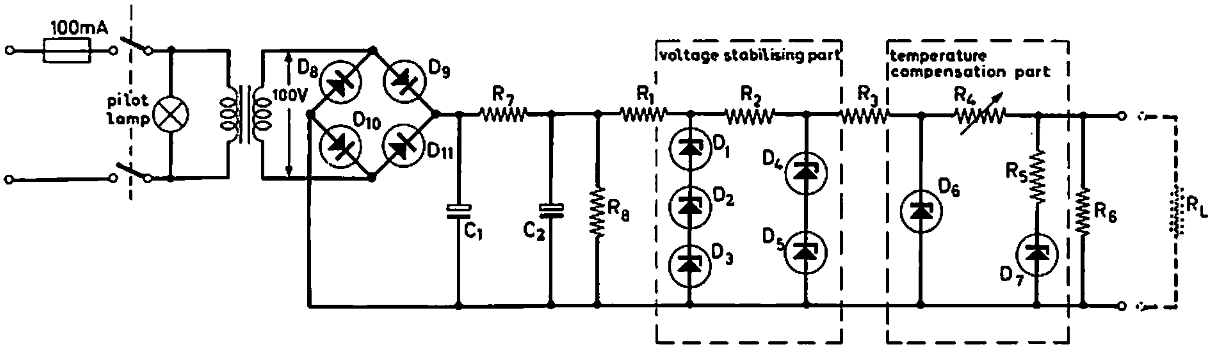
ADJUSTABLE REFERENCE VOLTAGE—IC op-amp and resistor divider translate zener diode reference to any desired precise voltage in range from −5 to +5 V, at low cost. Useful when required voltage reference is low, as for powering thermistor bridge. R1 adjusts reference voltage.—J. Althouse, IC Amplifier Provides Variable Reference Voltage, *Electronics*, Oct. 17, 1966, p 88.


10
TYPE 2N2102
910
TYPE 2N2102
8.2 1W
+8.2V
0
−4V
3.3K
500μF
2400
100 μF
100
115 V AC
11.6V AC

8.2 V—Used as reference voltage supply for 100-V series-regulated d-c power supply.—"Silicon Power Circuits Manual," RCA, Harrison, N.J., SP-51, p 216.


5kΩ
R1
390Ω
R2
600Ω
R3
500Ω
R4
D1
D2
D3
D4
D5
D6
R5
22kΩ
R6
D7
120V
±10%
≃4.5 V
6x OAZ 203
OAZ208

4.5-V ZENER SUBSTITUTE FOR WESTON CELL—Provides reference voltage between 4 and 6 V with better constancy than standard cell, despite a-c line voltage fluctuations up to 10% and temperature variations between 30 and 60 C. Supply voltage is first stabilized by shunt-regulated circuits connected in cascade. Final zener has opposite temperature coefficient to that of preceding diode, to eliminate effect of temperature.—S. T. Ho, Reference-Voltage Unit Equipped with Zener Diodes, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 24, No. 4, 1963–1964, p 153–161.


100mA
pilot lamp
100V
D8
D9
D10
D11
R7
C1
C2
R8
voltage stabilising part
R1
R2
D1
D2
D3
D4
D5
R3
temperature compensation part
R4
D6
R5
D7
R6
RL

R_1 = 5 kΩ, 5.5 W
R_2 = 390 Ω, 5.5 W
R_3 = see text

R_4 = 1 kΩ, linear
R_5 = 390 Ω *, 5.5 W
R_6 = 2.2 kΩ, 5.5 W

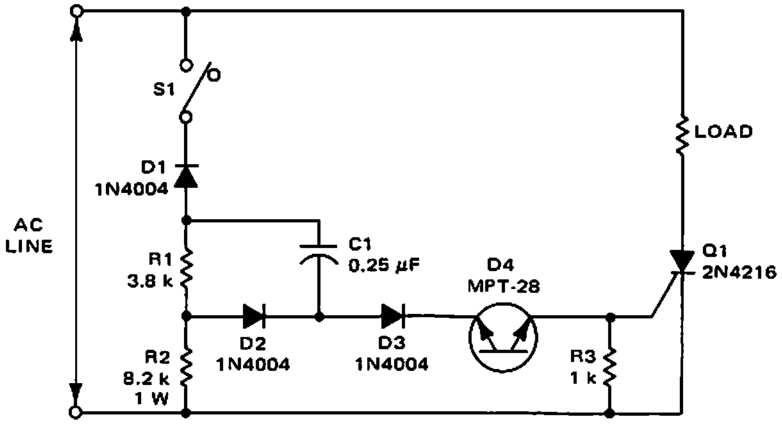
R_7 = 1 kΩ, 5.5 W
R_8 = 68 kΩ, 1 W
C_1, C_2 = 25 μF, 150 V

D_1 to D_6 = OAZ203
D_7 = OAZ208
D_8 to D_{10} = BYX10

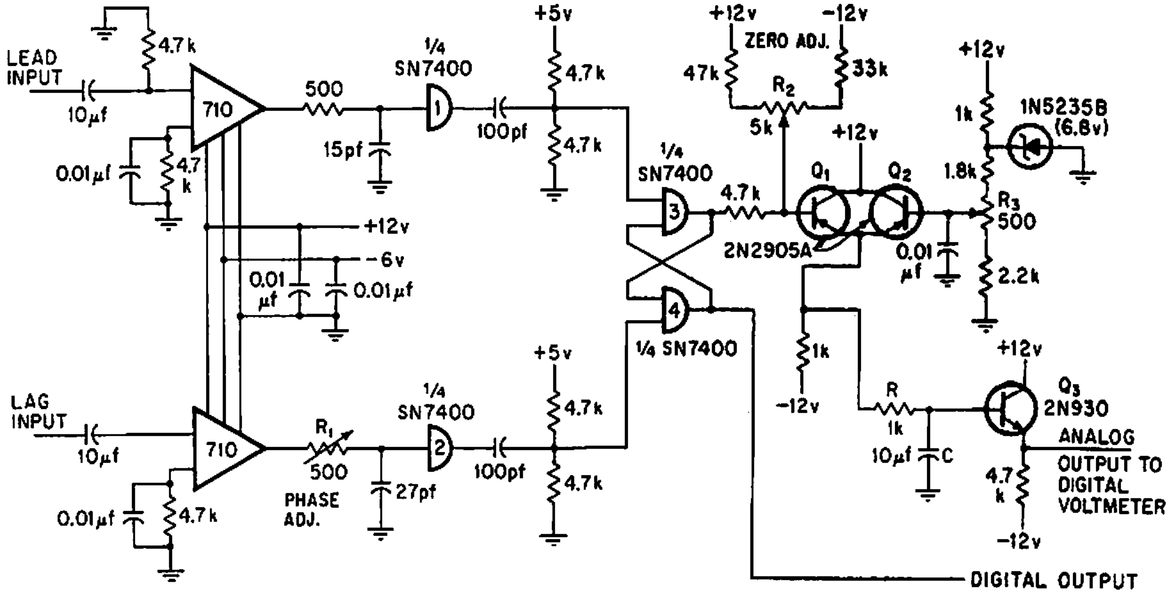
4–6 V SECONDARY STANDARD—Bridge rectifier across secondary of power-line transformer energizes zeners providing output voltage between 4 and 6 V, depending on components, having greater constancy than standard cells. Requires calibration against standard cell or equivalent-accuracy measuring instrument. Value of R5 is based on assumed permissible output voltage variation of 0.1 mV for 10% line voltage variation.—S. T. Ho, Reference-Voltage Unit Equipped with Zener Diodes, *Electronic Applications*, Philips, Pub. Dept., Elcoma Div., Eindhoven, The Netherlands, Vol. 24, No. 4, 1963–1964, p 153–161.

NOTE: To locate additional circuits in the category of this chapter, use the index at the back of this book. Check also the author's "Sourcebook of Electronic Circuits," published by McGraw-Hill in 1968.

CHAPTER 99
Zero-Voltage Detector Circuits

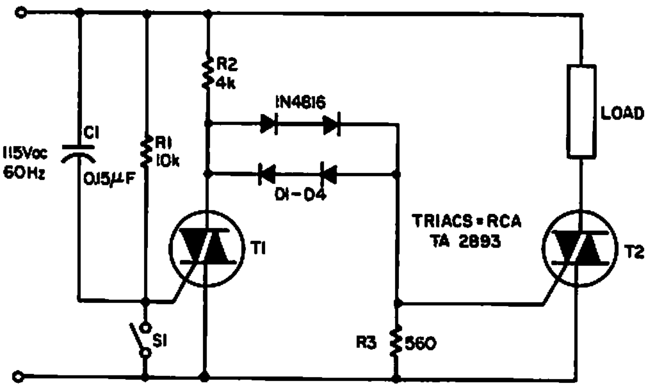

AC LINE
S1
D1
1N4004
R1
3.8 k
C1
0.25 μF
D4
MPT-28
LOAD
Q1
2N4216
R2
8.2 k
1 W
D2
1N4004
D3
1N4004
R3
1 k

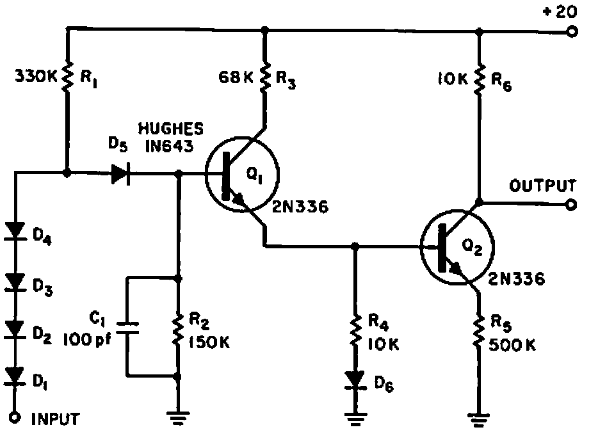
SENSITIVE-GATE SCR SWITCH—Zero-point switch ensures that control scr turns on at start of each positive alternation. If turned on later in cycle, voltage and current spikes produced could cause electromagnetic interference. Circuit actually oscillates near zero-crossing point and provides series of pulses to assure zero-point switching.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–5.


LEAD INPUT
10μf
4.7k
710
0.01μf
4.7 k
500
15pf
1/4 SN7400
1
100pf
+5v
4.7k
4.7k
+12v
−6v
0.01 μf
0.01μf
LAG INPUT
10μf
710
0.01μf
4.7k
R1
500
PHASE ADJ.
27pf
1/4 SN7400
2
100pf
+5v
4.7k
4.7k
1/4 SN7400
3
4
1/4 SN7400
+12v
−12v
ZERO ADJ.
47k
33k
R2
5k
4.7k
+12v
Q1
Q2
2N2905A
0.01 μf
1k
−12v
+12v
1k
1N5235B
(6.8v)
1.8k
R3
500
2.2k
R
1k
10μf
C
+12v
Q3
2N930
4.7 k
−12v
ANALOG OUTPUT TO DIGITAL VOLTMETER
DIGITAL OUTPUT

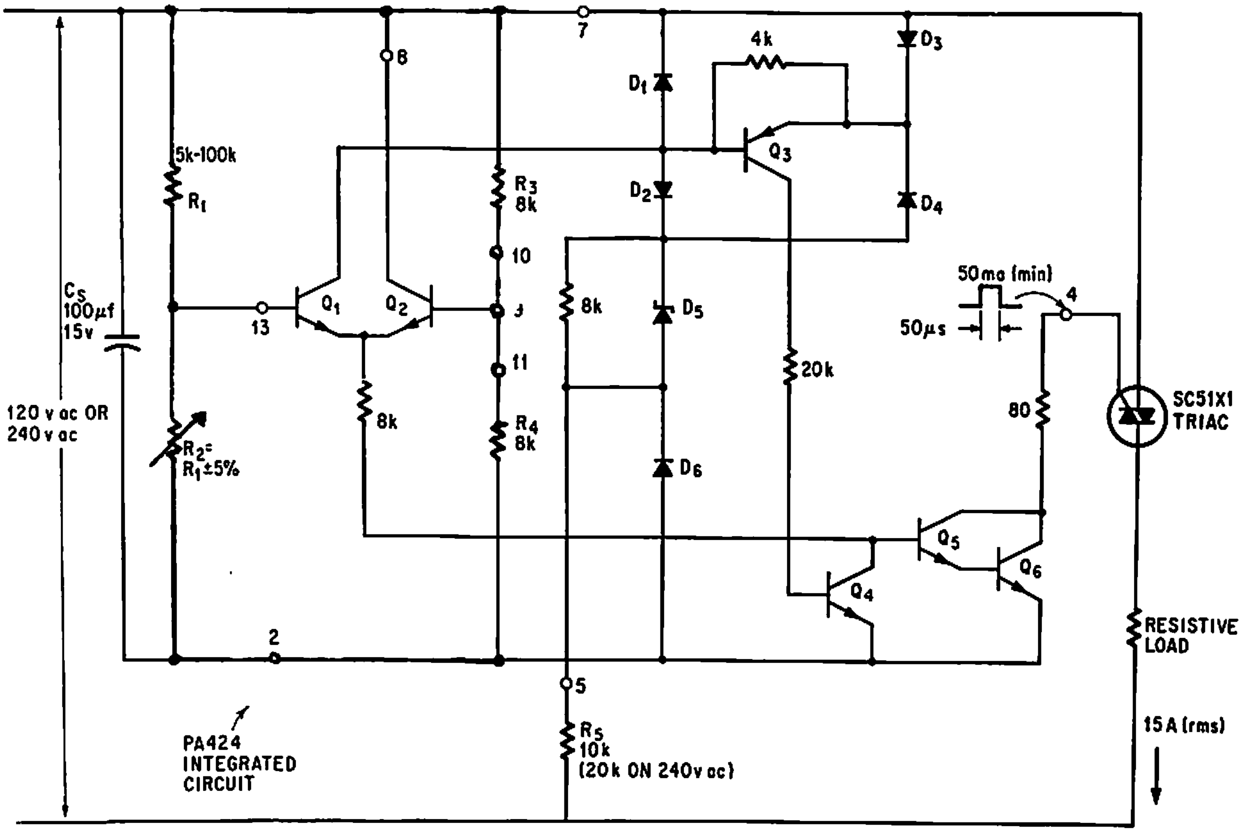
ZERO-CROSSING DETECTOR—Two voltage comparators and logic gate feed digital voltmeter to form digital-output phase comparator giving 1% accuracy at 1 MHz. Voltage comparators detect zero crossings of each input signal, for amplification by SN7400 TTL gate, differentiation, and setting of latch gates 3 and 4 for driving analog switch at duty cycle determined by phase relationship of input signals. D-c complement of resulting pulse train is applied to digital voltmeter. —R. H. Gruner, Phase Comparator Yields Digital Output, *Electronics*, Sept. 15, 1969, p 118.

RFI-FREE A-C SWITCH—Triacs close circuit only when line voltage is near zero and open it only when current is near zero, to minimize rfi. With S1 open, T1 fires at beginning of each a-c half-cycle and prevents T2 from firing. When S1 is closed, T1 commutates off at next zero crossing and R2 supplies gate current to T2 so it fires at beginning of each following half-cycle until S1 is opened.—W. B. Miles, Switch Your AC Loads at Zero Voltage or Current, *Electronic Design*, Sept. 13, 1967, p 128, 130, and 132.

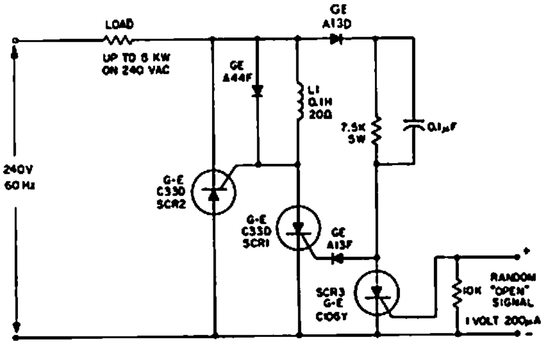

R2
4k
IN4816
LOAD
CI
115Vac
60Hz
0.15µF
RI
10k
DI-D4
TRIACS = RCA
TA 2893
TI
T2
SI
R3
560


+20
330K R1
68K R3
10K R6
HUGHES
D5 IN643
Q1
2N336
OUTPUT
D4
Q2
D3
2N336
C1
100pf
D2
R2
150K
R4
10K
R5
500K
D1
D6
INPUT

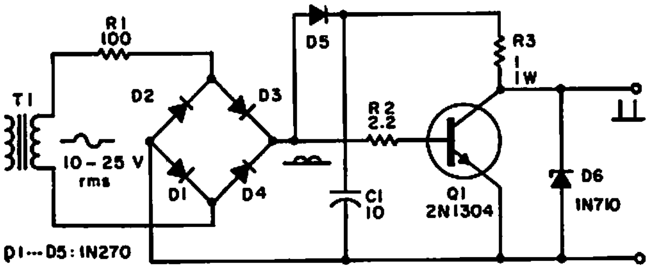
ZERO CROSSOVER—Gives output when positive-going signal is within 0.4 V of zero crossover, over temperature range of −55 to 80 C, for input signal peaks of up to 100 V in both directions and frequencies from d-c to 3,000 Hz. To reduce detection range to within 0.2 V of zero, diodes should be selected to have same forward voltage characteristics.—F. E. Olson, Zero Crossover Detector Shows High Sensitivity, *Electronic Design*, Dec. 7, 1964, p 67–68.


8
7
4k
D3
D1
Q3
5k-100k
R1
R3
8k
D2
D4
10
Q1
Q2
13
3
8k
D5
50ma (min)
4
50µs
Cs
100µf
15v
11
20k
120 v ac OR
240 v ac
8k
R4
8k
80
SC51X1
TRIAC
R2=
R1±5%
D6
Q5
Q6
Q4
RESISTIVE
LOAD
2
5
PA424
INTEGRATED
CIRCUIT
R5
10k
(20k ON 240v ac)
15A (rms)

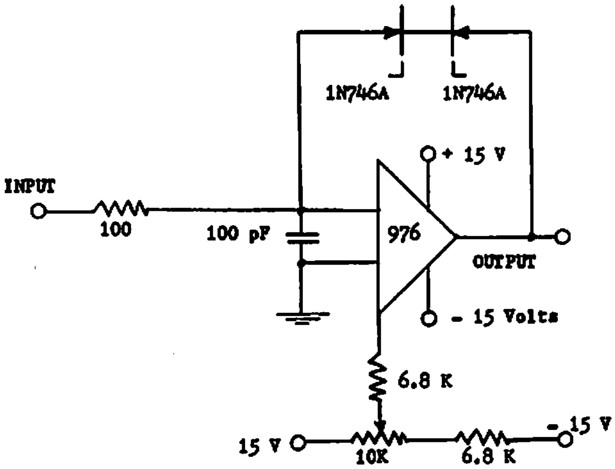
IC WITH TRIAC CONTROLS 1 KW—Uses GE PA424 IC with only five external components, by taking advantage of zero-voltage switching. Triac is fired only at zero-crossing points between half-cycles of a-c voltage. Requires no d-c power supply, and can control up to 15 A through resistive load. Article gives other power control applications for this IC. For temperature control, thermistor is used for R1.—F. W. Gutzwiller and J. H. Galloway, Power Grab By Linear IC's, *Electronics*, Aug. 21, 1967, p 81–86.


LOAD
UP TO 8 KW ON 240 VAC
GE A13D
GE A44F
L1 0.1H 20Ω
7.5K 5W
0.1μF
240V 60 Hz
G-E C330 SCR2
G-E C330 SCR1
GE A13F
SCR3 G-E C106Y
10K
RANDOM "OPEN" SIGNAL
1 VOLT 200μA
+
-

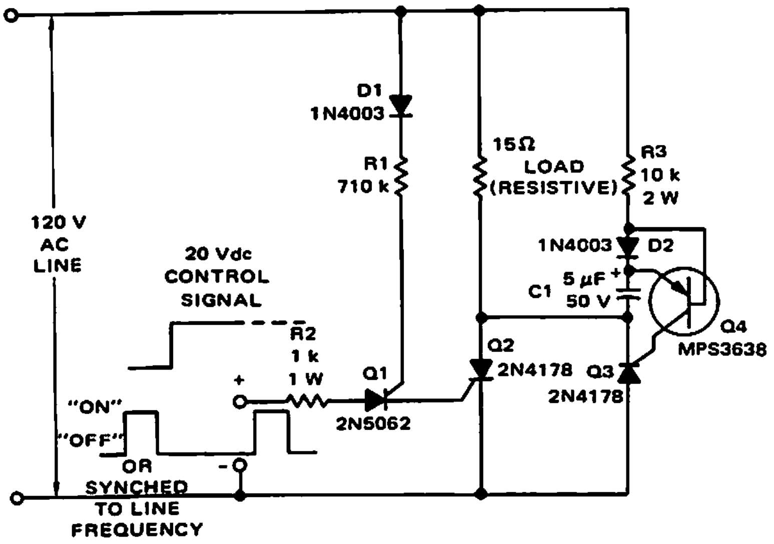
ZERO-VOLTAGE 8-KW SWITCHING—Combination of scr slaving circuit and synchronous switching insures that load voltage is always applied in essentially complete cycles, so voltage is zero at instant of switching and r-f interference is minimum. SCR2 fires at beginning of next half-cycle after SCR1 fires, to deliver even number of half-cycles and thereby reduce magnetic saturation effects in inductive load.—"SCR Manual," 4th Edition, General Electric, 1967, p 149.


R1 100
T1
10 - 25 V rms
D2
D3
D1
D4
D5
R2 2.2
C1 10
Q1 2N1304
R3 1 1W
D6 1N710
D1···D5: 1N270

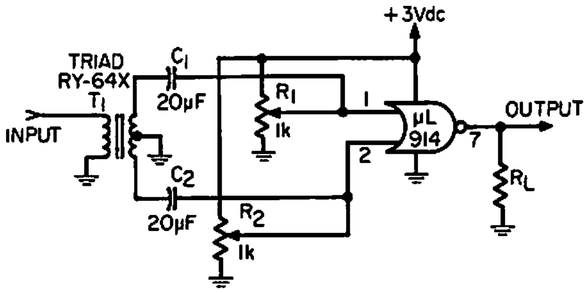
SYNC FOR FIRING SCR—Simple, inexpensive circuit requires no supply voltage or center-tapped transformer and can be used with any waveform. Used when precise synchronization with a-c line frequency is required, as in scr firing circuits. Output pulse is about 200 μs wide, with rise time of 20 μs. Q1 is normally ON; when signal level drops below that for conduction, in vicinity of zero crossing, Q1 cuts off and positive-going pulse appears at collector and output. —R. Billon, Zero-Crossing Detector Needs No Supply Voltage, *Electronic Design*, Jan. 4, 1968, p 144–145.


1N746A
1N746A
INPUT
100
100 pF
976
+ 15 V
OUTPUT
- 15 Volts
6.8 K
15 V
10K
6.8 K
-15 V

HIGH-SPEED ZERO-CROSSING DETECTOR—Uses OEI Model 976 opamp having slewing rate of 250 V per μs and minimum gain of 50 dB at 1 MHz. Requires negative input signal up to 1 V maximum and is inverting, with output of approximately 3.3 V when input is negative and with output transition occurring within nanoseconds of input zero crossing.—A High Speed Zero Crossing Detector Using an Operational Amplifier, Optical Electronics, Tucson, Ariz., No. 10041.

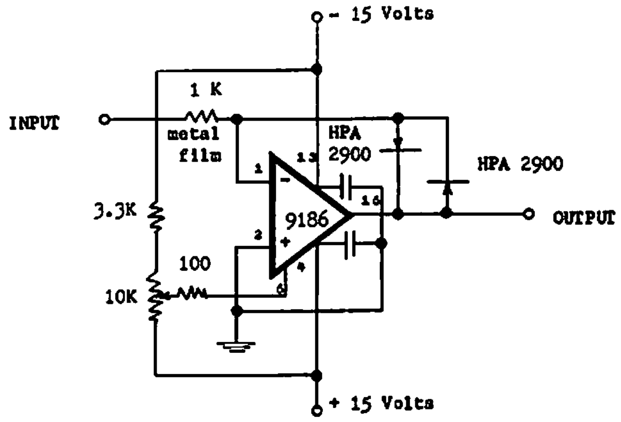

D1 1N4003
R1 710 k
15Ω LOAD (RESISTIVE)
R3 10 k 2 W
120 V AC LINE
20 Vdc CONTROL SIGNAL
1N4003 D2
C1 5 μF 50 V
Q4 MPS3638
R2 1 k 1 W
Q1 2N5062
Q2 2N4178
Q3 2N4178
"ON"
"OFF"
OR SYNCHED TO LINE FREQUENCY
+
-

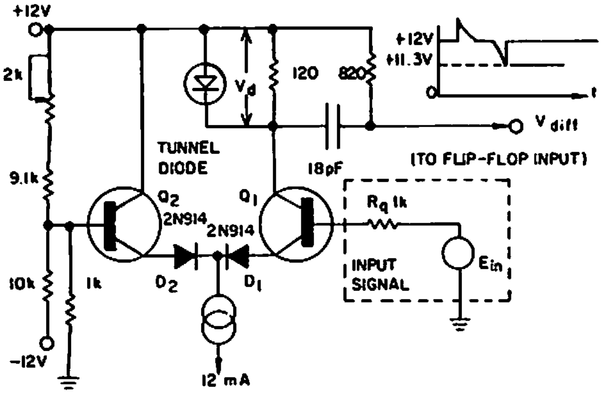
SCR A-C STATIC SWITCH—Used for zero-point switching of resistive load on a-c line. Application of control signal makes scr Q1 turn on during first positive half-cycle after signal is applied. Q1 provides gate current for turning Q2 on. Q2 charges C1 through D2 and D3 to peak line voltage. When D2 becomes reverse-biased by decaying line voltage, C1 discharges and turns on Q4 for desired switching action. Will not handle large inductive load.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 4–8.


+3Vdc
TRIAD
RY-64X
T1
INPUT
C1
20μF
R1
1k
C2
20μF
R2
1k
1
2
μL
914
7
OUTPUT
RL

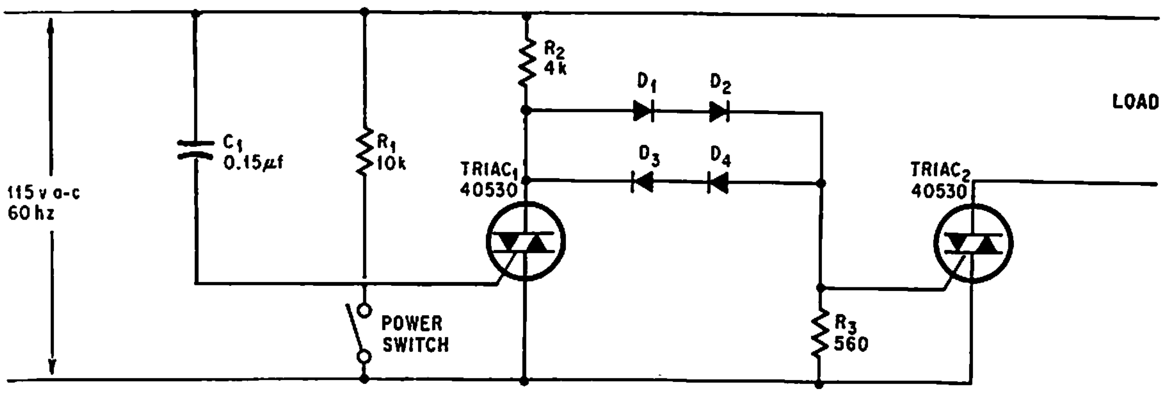
200–10,000 HZ ZERO-VOLTAGE DETECTOR—Delivers output pulse whenever a-c input waveform goes through zero. Applications include counters, phase-control circuits, and some types of analog-digital convertors. Provides 1.2 V peak output for 1 V rms input.—T. Polanoczky and A. Brand, IC NOR Gate Detects Zero-Axis Crossing, *EEE*, April 1968, p 107.

PRECISION ZERO-CROSSING DETECTOR—Uses OEI Model 9186 opamp with feedback diodes that limit output to 0.5 V with either polarity, depending on polarity of input before crossing zero. Output lags actual zero crossing by 90 deg because of amplifier phase shift, which means that detector output will be zero 95 ns after input is zero for 10-MHz signal.—A Precision Zero Crossing Detector, Optical Electronics, Tucson, Ariz., No. 10114.

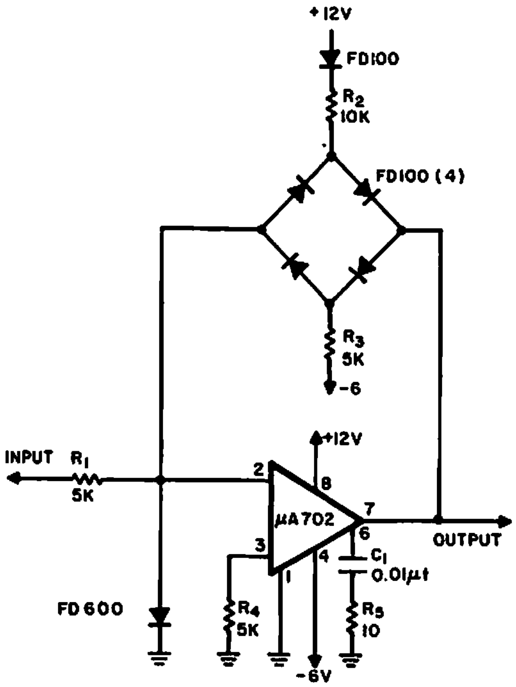

- 15 Volts
INPUT
1 K
metal
film
HPA
2900
HPA 2900
3.3K
9186
1
2
13
14
4
6
100
10K
OUTPUT
+ 15 Volts


+12V
2k
9.1k
10k
-12V
1k
TUNNEL
DIODE
Vd
120
820
18pF
Q2
2N914
Q1
2N914
D2
D1
12 mA
+12V
+11.3V
0
t
Vdiff
(TO FLIP-FLOP INPUT)
Rg 1k
INPUT
SIGNAL
Ein

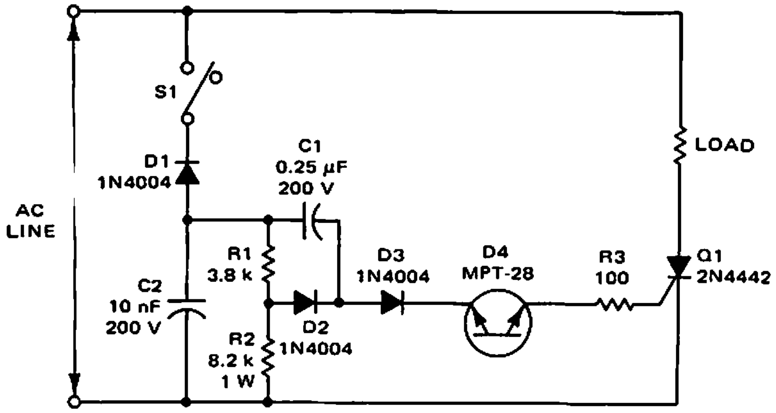
ZERO-CROSSING DISCRIMINATOR — High-speed circuit has broad dynamic range, high input resistance, and high input sensitivity. Collector currents of Q1 and Q2 are equal only when input signal is zero. When negative input signal is fed to Q1, collector current and voltage drop Vd decrease. When drop goes below tunnel diode voltage, it switches from high to low state, corresponding to low-level discrimination. With tunnel diode also in Q2 collector circuit, zero crossings of sine-wave input can be discriminated. —M. Sampaleanu, High-Speed Zero Crossing Detector Uses Tunnel Diodes, *Electronic Design*, March 15, 1970, p 214 and 216.


115 v a-c
60 hz
C1
0.15μf
R1
10k
POWER
SWITCH
R2
4k
TRIAC1
40530
D1
D2
D3
D4
R3
560
TRIAC2
40530
LOAD

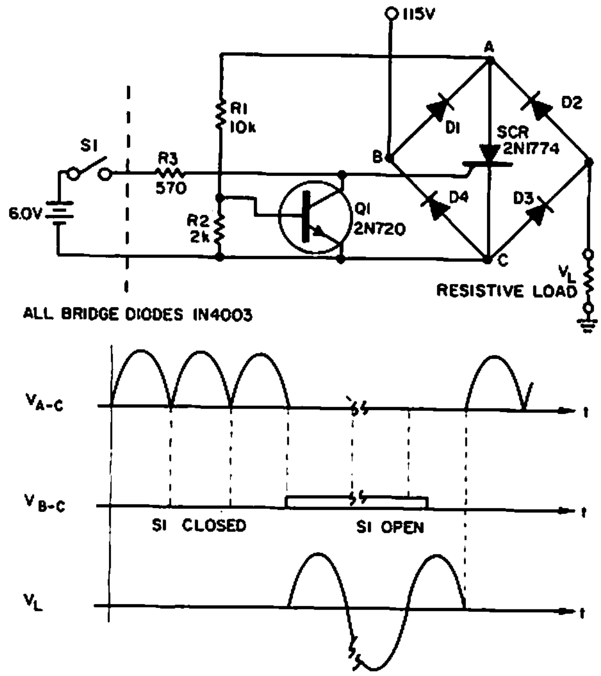
NOISE-FREE TRIAC A-C SWITCH—Permits switching of a-c voltages and currents only at zero points, to prevent generation of rfi that could destroy transistors.—W. B. Miles, Gated Semiconductors Clean A-C Switching, *Electronics*, May 27, 1968, p 105–106.


+12V
FD100
R_2
10K
FD100 (4)
R_3
5K
-6
+12V
INPUT R_1
5K
2
8
7
μA702
6
3
4
1
OUTPUT
C_1
0.01μf
FD600
R_4
5K
R_5
10
-6V

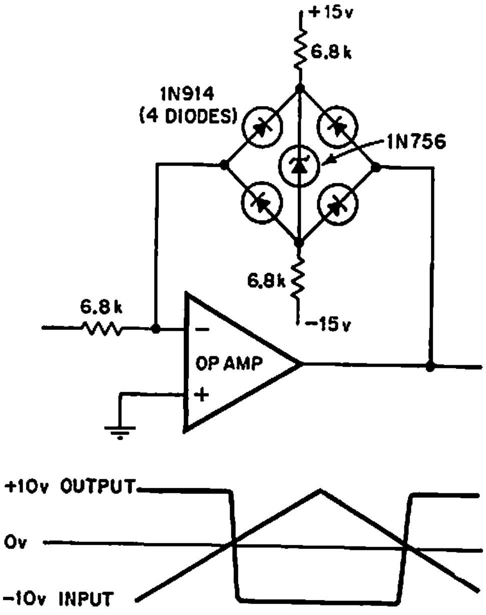
ZERO-CROSSING DETECTOR—Uses Fairchild IC opamp to perform power spectrum analysis of analog signal waveform, within specified passband, that is extracted from broadband signal and noise. Amplifier is driven to maximum output of 1.5 V for input voltage excursions as small as 500 μV to give uniform clipping of random analog waveform with negligible hysteresis and negligible loss of average reference level.—L. A. Watts, The Integrated Operational Amplifier: A Versatile and Economical Circuit, "Microelectronic Design," Hayden Book Co., N.Y., 1966, p 189–194.


S1
D1
1N4004
C1
0.25 μF
200 V
LOAD
AC
LINE
R1
3.8 k
D3
1N4004
D4
MPT-28
R3
100
Q1
2N4442
C2
10 nF
200 V
D2
1N4004
R2
8.2 k
1 W

ZERO-POINT SWITCH—Scr Q1 turns on at start of first positive half-cycle following closing of S1, to prevent generation of electromagnetic interference. Book describes capacitor-charging action of circuit.—"Semiconductor Power Circuits Handbook," Motorola, Phoenix, Ariz., 1968, p 6–5.


115V
A
D2
R1
10k
D1
SCR
2N1774
S1
B
R3
570
D4
D3
6.0V
Q1
2N720
R2
2k
C
V_L
RESISTIVE LOAD
ALL BRIDGE DIODES IN4003
V_{A-C}
t
V_{B-C}
t
S1 CLOSED
S1 OPEN
V_L
t

ZERO-VOLTAGE SWITCHING—Regardless of time S1 is closed, scr is turned on or off only at zero-voltage crossover point of a-c line voltage, for minimizing power-line rfi.—A. J. Marek, Simple Zero Crossing Detector Minimizes Power-Line RFI, *Electronic Design*, March 1, 1970, p 81.


+15v
6.8k
1N914
(4 DIODES)
1N756
6.8k
6.8k
-15v
-
OP AMP
+
+10v OUTPUT
0v
-10v INPUT

OPAMP WITH ZENER-BRIDGE FEEDBACK—Clips and squares edges of a-c inputs each time zero crossover is detected. Useful in phase-sensitive demodulation networks. Positive amplitudes of input generate negative output pulse, while negative inputs generate positive voltage level.—R. Liu, Zener Diode in Op Amp's Loop Enables Symmetrical Clipping, *Electronics*, Feb. 16, 1970, p 105.